

A National Survey on Naturally Occurring Radioactive Material (NORM) in Petroleum Production and Gas Processing Facilities

Exploration and Production Department
API Publication 7101
November, 1997



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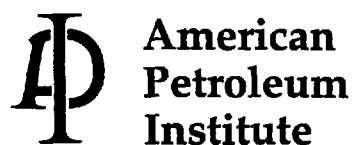
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for the API NORM Issue Group

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PREFACE

NATURALLY OCCURRING RADIOACTIVE MATERIALS

IN

PETROLEUM PRODUCING AND GAS PROCESSING FACILITIES

The presence of naturally occurring radioactive materials (NORM) in oil and gas producing operations has been recognized since the early 1930s when slightly elevated radium levels were detected in Russian oil fields. Over the years, scientists have studied various aspects of low level radiation from NORM associated with oil and gas production. Recently, in 1981, scale produced on large platforms located in the North Sea was found to contain NORM at measurable levels. In the United States, the issue of NORM in mineral scale deposits gained industry and government attention in 1986. During routine work on a well in Mississippi, barium sulfate scale deposited in production tubing was found to contain measurable quantities of NORM. Industry responded by 1) notifying appropriate state agencies and the Mid-Continent Oil & Gas Association, 2) initiating field surveys to locate the occurrence of NORM, 3) informing other oil and gas operators, employees, and contractors, 4) initiating training programs, and 5) reviewing operating practices.

The Mid-Continent Oil & Gas Association in Mississippi was established as a clearing house for information on NORM, initially coordinating field survey activities and outlining field handling guidelines. The American Petroleum Institute began coordinating action on the NORM issue at the national level beginning in late 1986. The following API-sponsored report by Dr. Gordon Otto of the University of Houston defines the general occurrence of NORM in the United States based on a statistical analysis of gamma measurements taken external to certain petroleum producing and gas processing equipment. While not exhaustive, the data base is large and indicates that NORM is not everywhere in the "oil patch," and is generally limited to certain geographical areas. In fact, since much of the data were collected at sites which were suspected of some radioactivity, the magnitude of occurrence is likely to be overstated.

Health, safety and environmental impact issues associated with NORM occurrence, while not addressed in Dr. Otto's report, are met by industry through the use of traditional industrial hygiene practices and work procedures since most oil and gas NORM resides inside of closed steel vessels and pipes. Additionally, the quantity of NORM at any given work location is generally very small, and radiation levels are low when compared with background levels. NORM exists on the inner surfaces of some oil and gas equipment, generally in the following forms:

- Radium 226 and Radium 228 - co-precipitated in some mineral scales.
- Lead 210 films in gas processing equipment, primarily propane and ethane pumps.
- Radon gas co-produced with natural gas.

The exposure to NORM of most concern in oil and gas operations is by ingestion and inhalation which is prevented utilizing work procedures routinely used for protection of other risks. Exposure to NORM is only one of several risks which must be dealt with in oil and gas producing operations. Equipment which may contain small quantities of NORM also contains large quantities of hydrocarbons which may in turn contain carbon dioxide and/or hydrogen sulfide. Because of the existence of these materials in the oilfield, industrial hygiene practices aimed at protecting against their hazards have long been in place and include:

- Purging of vessels prior to entry.
- Use of respirators and breathing apparatus while working inside of vessels.
- Use of masks while performing grinding and chipping operations.
- Utilization of protective clothing, including gloves, and the prohibition of eating, smoking, or chewing around open equipment.

NORM is widely dispersed in the earth's crust, and some industries, of necessity, concentrate NORM pursuant to the primary function. This occurs in the mining of uranium and certain other minerals...the production of some fertilizers...and in other very legitimate commercial undertakings. NORM derived from producing oil and gas is not generally concentrated; it is of very low specific activity; and oil and gas well locations are typically widespread, thus, a natural dispersion of oilfield NORM is maintained. The small quantities of NORM produced at only a few relatively remote sites constitutes no appreciable addition to natural radiation background levels. The following report by Dr. Otto presents information on the geographical occurrence of oilfield NORM, relating it to natural radiation background levels, and points toward further understanding of why there are no known NORM environmental, health, or safety concerns associated with oil and gas production sites.

R. D. Baker

for

J. C. Martin
Chairman - API Committee on NORM

A National Survey on
Naturally Occurring Radioactive Materials (NORM)
In Petroleum Producing and Gas Processing Facilities

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* State summaries contain figures, tables and appendices similar to the total U.S. information and state measurement data is provided for counties, parishes, etc.

A NATIONAL SURVEY ON
NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM)
IN PETROLEUM PRODUCING AND GAS PROCESSING FACILITIES

I. Introduction

The data summarized in this report is a compilation of over 36,000 individual observations submitted by a number of participating petroleum companies using similar equipment and collection protocols (see Section VIII). The purpose of the study was 1) to identify the geographic areas of producing and gas processing facilities (gas plants) which have the greatest occurrence of NORM and 2) to identify items of equipment at these facilities which have the highest NORM activity levels.

Results are first reported on a national basis so that the general patterns in background levels and the excess radioactivity over background for both types of facilities can be seen in geographic perspective. NORM activity levels are reported in this study in micro-rems/hr. In addition to geographic studies at the county, state and national level of aggregation, there are also summaries by item of equipment for each state and the total U.S.

II. Summary of Results

Section VI - National Summary contains figures, tables and appendices for the total U.S. This study consists of 36,890 observations collected in twenty states and two offshore areas. The geographical distribution of the survey points is shown in Figure 1 and includes both oil/gas producing equipment (33,042 readings) and gas processing equipment (3,848 readings). Figures 1A and 1B illustrate survey distribution for gas processing and oil/gas producing equipment respectively. The size of the data base is impressive. However, results must be used with some caution in evaluating state or local environmental conditions for reasons described in Section III.

Figure 2 illustrates median background levels and Figures 3 and 4 illustrate median activity levels over background for gas processing and oil/gas production facilities respectively. The 5th, 25th, 75th and 95th percentile points of the nationally aggregated data were used to define five categories for tabulation and mapping of both the background levels and the differences over background. In developing these categories, offshore data was deleted from the background compilation due to the abnormally low background provided by the marine environment. Likewise, equipment observations which were not above background were deleted from the differences compilation due to the large number of "zero" values. This is discussed further in Section IV. The median values for background and differences are shown on the next page for the five categories. These values are reported in the National Summary and were used to classify equipment, counties and states in the State Summaries.

<u>Category</u>	<u>Definition (National)</u>	<u>Background MR/hr</u>	<u>Differences MR/hr</u>
1	Lowest 5%	0.00 - 2.33	0.00 - 0.80
2	Next 20%	2.34 - 4.99	0.81 - 1.99
3	Middle 50%	5.00 - 9.00	2.00 - 33.00
4	Next 20%	9.01 - 14.00	33.01 - 245.00
5	Highest 5%	over 14.00	over 245.00

NORM activity levels showed wide variability, both geographically and between items of equipment in the same geographic area. As shown on Figure 2, lower background levels tend to occur offshore and near the coast. The Midwest and Rocky Mountain areas tend to have higher background levels. Background levels are not related to the equipment readings. Several areas of Colorado, Wyoming and Utah, for example, had high background levels and very few equipment readings above background. This can be seen by comparing the background levels shown in Figure 2 with the difference over background levels in Figures 3 and 4.

The geographic areas with the highest equipment readings are the entire gulf coast crescent (Florida panhandle to Brownsville, Texas), the northeast Texas crescent, southeast Illinois and a few counties in southern Kansas. These are shown in Figures 3 and 4 for gas processing and production facilities, respectively. The eastern gulf coast from Mississippi to the Florida panhandle has the highest consistent NORM activity levels surveyed in the entire United States.

Table 1 illustrates NORM activity levels over background for approximately 15 different types of equipment for both gas processing and production facilities. NORM activity levels tend to be higher in specific types of equipment. Gas processing facilities having the highest levels are reflux pumps, propane pumps and tanks, other pumps and product lines. Water handling equipment in the production facilities category exhibits the greatest NORM activity levels. Details on equipment types are provided in the national summary in the report.

When located in the same area, the gas processing equipment noted above tends to have higher activity levels than the water handling equipment in the producing facilities. This can be seen in the state summaries by comparing the median readings for the two types of facilities in the same county.

III. The Data

The data were supplied by a number of major petroleum companies from readings made on their own equipment under a common protocol using a similar type of scintillation detector. Calibration was done in accordance with the manufacturer's specifications by all participants. Thus this data base represents the most comprehensive and consistent set of NORM data available for petroleum operations. However, much of the data were collected at sites which were suspected of exhibiting some degree of radioactivity. Hence, the data is not typical of a randomly chosen site and tends to overstate the magnitude of NORM occurrence.

The data were not collected in statistically designed sampling plans and hence there is no scientific basis for extrapolating the results to unsurveyed areas of petroleum production/gas processing. The number of observations from gas processing and producing equipment for a given geographic area may not be proportional to the actual amount of operational equipment in the area. In addition to the lack of proportionality between equipment types, there is dis-proportionality in the representation among counties in the same state and between the states themselves. Many counties with oil and gas operations have no data reported and many others have only a single observation. The entire states of Kentucky and Nebraska have 21 and 30 observations respectively. All of the Nebraska data comes from a single county on its southern border and the Kentucky data is all from two counties on the western border with Illinois.

Readers should consider the sample size which is reported along with the NORM statistics. The reliability of statistical results are also related to the sample sizes collected. In many cases seemingly large NORM readings (relative to other such readings) for a county or item of equipment in a state may be the result of a single observation or a small group of observations taken at the same location.

IV. Additional Considerations

Since the survey was not conducted under statistically controlled conditions, interpretation of the results become difficult when the data are aggregated across dis-similar areas with different sample sizes and different potential for NORM activity levels in the equipment. In particular, a large number of low readings from benign areas may "average out" and thus minimize the influence of a smaller number of high readings.

One approach to this problem is to examine two different sets of statistics: 1) using all of the observations and 2) the tabulation of only those which are above background. The latter approach filters out the large number of "zero" values (relative to difference over background) which constitute 64.3% of the gas processing data and 56.9% of the production data. The first approach focuses on the overall result and the second focuses on conditions in only those cases where NORM was found to be present. The first approach tends to understate the median activity levels and the second tends to overstate the occurrence of NORM and activity levels if viewed as the "average" case.

The national summaries were prepared using both approaches. Table 1 and Appendix 1 show the summary by equipment types for all observations and Table 2 and Appendix 2 show the results for the non-zero differences only. Table 2 is more useful for identifying the items of equipment which are most likely to have higher NORM activity levels.

