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Using Pre-Statistical Analysis to Streamline Monitoring Assessments

by

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DISCLAIMER

Using Pre-Statistical Analysis to Streamline Monitoring Assessments:

Helping our facilities through a mid-life crisis

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Introduction

A variety of statistical methods exist to aid evaluation of groundwater quality and subsequent decision making in regulatory programs. These methods are applied because of large temporal and spatial extrapolations commonly applied to these data. In short, statistical conclusions often serve as a surrogate for knowledge. However, facilities with mature monitoring programs that have generated abundant data have inherently less uncertainty because of the sheer quantity of analytical results. In these cases, statistical tests can be less important, and "expert" data analysis should assume an important screening role.

The WSRC Environmental Protection Department, working with the General Separations Area BSRI Environmental Restoration project team has developed a method for an Integrated Hydrogeological Analysis (IHA) of historical water quality data from the F&H Seepage Basins groundwater remediation project (Figure 1). The IHA combines common sense analytical techniques and a GIS presentation that force direct interactive evaluation of the data. The IHA can perform multiple data analysis tasks required by the RCRA permit. These include:

- *Development of a groundwater quality baseline prior to remediation startup*
- *Targeting of constituents for removal from RCRA GWPS*
- *Targeting of constituents for removal from UIC permit*
- *Targeting of constituents for reduced monitoring*
- *Targeting of monitoring wells not producing representative samples*
- *Reduction in statistical evaluation*
- *Identification of contamination from other facilities*

Background

Regulatory

The F&H Seepage Basins were used for wastewater disposal between 1955 and 1988. The basins were certified closed under RCRA in 1991 and a postclosure permit was issued in 1992 that required remediation of groundwater contaminant plumes in the upper aquifer zones. Two pump-treat-reinject systems were installed and began operating in 1997. Start-up problems have led to the negotiation of a consent agreement between SRS and South Carolina Department of Health and Environmental Control (SCDHEC), applying additional regulatory pressure to understand the system's effectiveness. Monitoring of the groundwater network of over two hundred wells is performed quarterly for indicator parameters. Semi-annual and annual monitoring for other permitted constituents is ongoing, and a minimum of

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20,000 analytical records is generated each year. Almost total 700,000 records exist in the groundwater database (not included lab QC samples).

Hydrogeological

Groundwater flows through a sedimentary wedge of the Atlantic Coastal Plain under the basins. There is a regional, effective confining unit near the Cretaceous-Tertiary boundary, and the three aquifer zones comprised by the upper sediments are regulated as the RCRA "uppermost aquifer". These zones are shown along with the local hydrostratigraphy in Figure 2. They include from the water table down, the Upper Aquifer Zone of the Upper Three Runs Aquifer (UAZ) [moderate permeability], the Lower Aquifer Zone of the Upper Three Runs Aquifer (LAZ) [lower permeability], and the Gordon Aquifer (GA) [higher permeability]. Contamination historically occurred in the UAZ, but often exists at higher concentrations/activities in the LAZ due to flushing of the water table. There is very little contamination in the GA.

The primary contaminants include tritium, nitrates, alpha-emitting radionuclides, beta-emitting radionuclides, and low concentrations of a variety of RCRA metals, commonly associated with geochemical changes induced by nitric acid in the waste streams. SCDHEC is currently pursuing a strategy of plume capture and upgradient reinjection to address the perceived hazard of tritium in the groundwater (present at up to 10,000 pCi/mL), and recapture of the bulk of the injectate to recycle tritium, increasing its travel time and maximizing decay.

A comprehensive, long-term evaluation of the mass of analytical data has never been performed for the facilities, but such an evaluation is required implicitly as a baseline for annual corrective action effectiveness reporting, and for more comprehensive evaluation of different phases of the remediation defined in the permit. The IHA was developed in an effort to provide such a baseline and to integrate knowledge of the regulatory and geological framework with the large amounts of available water quality data.