Table 3 constructs an "incidence" measure for each state which is an alternative statistical method of comparing NORM occurrence by providing a ranking in terms of both frequency of occurrence and intensity of activity levels. This index is the product of the percentage of above-background readings times the median value of the above-background observations. From Table 3 we see that Alabama/Florida and Mississippi have a much higher incidence measure than any other states with Illinois not too far behind. The Texas coast, Alaska and Kentucky form the next grouping.

V. Glossary

The data was collected using abbreviations for the equipment types surveyed. The glossary of abbreviations used is given below.

A. Gas Processing Equipment (GP)

1. BOTTOMS PUMP - Pumps transferring liquids from the bottoms of towers.
2. COMPRESSOR - Compressors and associated equipment. This includes compressors located on the lease.
3. CRYO UNIT - All equipment associated with the cryogenic process.
4. DEHYDRATOR - Dehydration equipment to include Glycol, EG and TEC systems, etc.
5. FRAC TOWER - All process towers and columns.
6. INLET SCRUBBER - Inlet scrubbers, separators, fwko etc.. This includes those located on the lease.
7. METER - All metering equipment to include meters, meter runs, screens, strainers, filters, etc..
8. OPUMP - All other pumps.
9. OTANK - All other tanks.
10. OTHER - All other gas processing equipment, including pig launcher and receiver.
11. PPUMP - Propane pump.
12. PTANK - Propane tank.
13. PRODUCT LINE - All product lines.
14. REFLUX PUMP - All reflux pumps.
15. REFRIGERATION - All equipment associated with the propane refrigeration system.
16. SWEETENER - All gas sweetening equipment to include amine systems, etc..

B. Production Facilities (PROD)

1. FLINE - Flow lines to include all valves and elbows.
2. H/T - Heater treater.
3. MANIFOLD - Manifold/header piping, valves and chokes, etc.
4. OTHER - All other measurements on in service equipment.
5. PUMP - All pumps.
6. SEP - Separators to include production separators, fwko, gunbarrels, etc..
7. STANK - Stock tanks.
8. SUMP - Sumps to include pits, pigtraps, ponds, etc.
9. VRU - Vapor recovery units.
10. WINJ - Injection wellhead.
11. WOTHER - Other wellheads.
12. WPROD - Production wellhead.
13. WLINE - Water lines to include all valves and elbows.
14. WTANK - Water tanks.

VI. National Summary

Overview

I. Differences in Equipment (all observations)

The equipment with the most pronounced differences over background based on Median ranking are listed below in descending order. The difference is the excess of the reading over background using all observations:

Equipment	Median Difference	75 th Percentile
1. Reflux Pumps (GP)	52.7 μ R/hr	242.0 μ R/hr
2. Propane Pumps (GP)	19.0	70.0
3. Propane Tanks (GP)	9.0	45.8

II. Differences in Equipment (observations in excess of background)

A second way of looking at the data is to exclude all values which were at or below background and focus on what happens when NORM is detected.

The equipment with the most pronounced differences over background based on Median ranking are listed below in descending order. The difference is the excess of the reading over background using only those observations in excess of background:

Equipment	Over	Median Difference	75 th Percentile
1. Reflux Pumps (GP)	86.4	76.0 μ R/hr	291.0 μ R/hr
2. Flow Line (Prod)	24.0	42.0	112.0
3. Pump (GP)	66.7	38.0	73.0
4. Product Line (GP)	56.1	35.0	110.5
5. Water Line (Prod)	51.6	34.6	100.0
6. Propane Pumps (GP)	74.7	31.0	97.5
7. Other Pump (GP)	49.1	27.8	96.3
8. Propane Tanks (GP)	72.6	25.0	65.7
9. Injection Well(Prod)	49.0	20.0	56.3

III. Overall Summary

1. Nationwide (all Obsns)

ITEM	No	5 th Pct. (low)	25 th Pct. (-----)	Median mid-range	75 th Pct. -----)	95 th Pct. (high)
a. Background*	33970	2.3	5.0	7.0	9.0	14.0
b. Max Reading	36890	1.5	6.0	9.0	13.0	110.0
c. Difference	36890	0.0	0.0	0.0	4.0	104.6

* On-shore backgrounds only. Based on these numbers, back-

grounds for each county were classified if their median values were below 2.34 (very low), between 2.34 and 5.99 (low), between 5.99 and 9.0 (mid-range), between 9.01 and 14.0 (high) and above 14.0 (very high).

2. Nationwide (observations over background only)

ITEM	No	5 th Pct. (low)	25 th Pct. (----- mid-range -----)	Median	75 th Pct. (-----)	95 th Pct. (high)
Difference	15630	0.8	2.0	6.0	33.0	245.0

This distribution was used to classify all difference readings (by county or equipment) as very low (< 0.8), low (.8 - 1.99), mid-range (2.0-33.0), high (33.01 - 245) and very high (above 245).

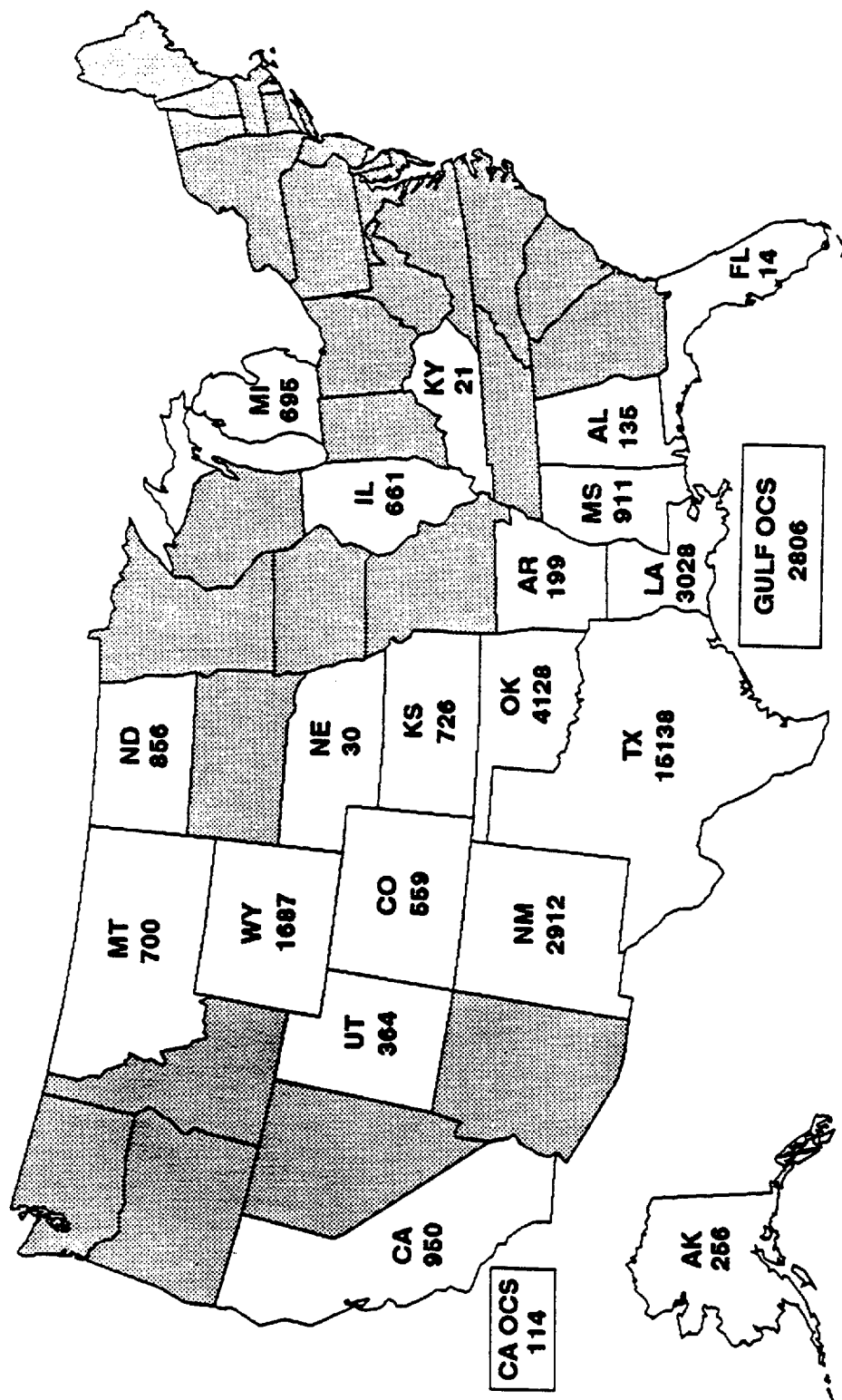
3. Facility

ITEM	No	5 th Pct. (low)	25 th Pct. (----- mid-range -----)	Median	75 th Pct. (-----)	95 th Pct. (high)
Difference (All observations)						
Gas Processing	3864	0.8	0.8	0.8	3.0	95.0
Production	33026	0.8	0.8	0.8	4.0	105.0

Difference (Observations in excess of background)						
Gas Processing	1379	0.8	2.0	9.0	46.0	261.9
Production	14250	0.8	2.0	6.0	31.0	245.0