Stepping Through the IHA

The Integrated Hydrogeological Analysis is a fancy name for a common-sense evaluation of the groundwater data. Because it is a tool that has been tailored for the SRS F&H data, all of the details may not be applicable to dissimilar facilities. However, the IHA has proven to be an effective tool for evaluation of the F&H data. The method can be described as a series of steps in the format of a problem-solution pair.

Step 1. Data Filtering

Problem: presence of false positive data in large datasets, especially low-level estimated data. False negative results are assumed to be minimized by the quantity of the data set.

Solution: "grading" of analytical data by filtering J-qualified data for compliance decision making. Approved by SCDHEC in 1997, implemented in 1998. Applicable only to RCRA regulated facilities (i.e., lots of data).

Step 2. Create Data Categories

Problem: large quantity of data requires grouping that will highlight data required for decision making.

Solution: seven categories of data were derived from an empirical analysis of F&H data and the consideration of regulatory decision making. Analysis of data sets from different facilities may require changes in the categorization listed below.

Category 1. No hits in the historical data record (Figure 3).
Category 2. Infrequent hits in the historical data record (usually one) accompanied by at least one additional result from the same date that is below detect. Treat as confirmation sample (Figure 4).
Category 3. Infrequent hits in the historical record more than three years older than the most recent result evaluated. Treat as evidence of "clean up" (Figure 5).
Category 4. One hit in the data record less than three years older than the most recent result evaluated (Figure 6).
Category 5. Good trend less than MCL or equivalent standard. Requires RCRA monitoring, but not corrective action (Figure 7).
Category 6. Good trend above MCL or equivalent standard. Requires RCRA corrective action (Figure 8).
Category 7. Other. Treat as research projects for interested parties (Figure 9).

Step 3. Apply Data Categories

Problem: large quantity of data requires retrieval techniques that will arrange data required for quick categorization.

Solution: the initial retrieval of the F&H data was performed using a custom programmed method. Later evaluation of its strengths and weaknesses led to development of customized, user-friendly data retrievals from the SRS oracle database. Actual categorization of data in resulting data tables should take time – it is a step that forces interactive analysis by hydrogeological staff.

Step 4. Present Data Categories

Problem: large quantity of data requires temporal and spatial arrangement of categories for evaluation.

Solution: several tabular arrangements were employed, and a GIS solution was developed for map summaries of both temporal and spatial trends.

A base map of each facility was developed in ArcView using existing site coverages and a few customized tables for some of the wells. A summary table of well-contaminant categories was imported into ArcView. The categories were assigned colored dots in a legend, and a script was developed to automate the construction of views for each contaminant in each aquifer zone. Layouts of each view were then printed to create a series of category maps for each aquifer zone for each GWPS contaminant. The advantage of this presentation technique is the spatial examination of temporal trends on one plot, contrary to conventional contoured plume maps.

Step 5. Evaluate and Report the Data

Problem: how to present resulting data and analysis.

Solution: format of data report depends on application. F&H report will be comprehensive and large, because it will be a generic data baseline for future corrective action evaluations.

A final report is in draft. It includes:

- comprehensive tables of categorized contaminant data
- summary tables of categories for each contaminant
- summary tables of GWPS contaminants
- color dot maps of historical trends delineated by categorization

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- summary write up of each contaminant with recommendations for further action

Using the IHA

The IHA was originally developed to address the specific need of a baseline data summary of the pre-corrective action groundwater at the F&H facilities. This baseline summary will serve as a basis for comparison of future corrective action effectiveness evaluations under the RCRA permit. However, the IHA has proven to be a versatile interpretive tool, and has produced spin-off results in the following areas.