NOTE: All data are measured in micro-rem/hr

FIGURE 1 - STATES/AREAS REPRESENTED IN SURVEY



TOTAL MEASUREMENTS
PRODUCING EQPT. 33,042
GAS PROCESSING 3,848
36,890

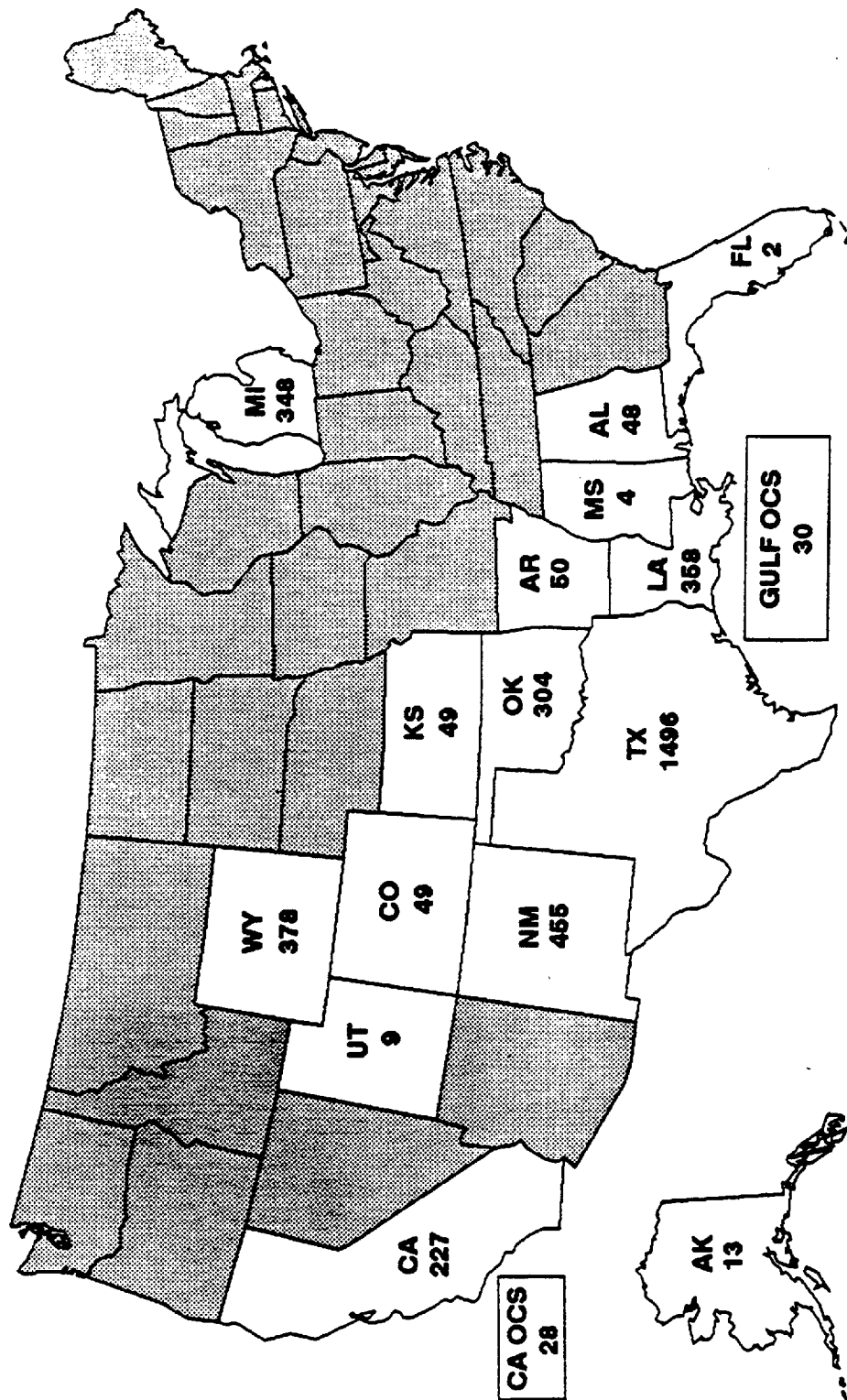
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'MT' = STATE
 '700' = NO. DATA PTS.



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FIGURE 1A - GAS PROCESSING MEASUREMENTS

'NM' = STATE
'455' = NO. DATA PTS.

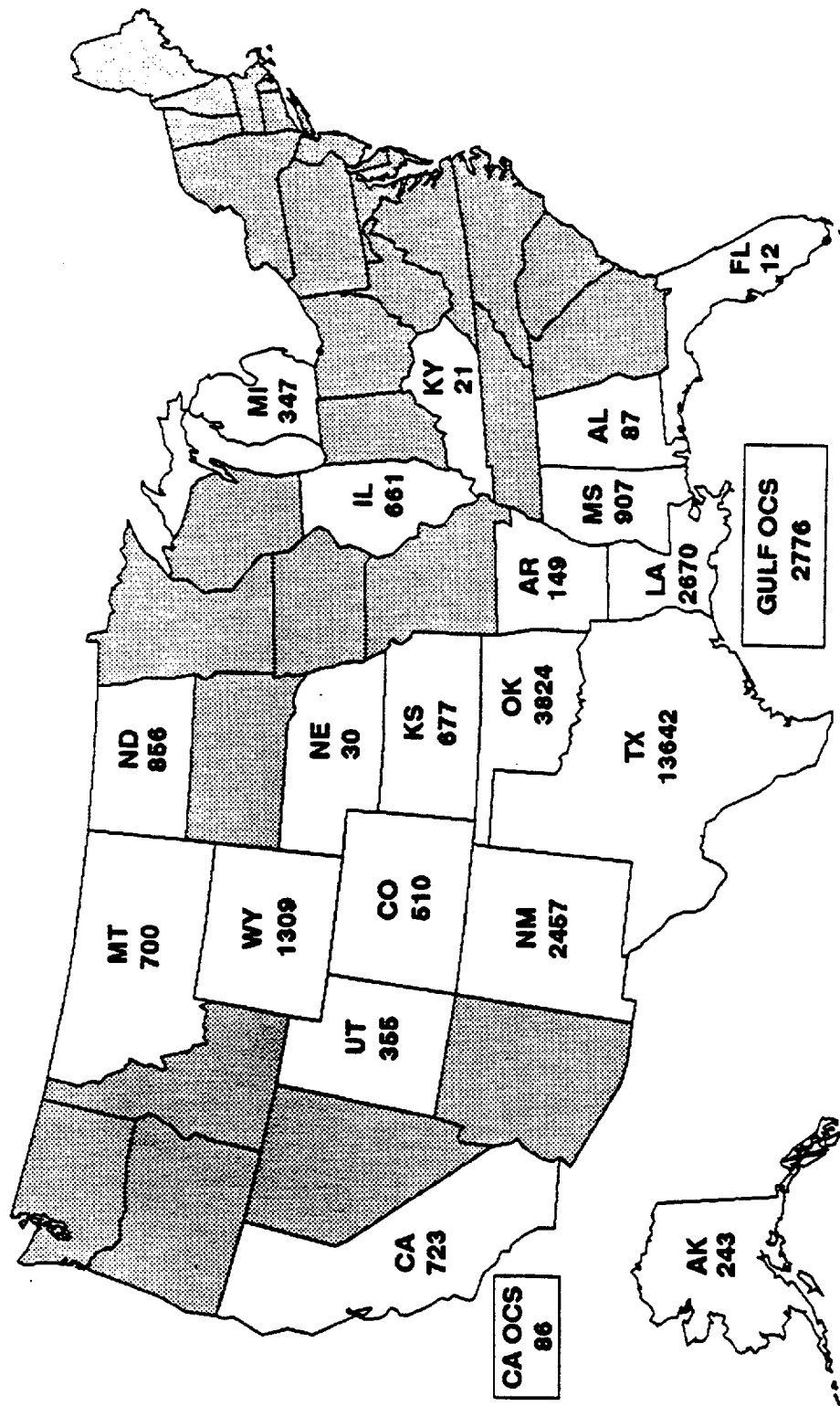
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FIGURE 1B - PRODUCTION FACILITY MEASUREMENTS



'MT' = STATE
'700' = NO. DATA PTS.

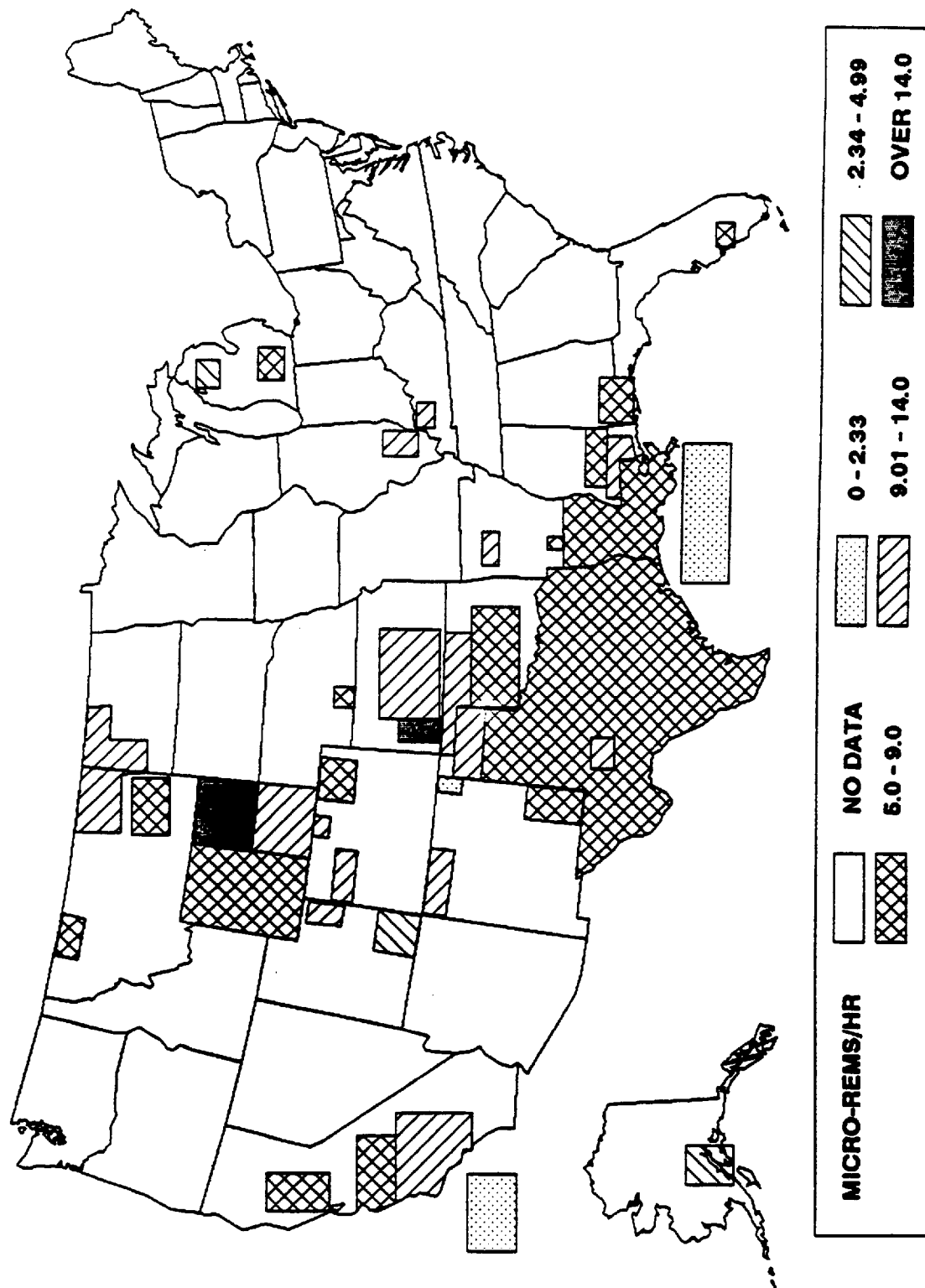
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FIGURE 2 - MEDIAN BACKGROUND LEVELS