1. Identification of GWPS contaminants to remove from RCRA and UIC monitoring that were originally included because of the presence of apparent hits in a limited data set that included lower quality (older methods) data and did not apply data filtering.
2. The IHA is a surrogate for the statistical re-evaluation of historical data in the current permit renewal. After the need for a re-evaluation had been identified, the conclusions of the IHA demonstrated that constituents could be broken down into three groups: (1) constituents clearly present and elevated above applicable limits; (2) constituents clearly not present; and (3) constituents whose presence or absence could not be determined by the IHA. The last group was targeted for statistical analysis, but the elimination of the first two groups from this analysis resulted in eliminating approximately three-quarters of the constituents from the statistical task (Figures 10 and 11).
3. Combining the temporal and spatial information onto one set of maps has provided the basis for redesign of monitoring system emphasizing a focused approach to gathering information rather than data.
4. The IHA historical trend maps allow a cross-check of "snapshot" plume mapping.

Conclusion

The IHA developed for the F&H Areas ongoing RCRA groundwater corrective action assessments incorporates an empirical method of data analysis that logically precedes more complex statistical evaluation based on the assumption of uncertainty that may not be appropriate in large data sets. The IHA groups and organizes large quantities of data, highlights those data crucial to decision making, and allows quick decisions regarding the presence or absence, and the distribution of groundwater contaminants over time. By combining contaminant trends over both space and time in one GIS visual presentation, hydrogeologists (both SRS and regulatory staff) can make more efficient decisions regarding remedial effectiveness.

Figure 1. Location of F&H RCRA HWMFs at SRS

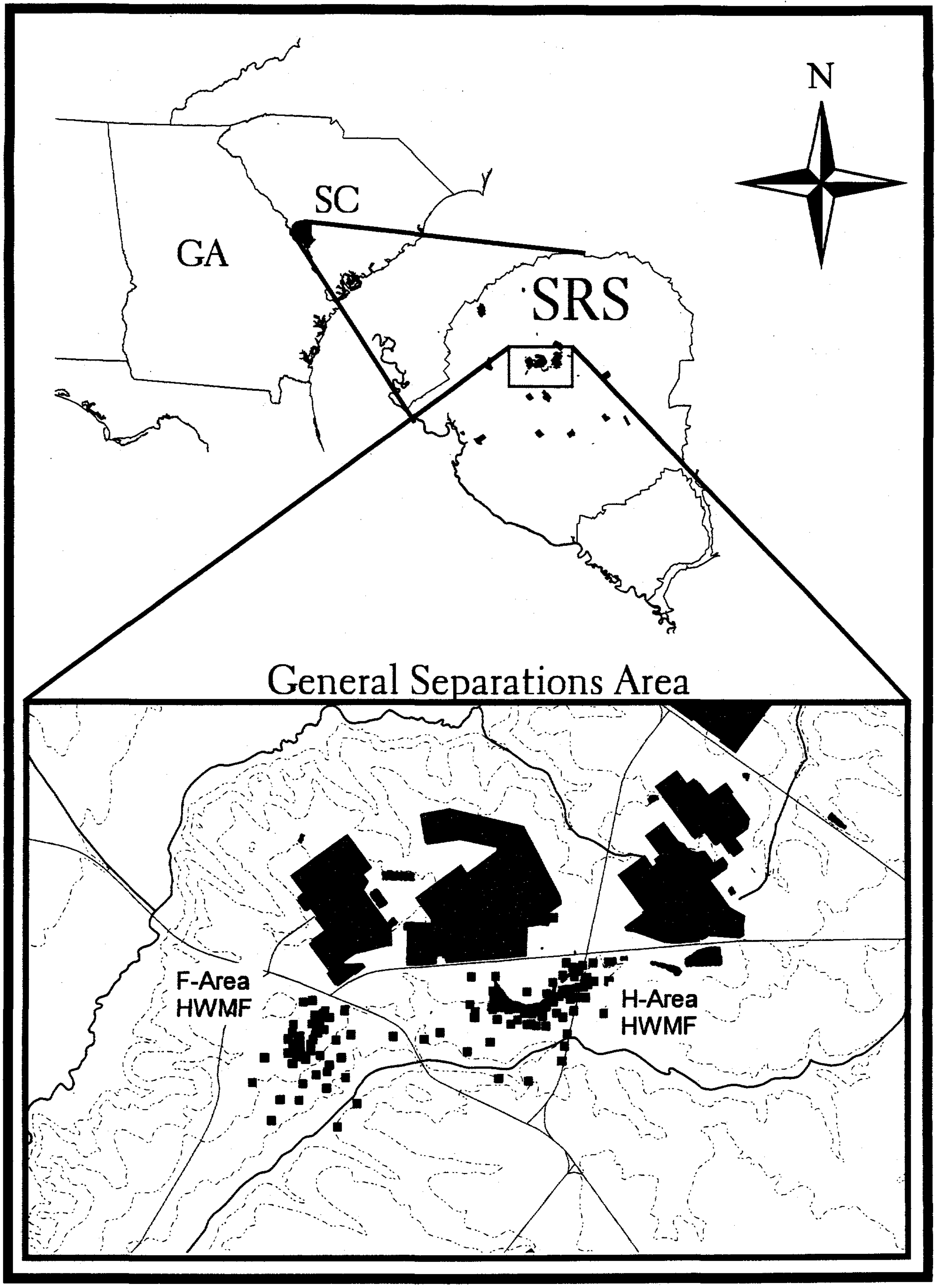

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Figure 2. Hydrostratigraphy of the F&H aquifers.