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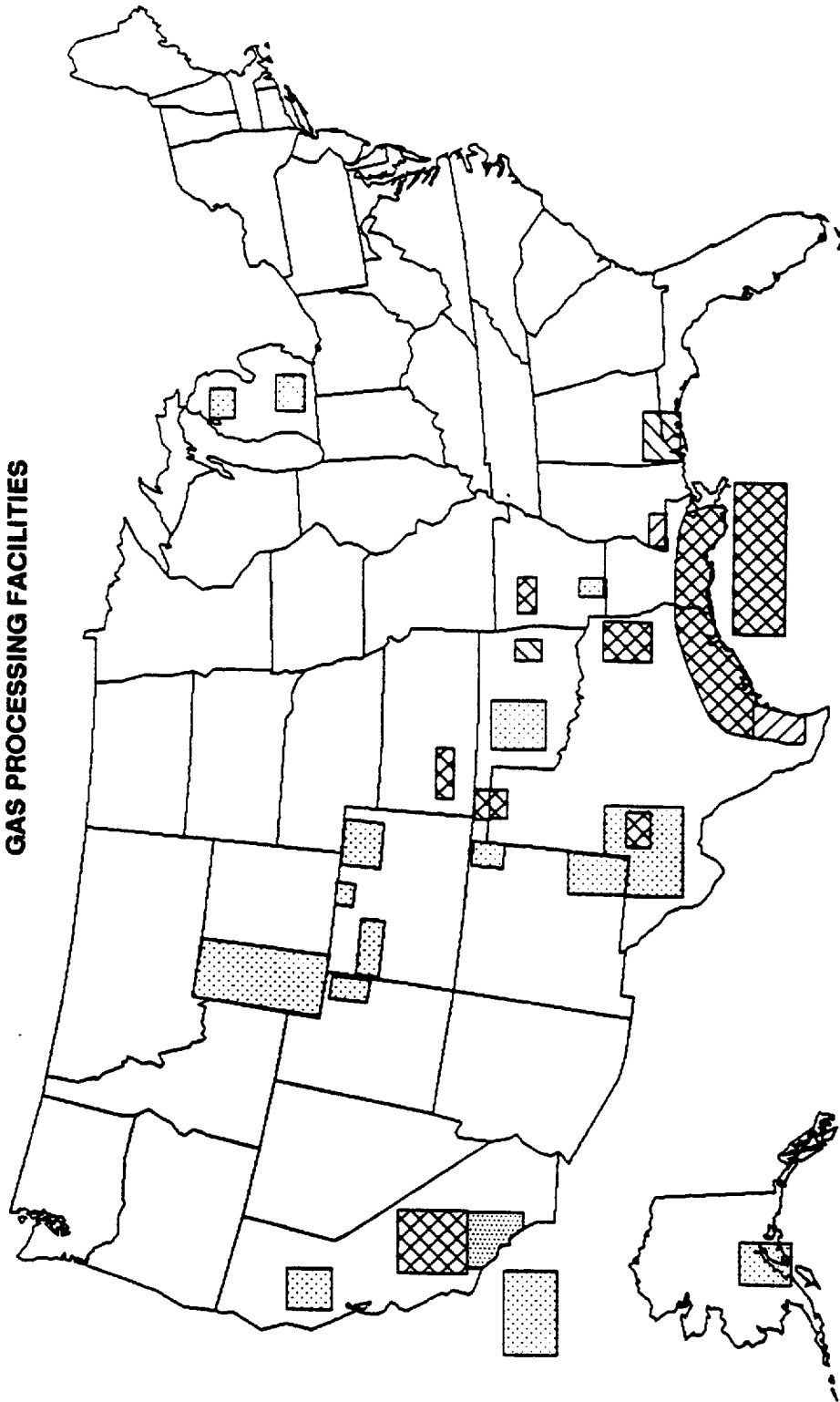


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FIGURE 3 - MEDIAN OF DIFFERENCE OVER BACKGROUND

GAS PROCESSING FACILITIES



MICRO-REMS/HR	NO DATA	BELOW .8	.8 - 1.99
	2 - 33	33.01 - 245	OVER 245

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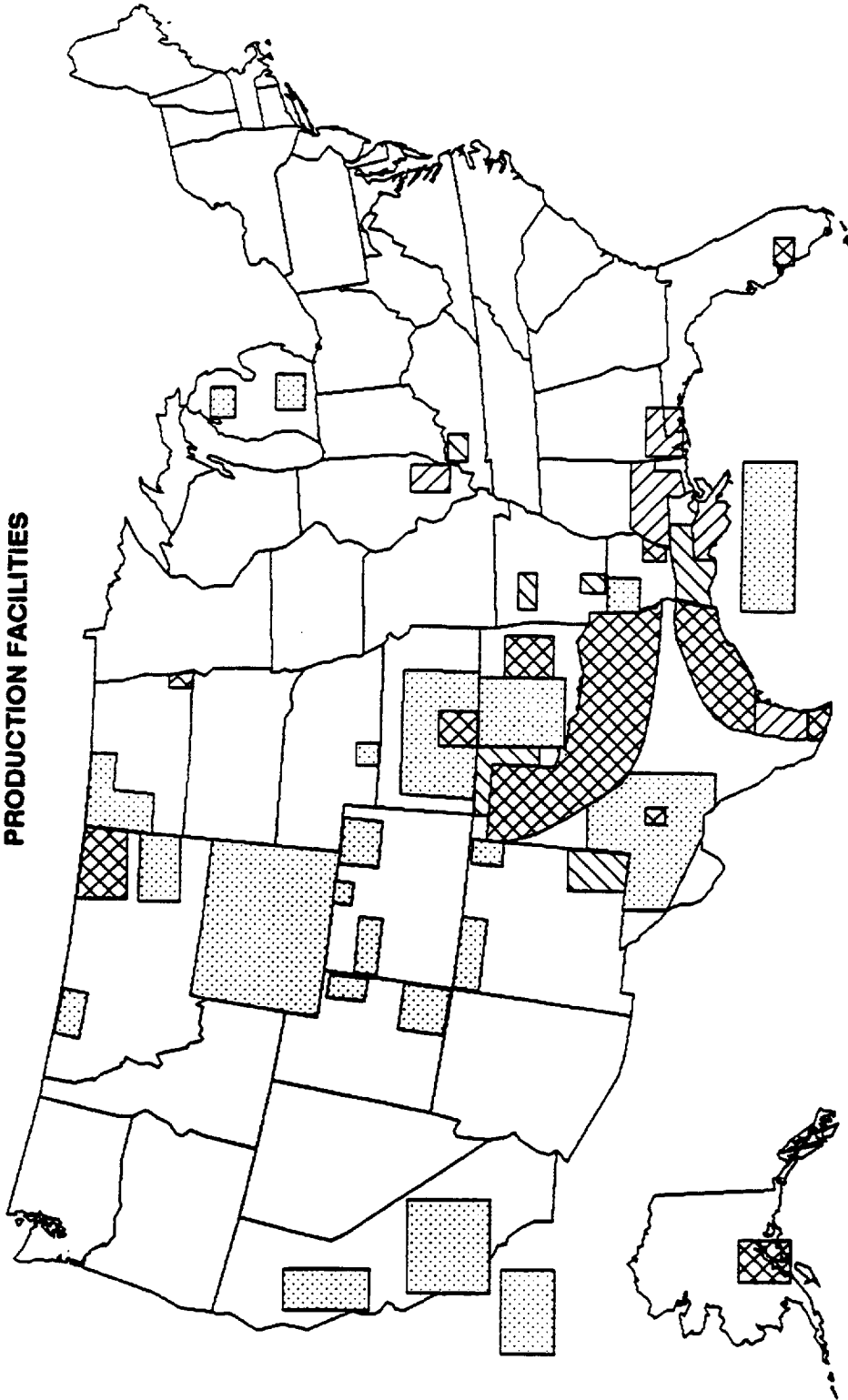


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FIGURE 4 - MEDIAN OF DIFFERENCE OVER BACKGROUND

PRODUCTION FACILITIES



MICRO-REMS/HR



NO DATA



BELOW .8



.8 - 1.99



2 - 33



33.01 - 245



OVER 245

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NATURALLY OCCURRING RADIOACTIVITY SURVEY

Table 1

Difference of Maximum Reading over Background by Equipment
Sequenced by Increasing Median Difference
(Micro-Rems/Hr)

National Summary
(All Observations)

FACILITY: Gas Processing

Obsns	Equipment		Median Difference	75th Percentile
648	COMPRESSOR		0.0	0.0
50	CRYO UNIT		0.0	2.5
244	DEHYDRATOR		0.0	1.0
272	FRAC TOWER		0.0	6.0
593	INLET SCRUBBER		0.0	0.5
101	METER		0.0	1.0
232	OPUMP		0.0	25.5
423	OTANK		0.0	2.0
430	OTHER		0.0	4.0
143	REFRIGERATION		0.0	4.0
243	SWEETENER		0.0	0.0
3	PUMP	**	3.0	73.0
146	PRODUCT LINE	**	3.3	46.5
40	BOTTOMS PUMP	****	7.0	28.0
124	PTANK	*****	9.0	45.0
71	PPUMP	*****	9.0	70.0
110	REFLUX PUMP	*****	52.7	242.0
3864				

-----+-----+-----+-----+-----+-----+-----
10 20 30 40 50 60
Median of Difference Over Background

FACILITY: Production

1748	PLINE		0.0	0.0
2537	MANIFOLD		0.0	2.0
306	METER		0.0	0.0
2397	OTHER		0.0	3.0
1393	PUMP		0.0	1.0
7887	SEP		0.0	7.0
7005	STANK		0.0	2.0
115	VRU		0.0	0.0
102	WINJ		0.0	20.0
24	WOTHER		0.0	0.0
2324	WPROD		0.0	1.0
2962	H/T		0.3	8.0
454	SUMP	*	1.0	9.3
341	WLINE	*	1.0	39.0
3431	WTANK	*	2.0	14.0
33026				

-----+-----+-----+-----+-----+-----+-----
10 20 30 40 50 60
Median of Difference Over Background

Table 3
NORM Incidence by State
(All Facilities)

State Name	All Observations		Obsns. Above Background		Incidence Measure
	No. of Obsns.	Median Difference	% of Total	Median Difference	
Alaska	256	6.0	76.2	10.0	7.62
Alabama/Fl	149	20.0	69.8	58.5	40.83
Arkansas	199	1.0	61.3	2.0	1.23
California	950	0.0	34.2	10.0	3.42
Colorado	559	0.0	18.8	8.5	1.60
Illinois	661	17.0	91.8	23.0	21.12
Kansas	726	0.0	45.5	10.5	4.77
Kentucky	21	3.0	57.1	12.0	6.86
Lousiana	3,028	0.0	43.7	11.8	5.15
Michigan	695	0.0	19.4	2.6	0.51
Mississippi	911	20.0	76.1	46.0	35.01
Montana	700	0.0	12.3	37.0	4.55
North Dakota	856	0.0	19.7	9.0	1.77
Nebraska	30	0.0	20.0	5.4	1.08
New Mexico	2,912	0.0	40.1	4.0	1.60
Oklahoma	4,128	0.0	43.7	4.0	1.75
Texas (all)	15,138	0.0	41.4	5.0	2.07
* Coastal	2,567	1.0	54.3	15.0	8.15
* Northern	4,927	1.0	52.4	4.0	2.10
* Western	7,278	0.0	29.9	5.7	1.68
Utah	364	0.0	19.5	5.0	0.98
Wyoming	1,687	0.0	16.8	2.3	0.39
Offshore	2,920	0.5	62.3	3.2	1.99
* Gulf	2,806	0.5	63.4	3.2	2.03
* California	114	0.0	33.3	3.46	1.15

Note: The Texas total includes 366 observations which could not be classified by Region because the county name was not reported.

Appendix 1

Statistical Data by Facility and Equipment
Difference Over Background
(Micro-Rems/Hr)National Summary
(All Observations)

Equipment	No	Average	Maximum	Minimum	25 %	Median	75 %
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Gas Processing Facilities

COMPRESSOR	648	1.481	498.0	0	0.000	0.00	0.000
CRYO UNIT	50	70.292	2985.0	0	0.000	0.00	2.525
DEHYDRATOR	244	4.693	529.0	0	0.000	0.00	1.000
FRAC TOWER	272	16.676	395.0	0	0.000	0.00	6.000
INLET SCRUBBER	593	7.479	701.0	0	0.000	0.00	0.450
METER	101	19.497	695.0	0	0.000	0.00	1.050
OPUMP	232	55.608	1391.0	0	0.000	0.00	25.500
OTANK	423	9.574	383.0	0	0.000	0.00	2.000
OTHER	430	11.800	995.0	0	0.000	0.00	4.000
REFRIGERATION	143	18.823	595.0	0	0.000	0.00	4.000
SWEETENER	234	2.942	220.5	0	0.000	0.00	0.000
PUMP	3	25.333	73.0	0	0.000	3.00	73.000
PRODUCT LINE	146	54.138	1080.0	0	0.000	3.25	46.500
BOTTOMS PUMP	40	25.130	220.0	0	0.125	7.00	28.000
PTANK	124	37.633	680.0	0	0.000	9.00	45.000
PPUMP	71	86.303	1041.0	0	0.000	19.00	70.000
REFLUX PUMP	110	225.262	2985.0	0	2.000	52.65	242.000

Production Facilities

FLINE	1748	21.5717	2991.0	0	0	0.0	0.00
MANIFOLD	2537	23.3713	2995.0	0	0	0.0	2.00
METER	306	2.2288	92.0	0	0	0.0	0.00
OTHER	2397	18.9506	3785.0	0	0	0.0	3.00
PUMP	1393	8.7212	986.0	0	0	0.0	1.00
SEP	7887	31.2279	4491.0	0	0	0.0	7.00
STANK	7005	10.5057	2475.0	0	0	0.0	2.00
VRU	115	36.6696	1287.0	0	0	0.0	0.00
WINJ	102	32.2451	886.0	0	0	0.0	20.00
WOTHER	24	0.5292	5.5	0	0	0.0	0.00
WPROD	2324	9.8176	1487.0	0	0	0.0	1.00
H/T	2962	43.4679	3490.0	0	0	0.3	8.00
SUMP	454	25.3998	793.0	0	0	1.0	9.25
WLINE	341	74.8135	2790.0	0	0	1.0	39.00
WTANK	3431	35.4036	3786.0	0	0	2.0	14.00

Appendix 2

Statistical Data by Facility and Equipment
Difference Over Background
(Micro-Rems/Hr)National Summary
(Observations in excess of Background)

Equipment	No	Average	Maximum	Minimum	25 %	Median	75 %
<u>Gas Processing Facilities</u>							
COMPRESSOR	119	7.631	490.0	0.3	1.000	2.00	3.000
DEHYDRATOR	72	15.904	529.0	0.3	1.350	3.00	6.650
SWEETENER	30	22.947	220.5	0.2	1.000	3.45	19.500
INLET SCRUBBER	156	20.431	701.0	0.1	1.000	5.00	19.000
METER	32	61.537	695.0	0.3	1.150	5.50	51.000
CRYO UNIT	20	175.730	2985.0	1.0	2.000	6.00	21.925
OTANK	140	28.927	383.0	0.2	2.000	6.00	30.000
OTHER	165	30.752	995.0	0.3	2.900	7.00	23.000
FRAC TOWER	123	36.876	395.0	0.2	1.500	9.50	33.200
REFRIGERATION	56	48.066	595.0	0.1	2.000	16.00	68.750
BOTTOMS PUMP	30	33.507	220.0	0.5	3.000	17.00	45.250
PTANK	90	51.850	600.0	0.5	7.325	25.00	65.750
OPUMP	114	113.168	1391.0	0.4	6.825	27.75	96.250
PPUMP	53	115.613	1041.0	0.1	9.500	31.00	97.500
PRODUCT LINE	02	96.391	1000.0	0.1	13.750	35.00	110.500
PUMP	2	38.000	73.0	3.0	3.000	38.00	73.000
REFLUX PUMP	95	260.829	2985.0	0.2	15.800	76.00	291.000

Production Facilities

WOTHER	5	2.540	5.5	1.2	1.6	2.0	3.75
WPROD	777	29.364	1487.0	0.1	1.0	2.3	7.90
METER	72	9.472	92.0	1.0	1.0	3.0	5.75
PUMP	424	28.652	986.0	0.1	1.0	3.0	14.00
OTHER	1007	45.109	3785.0	0.1	1.0	4.0	15.00
STANK	2696	27.297	2475.0	0.1	2.0	4.0	14.00
MANIFOLD	895	66.249	2995.0	0.1	1.0	6.0	55.00
SUMP	253	45.579	793.0	0.1	3.0	7.0	26.50
SEP	3816	64.543	4491.0	0.1	2.0	7.0	40.00
H/T	1495	86.122	3490.0	0.1	2.0	8.0	47.00
WTANK	2140	56.761	3786.0	0.1	3.0	8.0	35.00
VRU	25	168.680	1287.0	0.2	2.0	17.0	207.50
WINJ	50	65.780	886.0	1.0	4.0	20.0	56.25
WLINE	176	144.951	2790.0	0.2	6.0	34.6	100.00
PLINE	419	89.994	2991.0	0.1	7.0	42.0	112.00

VII. State Summaries

Overview

The state summaries are each organized in the same order to give the following information:

- A. Summary Statistics for the state (one page)
- B. State Maps showing the counties in the survey.
A separate map has been made for Background Levels (Figure 1), Difference Over Background for Gas Processing Facilities (Figure 2), and Difference Over Background for Production Facilities (Figure 3).

In each figure the counties are summarized into the following categories according to their median values:

Category	Definition (National)	Background μ R/hr	Difference μ R/hr
1	- Lowest 5 %	0.00 - 2.33	0.00 - 0.80
2	- Next 20 %	2.34 - 4.99	0.80 - 1.99
3	- Middle 50 %	5.00 - 9.00	2.00 - 33.00
4	- Next 20 %	9.01 - 14.00	33.01 - 245.00
5	- Highest 5 %	over 14.00	over 245.00

A Background map was prepared for every state. If the difference over background was the same in every county the Difference Over Background map was deleted.

- C. Tables in Bar Chart form showing the median values for equipment, county, and background ranked in increasing order. The differences over background for equipment and county are reported separately for Gas Processing and Production Facilities.
- D. Appendices 1,2, and 3 give the detail data shown in the tables, plus a few other statistics.

SUMMARY

(Alabama and Florida)

I. All significant differences were equipment specific.

The equipment with the most pronounced differences over background based on Median ranking are listed below in descending order. The difference is the excess of the reading over background. These items were located in Escambia county Alabama and its adjacent neighbor, Santa Rosa county Florida.

Equipment		Median Difference	75 th Percentile
1. Separator	(Prod)	121 μ R/hr	220.0 μ R/hr
2. Other Pumps	(GP)	100	145.0
3. Reflux Pumps	(GP)	65	120.0
4. Flow Lines	(Prod)	50	184.5
5. Water Line	(prod)	35	125.0

II. Santa Rosa (Fl) and Mobile county had low background readings while Monroe county had a high background level. All of the others were mid-range.

III. Overall Summary

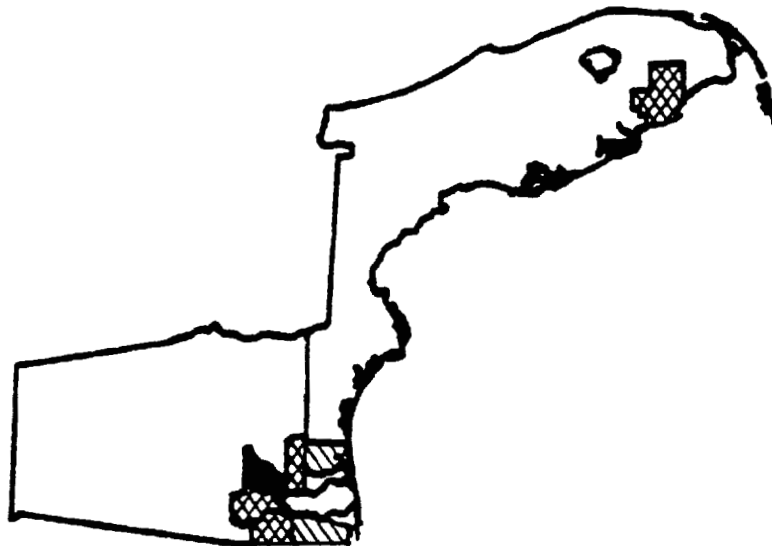
ITEM	No	Median	75 th Pct.	90 th Pct.	Max Value
1. Statewide					
a. Background	149	5.0	15.0	15.0	15
b. Max Reading	149	30.0	110.0	220.0	625
c. Difference	149	20.0	106.0	205.0	621
2. Facility					
a. Background					
Gas Processing	50	15.0	15.0	15.0	15
Production	99	5.0	15.0	15.0	15
b. Max Reading					
Gas Processing	50	15.0	35.0	100.5	150
Production	99	50.0	150.0	250.0	625
c. Difference					
Gas Processing	50	0.0	24.6	94.6	145
Production	99	42.0	147.0	245.0	621

NOTES: 1) All data are measured in micro-rems/hr

2) The apparent differences between facilities are due to the specific items of equipment listed in Section I above.