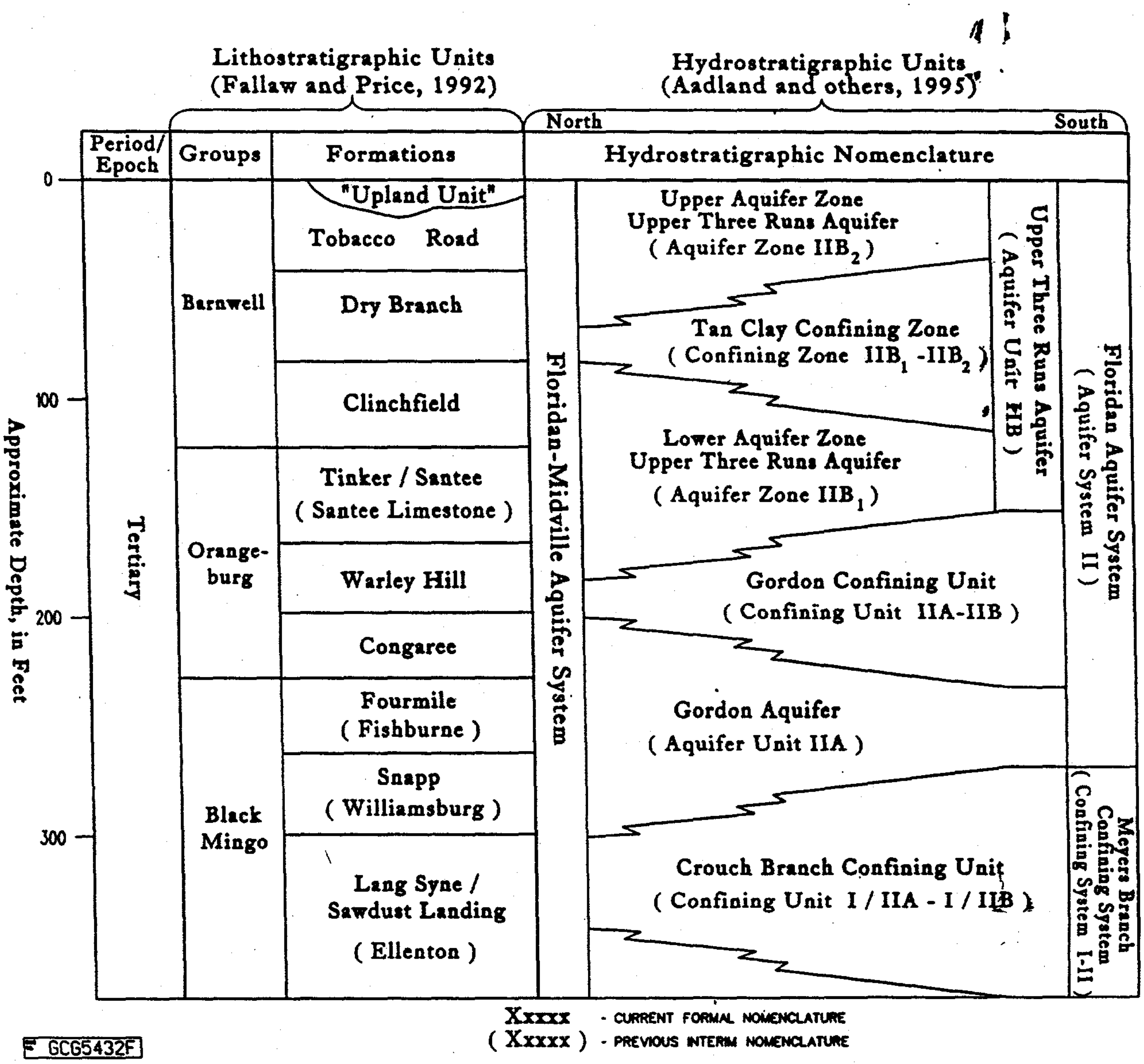

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Figure 3. Example of Category 1 data.

Constituent	*Well*	*Sample Date*	*QTR*	*Filtered Result*	*Unfiltered Result*	*Units*	*Method*
Benzene	FSB 99A	12/02/1987	87Q4	<5	<5	ug/L	APPENDX9
Benzene	FSB 99A	07/30/1988	88Q3	<1	<1	ug/L	.
Benzene	FSB 99A	03/07/1989	89Q1	<5	<5	ug/L	624/601
Benzene	FSB 99A	05/16/1989	89Q2	<5	<5	ug/L	EPA624
Benzene	FSB 99A	07/22/1989	89Q3	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	07/22/1989	89Q3	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	07/22/1989	89Q3	<5	<5	ug/L	EPA624
Benzene	FSB 99A	07/22/1989	89Q3	<5	<5	ug/L	EPA624
Benzene	FSB 99A	10/01/1989	89Q4	<5	<5	ug/L	EPA624
Benzene	FSB 99A	01/16/1990	90Q1	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	01/16/1990	90Q1	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	01/16/1990	90Q1	<5	<5	ug/L	EPA624
Benzene	FSB 99A	01/16/1990	90Q1	<5	<5	ug/L	EPA624
Benzene	FSB 99A	04/22/1990	90Q2	<5	<5	ug/L	EPA624
Benzene	FSB 99A	07/16/1990	90Q3	<5	<5	ug/L	EPA624
Benzene	FSB 99A	10/09/1990	90Q4	<5	<5	ug/L	EPA624
Benzene	FSB 99A	01/10/1991	91Q1	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	01/10/1991	91Q1	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	01/10/1991	91Q1	<5	<5	ug/L	EPA624
Benzene	FSB 99A	01/10/1991	91Q1	<5	<5	ug/L	EPA624
Benzene	FSB 99A	04/08/1991	91Q2	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	07/17/1991	91Q3	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	07/17/1991	91Q3	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	02/21/1993	93Q1	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	02/21/1993	93Q1	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	05/08/1993	93Q2	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	05/08/1993	93Q2	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	05/08/1993	93Q2	<5	<5	ug/L	EPA8240
Benzene	FSB 99A	05/08/1993	93Q2	<5	<5	ug/L	EPA8240
Benzene	FSB 99A	08/20/1993	93Q3	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	08/20/1993	93Q3	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	11/07/1993	93Q4	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	11/07/1993	93Q4	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	11/07/1993	93Q4	<5	<5	ug/L	EPA8240
Benzene	FSB 99A	11/07/1993	93Q4	<5	<5	ug/L	EPA8240
Benzene	FSB 99A	02/15/1994	94Q1	<1	<1	ug/L	EPA8240
Benzene	FSB 99A	08/05/1994	94Q3	<5	<5	ug/L	EPA8240
Benzene	FSB 99A	02/12/1995	95Q1	<1.67	<1.67	ug/L	EPA8240
Benzene	FSB 99A	07/17/1995	95Q3	<2	<2	ug/L	EPA8240
Benzene	FSB 99A	01/08/1996	96Q1	<2	<2	ug/L	EPA8260