FIGURE 1 -- MEDIAN BACKGROUND LEVELS

ALABAMA--FLORIDA



2.34 - 4.99
OVER 14.0

0 - 2.33
9.01 - 14.0

NO DATA
5.0 - 9.0

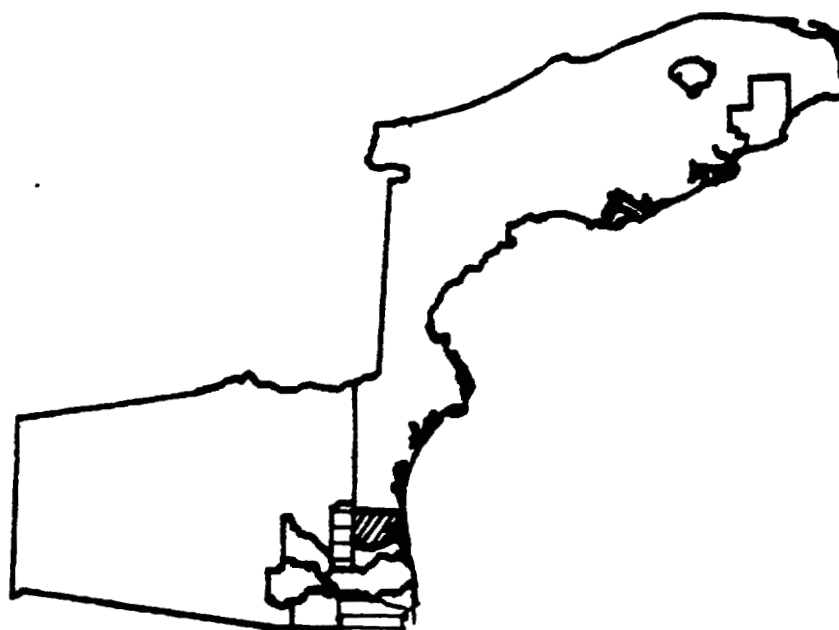
MICRO-REMS/HR

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FIGURE 2 — DIFFERENCE OVER BACKGROUND

ALABAMA-FLORIDA

GAS PROCESSING FACILITIES



MICRO-REMS/HR

NO DATA
2 - 33

BELOW .8
33.01 - 245

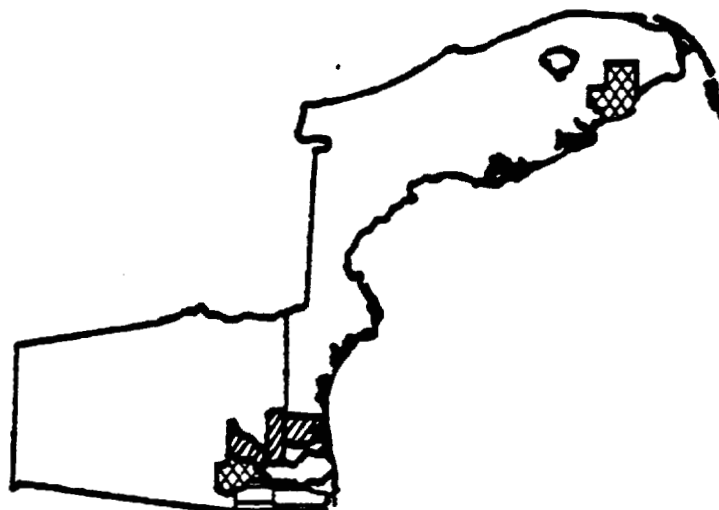
.8 - 1.99
OVER 245

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FIGURE 3 — DIFFERENCE OVER BACKGROUND

ALABAMA—FLORIDA

PRODUCTION FACILITIES



MICRO-RENS/HR

NO DATA
2 - 33

BELOW .8
33.01 - 245

.8 - 1.99
OVER 245

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NATURALLY OCCURRING RADIOACTIVITY SURVEY

Table 3

Median Background by County
Sequenced by Increasing Median Difference
(Micro-Rems/Hr)

Alabama and Florida

Obs	County		Median	75 th Percentile
8	SANTA ROSA	*****	3.0	4.0
34	MOBILE	*****	4.5	7.5
84	ESCAMBIA	*****	5.0	15.0
3	WASHINGTON	*****	7.5	7.5
2	CLARKE	*****	8.0	8.0
6	COLLIER	*****	8.0	10.0
12	MONROE	*****	15.0	15.0
		-----+-----+-----+-----+-----+-----+-----+-----+-----+		
		2 4 6 8 10 12 14 16 18		

Median of Background Readings

Note: Santa Rosa is in the Florida Panhandle and Collier is
in the southern tip of Florida (Naples). All other
counties are in Alabama.

Appendix 1

Statistical Data by Facility and Equipment
Difference Over Background
(Micro-Rems/Hr)

Alabama and Florida

Equipment	No	Average	Maximum	Minimum	25 %	Median	75 %
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Gas Processing Facilities

BOTTOMS PUMP	1	0.000	0.0	0	0.00	0.0	0.0
COMPRESSOR	1	0.000	0.0	0	0.00	0.0	0.0
CRYO UNIT	2	0.000	0.0	0	0.00	0.0	0.0
DEHYDRATOR	2	0.000	0.0	0	0.00	0.0	0.0
FRAC TOWER	3	15.000	45.0	0	0.00	0.0	45.0
INLET SCRUBBER	21	18.133	95.0	0	0.00	0.0	22.2
METER	1	0.000	0.0	0	0.00	0.0	0.0
OTANK	5	9.820	27.8	0	0.00	0.0	24.5
REFRIGERATION	1	0.000	0.0	0	0.00	0.0	0.0
SWEETENER	1	0.000	0.0	0	0.00	0.0	0.0
OTHER	6	38.633	121.0	0	2.25	8.4	98.5
PRODUCT LINE	1	20.000	20.0	20	20.00	20.0	20.0
REFLUX PUMP	3	61.667	120.0	0	0.00	65.0	120.0
OPUMP	2	100.000	145.0	55	55.00	100.0	145.0

Production Facilities

WINJ	2	0.000	0	0	0.00	0.0	0
WOTHER	1	0.000	0	0	0.00	0.0	0
MANIFOLD	5	19.600	46	0	2.50	5.0	44
OTHER	9	24.111	10	0	3.50	7.0	37.5
WPROD	4	11.250	30	0	1.25	7.5	25
WTANK	10	32.100	105	0	0.00	10.0	72
STANK	4	45.250	142	0	4.25	19.5	112
WLINE	3	53.333	125	0	0.00	35.0	125
H/T	11	65.364	275	0	0.00	13.0	145
FLINE	9	88.222	245	0	15.00	50.0	184.5
SEP	41	164.488	621	0	42.00	121.0	220

Appendix 2

Statistical Data on Median Difference over Background
By Facility and County
(Micro-Rems/Hr)

Alabama and Florida

FACILITY	COUNTY	NO	AVERAGE	MAXIMUM	MINIMUM	PCT25	MED	PCT75
GP	MOBILE	19	6.405	27.8	0	0.00	0.0	13.20
GP	ESCAMBIA	29	26.828	145.0	0	0.00	0.0	50.00
GP	SANTA ROSA	2	106.000	121.0	91	91.00	106.0	121.00
PROD	MOBILE	15	31.667	275.0	0	0.00	0.0	13.00
PROD	WASHINGTON	3	0.000	0.0	0	0.00	0.0	0.00
PROD	COLLIER	6	51.333	193.0	5	5.00	31.5	79.75
PROD	CLARKE	2	32.000	47.0	17	17.00	32.0	47.00
PROD	MONROE	12	64.167	205.0	0	6.25	40.0	120.00
PROD	ESCAMBIA	55	123.764	621.0	0	16.00	71.0	196.00
PROD	SANTA ROSA	6	142.500	397.0	30	39.00	107.0	228.25

Note: Santa Rosa is in the Florida Panhandle and Collier is in the southern tip of Florida (Naples). All other counties are in Alabama.

Appendix 3

Statistical Data on Background by County
(Micro-Rems/Hr)

Alabama and Florida

COUNTY	NO	AVERAGE	MAXIMUM	MINIMUM	PCT25	MED	PCT75
SANTA ROSA	8	4.1250	10.0	3.0	3.00	3.0	4.0
MOBILE	34	7.0735	15.0	4.5	4.50	4.5	7.5
ESCAMBIA	84	8.4286	15.0	3.0	4.00	5.0	15.0
WASHINGTON	3	7.5000	7.5	7.5	7.50	7.5	7.5
CLARKE	2	8.0000	8.0	8.0	8.00	8.0	8.0
COLLIER	6	8.8333	13.0	7.0	7.75	8.0	10.0
MONROE	12	15.0000	15.0	15.0	15.00	15.0	15.0

Note: Santa Rosa is in the Florida Panhandle and Collier is in the southern tip of Florida (Naples). All other counties are in Alabama.

SUMMARY

(Alaska)

I. There were no significant differences over background in any of the items of equipment.

II. Offshore areas had low background readings and Anchorage county was very low.

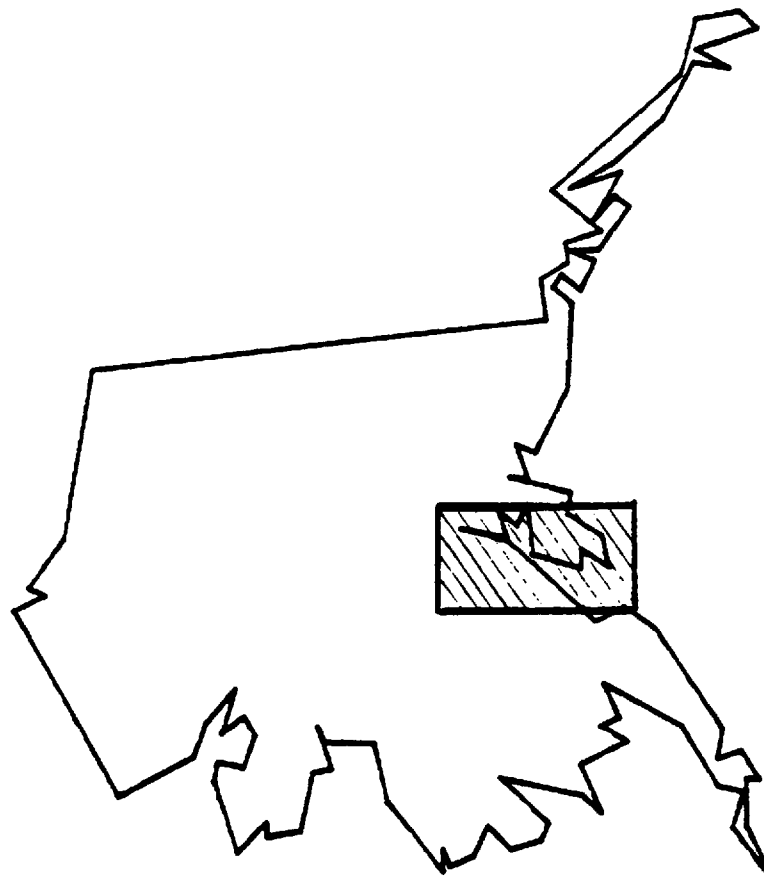
III. Overall Summary

ITEM	No	Median	75 th Pct.	90 th Pct.	Max Value
1. Statewide					
a. Background	256	4.0	4.0	5.0	6
b. Max Reading	256	9.5	29.0	84.5	706
c. Difference	256	6.0	25.0	80.9	701
2. Facility					
a. Background					
Gas Processing	13	4.0	4.5	6.0	6
Production	243	4.0	4.0	5.0	6
b. Max Reading					
Gas Processing	13	5.0	8.5	428.	706
Production	243	10.0	30.0	85.8	500
c. Difference					
Gas Processing	13	0.0	4.0	423.5	701
Production	243	6.0	26.0	81.8	495

NOTE: All data are measured in micro-rem/hr

FIGURE 1 — MEDIAN BACKGROUND LEVELS

ALASKA

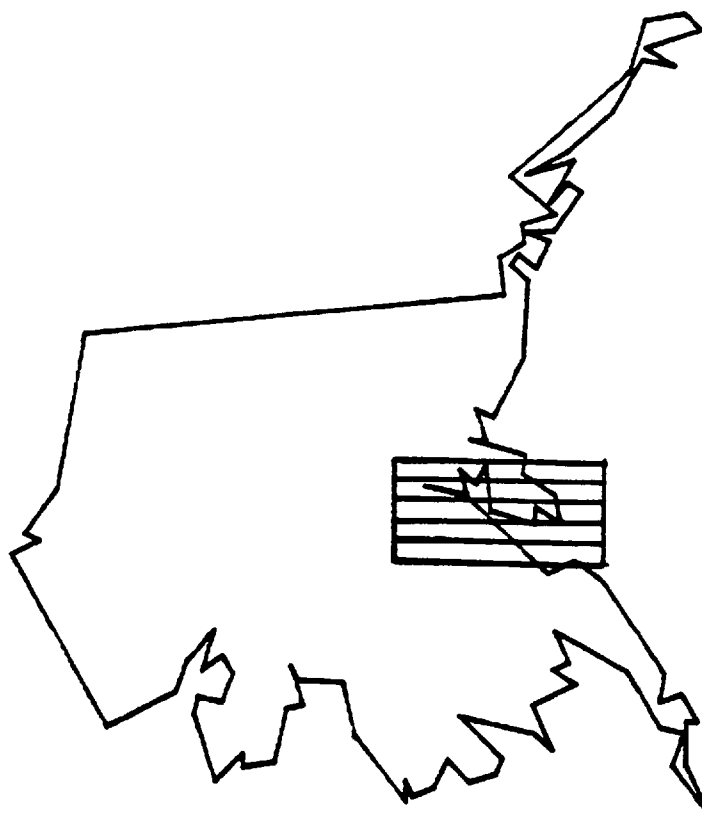


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FIGURE 2 -- DIFFERENCE OVER BACKGROUND

ALASKA

GAS PROCESSING FACILITIES



MICRO-REMS/HR

NO DATA
2 - 33

BELOW .8
33.01 - 245

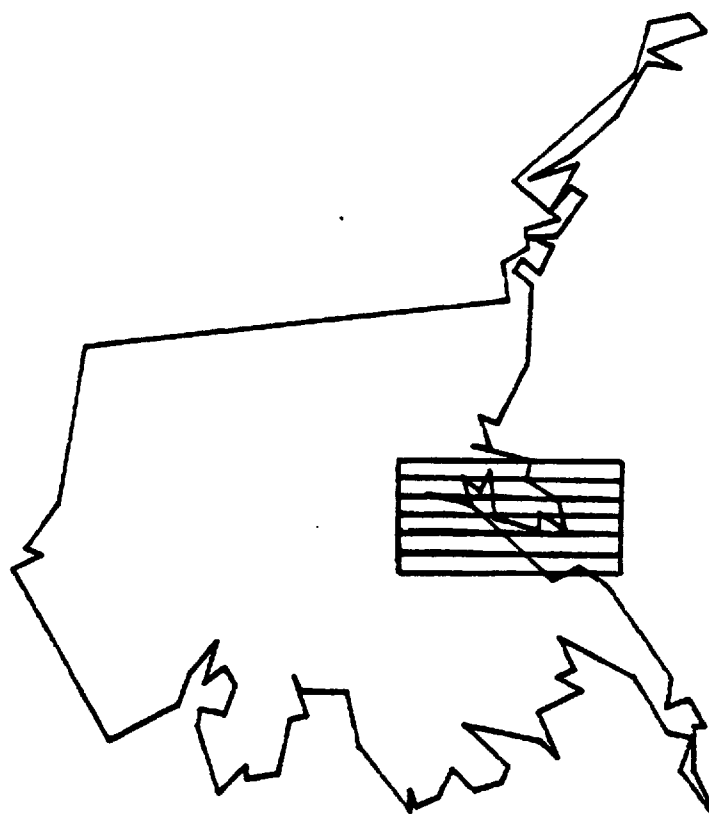
.8 - 1.99
OVER 245

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FIGURE 3 — DIFFERENCE OVER BACKGROUND

ALASKA

PRODUCTION FACILITIES



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NATURALLY OCCURRING RADIOACTIVITY SURVEY

Table 1

Difference of Maximum Reading over Background by Equipment
Sequenced by Increasing Median Difference
(Micro-Rems/Hr)

Alaska

FACILITY: Gas Processing

Obsns	Equipment		Median Difference	75 th percentile
1	OTHER		0.0	0.00
4	COMPRESSOR		0.0	0.75
1	PRODUCT LINE	*	1.0	1.0
7	INLET SCRUBBER	*	1.0	7.0
13		-----+-----+-----+-----+-----+-----+-----		
		10 20 30 40 50 60		

Median of Difference Over Background

FACILITY: Production

1	METER		0.0	0.0
8	WPROD		0.0	0.75
11	WLINE		0.0	5.0
2	WINJ		1.0	1.0
3	VRU	*	2.0	2.0
34	OTHER	*	2.0	5.0
8	WTANK	**	3.5	13.0
12	STANK	**	4.5	8.0
24	SUMP	***	5.5	13.0
30	MANIFOLD	****	7.0	42.0
34	SEP	*****	18.5	54.0
7	PUMP	*****	19.0	28.0
44	H/T	*****	19.0	67.5
25	FLINE	*****	31.0	83.0
243		-----+-----+-----+-----+-----+-----+-----		
		10 20 30 40 50 60		

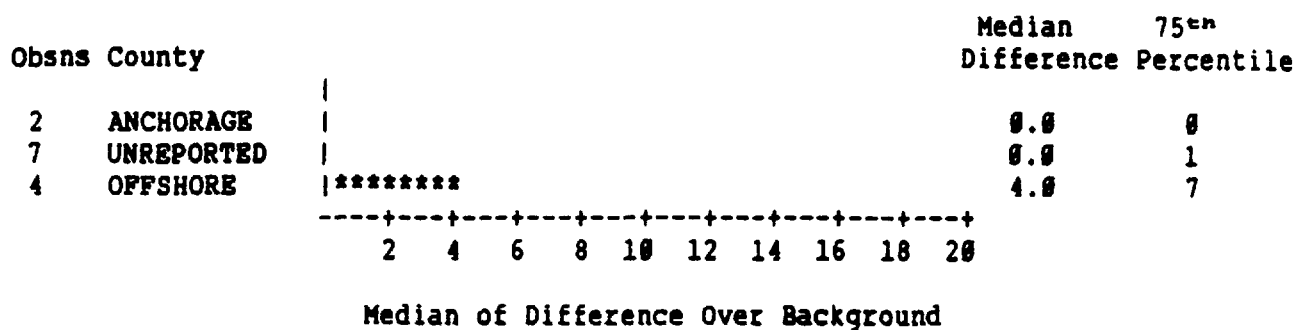
Median of Difference Over Background

Table 2

Median Difference Over Background by County
Sequenced by Increasing Median Difference
(Micro-Rems/Hr)

Alaska

FACILITY: Gas Processing



FACILITY: Production

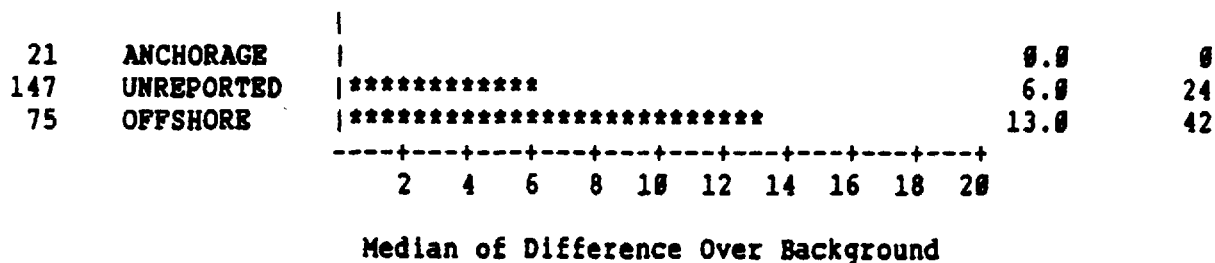
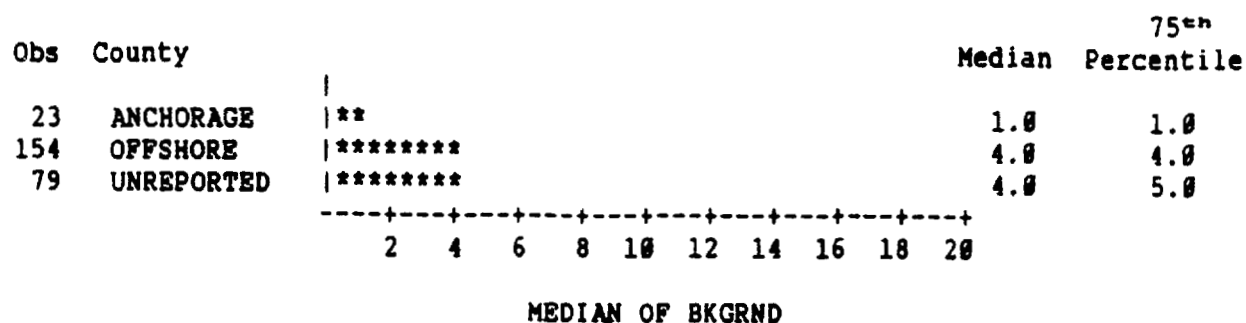


Table 3

Median Background by County
Sequenced by Increasing Median Difference
(Micro-Rems/Hr)

Alaska



Appendix 1

Statistical Data by Facility and Equipment
Difference Over Background
(Micro-Rems/Hr)

Alaska

Equipment	No	Average	Maximum	Minimum	25 %	Median	75 %
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Gas Processing Facilities

OTHER	1	0.0000	0	0	0	0	0.00
COMPRESSOR	4	0.250	1	0	0	0	0.75
PRODUCT LINE	1	1.000	1	1	1	1	1.00
INLET SCRUBBER	7	102.286	701	0	0	1	7.00

Production Facilities

METER	1	0.0000	0	0	0.00	0.0	0.00
WPROD	8	0.2500	1	0	0.00	0.0	0.75
WLINE	11	2.6364	14	0	0.00	0.0	5.00
WINJ	2	1.0000	1	1	1.00	1.0	1.00
VRU	3	1.3333	2	0	0.00	2.0	2.00
OTHER	34	4.0588	25	0	0.75	2.0	5.00
WTANK	8	6.1250	16	0	0.00	3.5	13.00
STANK	12	7.4167	36	0	0.00	4.5	8.00
SUMP	24	11.3750	92	0	1.00	5.5	13.00
MANIFOLD	30	25.9667	159	0	2.50	7.0	42.00
SEP	34	53.2059	307	0	3.00	18.5	54.00
PUMP	7	18.0000	54	0	0.00	19.0	28.00
H/T	44	55.2727	495	0	6.00	19.0	67.50
FLINE	25	51.4000	191	0	1.50	31.0	83.00

Appendix 2

Statistical Data on Median Difference over Background
By Facility and County
(Micro-Rems/Hr)

Alaska

FACILITY	COUNTY	NO	AVERAGE	MAXIMUM	MINIMUM	PCT25	MED	PCT75
GP	ANCHORAGE	2	0.000	0	0	0.00	0	0
GP	UNREPORTED	7	100.429	701	0	0.00	0	1
GP	OFFSHORE	4	3.750	7	0	0.25	4	7
PROD	ANCHORAGE	21	0.048	1	0	0.00	0	0
PROD	UNREPORTED	147	31.272	495	0	1.00	6	24
PROD	OFFSHORE	75	32.253	287	0	4.00	13	42

Appendix 3

Statistical Data on Background by County
(Micro-Rems/Hr)

Alaska

COUNTY	NO	AVERAGE	MAXIMUM	MINIMUM	PCT25	MED	PCT75
ANCHORAGE	23	1.00000	1	1	1	1	1
OFFSHORE	79	2.97468	4	1	1	4	4
UNREPORTED	154	4.17532	6	2	4	4	5



Documents

Document Sharing Hub

SUMMARY

(Arkansas)

I. There were no significant differences between items of equipment.

II. Columbia and Logan counties had mid-range background levels and Franklin and Pope counties had high background levels.

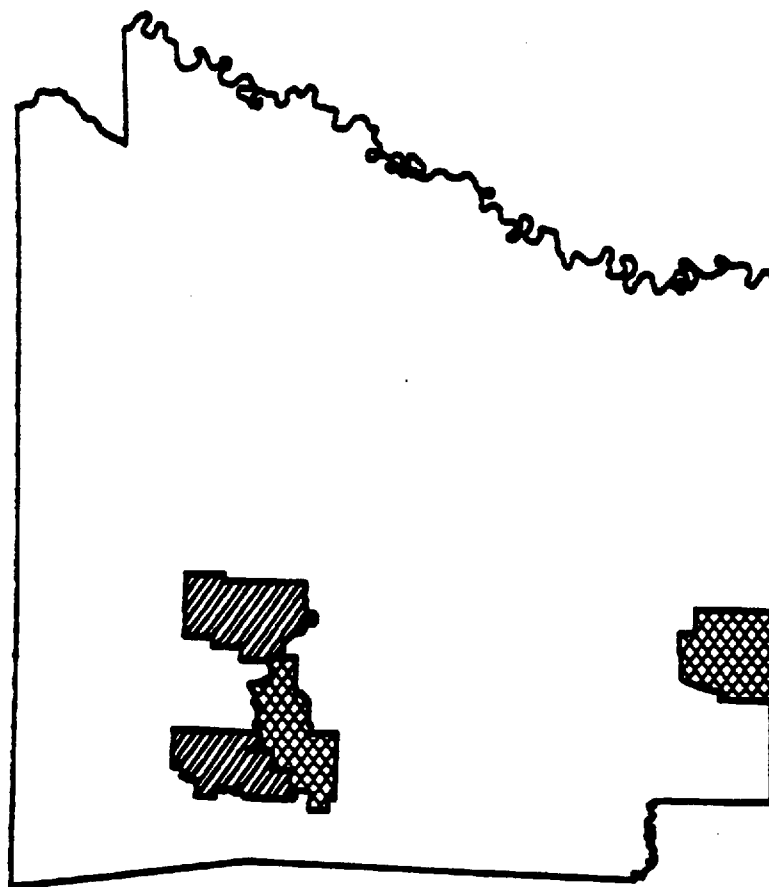
III. Overall Summary

ITEM	No	Median	75 th Pct.	90 th Pct.	Max Value
1. Statewide					
a. Background	199	9.0	10.0	12.0	13
b. Max Reading	199	11.0	12.0	14.0	300
c. Difference	199	1.0	2.0	3.4	292
2. Facility					
a. Background					
Gas Processing	50	7.0	9.0	10.9	13
Production	149	9.0	10.0	12.0	13
b. Max Reading					
Gas Processing	50	8.5	11.3	19.5	300
Production	149	11.0	12.0	14.0	90
c. Difference					
Gas Processing	50	0.0	2.0	12.3	292
Production	149	1.0	2.0	3.0	81

NOTE: All data are measured in micro-rem/hr

FIGURE 1 — MEDIAN BACKGROUND LEVELS

ARKANSAS



2.34 - 4.99
OVER 14.0

0 - 2.33
9.01 - 14.0

NO DATA
5.0 - 9.0

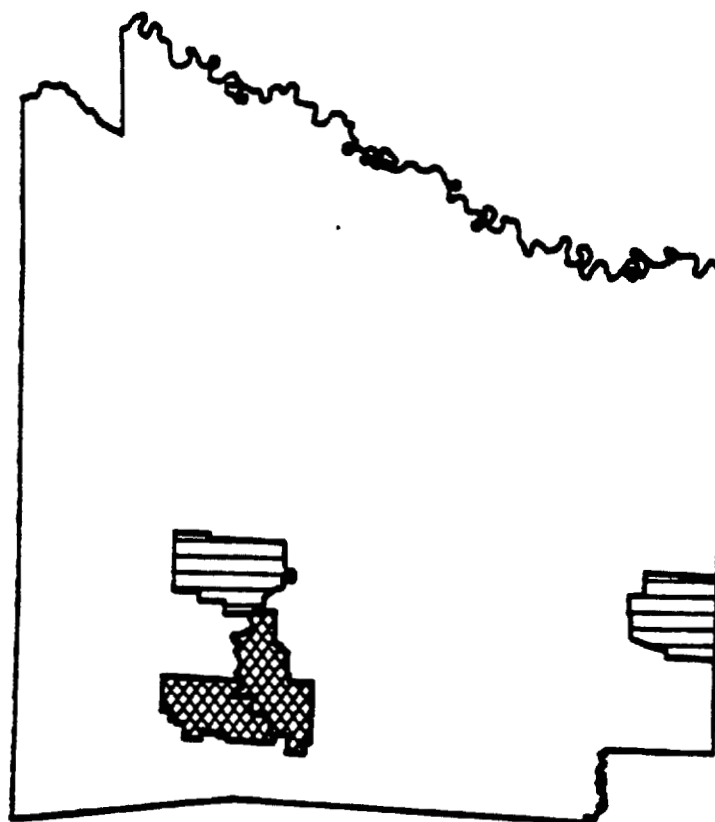
MICRO-REMS/YR

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FIGURE 2 — DIFFERENCE OVER BACKGROUND

ARKANSAS

GAS PROCESSING FACILITIES

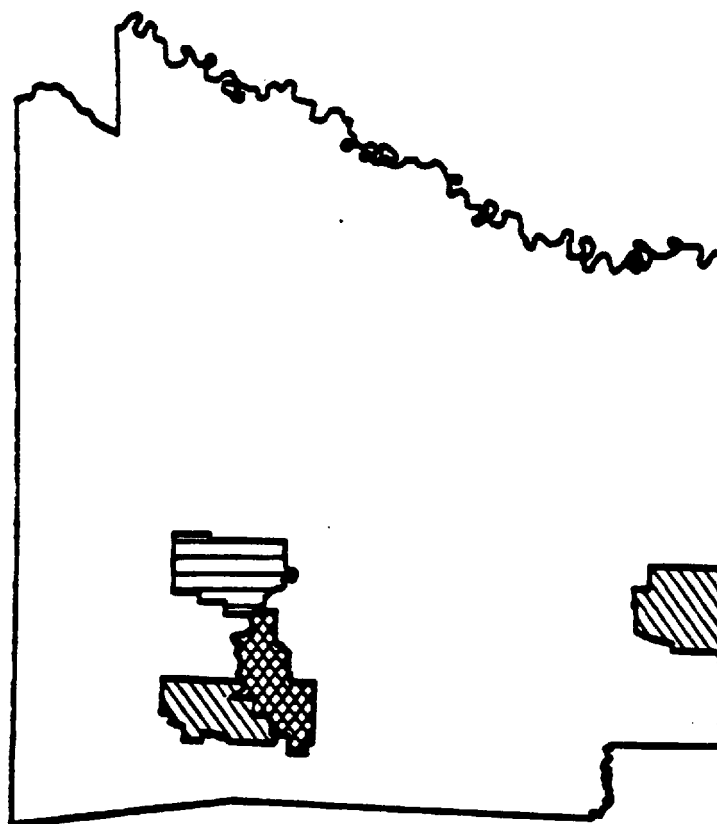


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FIGURE 3 — DIFFERENCE OVER BACKGROUND

ARKANSAS

PRODUCTION FACILITIES



BELOW .8
33.01 - 245

NO DATA
2 - 39

40 - 59
60 - 79
80 - 99
100 - 119
120 - 139
140 - 159
160 - 179
180 - 199
200 - 219
220 - 239
240 - 259
260 - 279
280 - 299
300 - 319
320 - 339
340 - 359
360 - 379
380 - 399
400 - 419
420 - 439
440 - 459
460 - 479
480 - 499
500 - 519
520 - 539
540 - 559
560 - 579
580 - 599
600 - 619
620 - 639
640 - 659
660 - 679
680 - 699
700 - 719
720 - 739
740 - 759
760 - 779
780 - 799
800 - 819
820 - 839
840 - 859
860 - 879
880 - 899
900 - 919
920 - 939
940 - 959
960 - 979
980 - 999

1.0 - 1.99
OVER 245

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