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Benzene	FSB 99A	07/24/1996	96Q3	<2		<2	ug/L	EPA8260

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Figure 4. Example of Category 2 data.

Constituent	Well	Sample Date	QTR	Filtered Result	Unfiltered Result	Units	Method
Americium-241	HSB101C	01/06/1993	93Q1	<1	<1	PCL	HASL300
Americium-241	HSB101C	01/06/1993	93Q1	<1	<1	PCL	HASL300
Americium-241	HSB101C	04/01/1993	93Q2	<1	<1	PCL	HASL300
Americium-241	HSB101C	04/01/1993	93Q2	<1	<1	PCL	HASL300
Americium-241	HSB101C	07/13/1993	93Q3	<1	<1	PCL	EPIA<011
Americium-241	HSB101C	07/13/1993	93Q3	<1	<1	PCL	EPIA<011
Americium-241	HSB101C	10/04/1993	93Q4	<1	<1	PCL	CTC0009
Americium-241	HSB101C	10/04/1993	93Q4	<1	<1	PCL	CTC0009
Americium-241	HSB101C	01/10/1994	94Q1	<0.0716	<0.0716	PCL	EPIA<011
Americium-241	HSB101C	07/06/1994	94Q3	0.288	0.288	PCL	CTC0009
Americium-241	HSB101C	07/06/1994	94Q3	<0.00788	<0.00788	PCL	EPIA<011
Americium-241	HSB101C	07/06/1994	94Q3	<0.189	<0.189	PCL	CTC0009
Americium-241	HSB101C	01/04/1995	95Q1	<0.00804	<0.00804	PCL	EPIA<011
Americium-241	HSB101C	07/12/1995	95Q3	<0.00882	<0.00882	PCL	EPIA<011
Americium-241	HSB101C	02/09/1996	96Q1	<0.0961	<0.0961	PCL	EPIA<011
Americium-241	HSB101C	07/22/1996	96Q3	<0.0984	<0.0984	PCL	EPIA<011

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Figure 5. Example of Category 3 data.

Constituent	*Well*	*Sample Date*	*QTR*	*Filtered Result*	*Unfiltered Result*	*Units*	*Method*
Cyanide	HSB115C	04/13/1988	88Q2	23	23	ug/L	APPENDX9
Cyanide	HSB115C	02/12/1989	89Q1	<5	<5	ug/L	EPA335.2
Cyanide	HSB115C	04/12/1989	89Q2	<5	<5	ug/L	EPA335.2
Cyanide	HSB115C	07/04/1989	89Q3	<5	<5	ug/L	EPA335.2
Cyanide	HSB115C	10/03/1989	89Q4	<5	<5	ug/L	EPA335.2
Cyanide	HSB115C	01/03/1990	90Q1	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	04/04/1990	90Q2	<5	<5	ug/L	EPA335.2
Cyanide	HSB115C	07/10/1990	90Q3	<5	<5	ug/L	EPA335.2
Cyanide	HSB115C	10/03/1990	90Q4	<5	<5	ug/L	EPA335.2
Cyanide	HSB115C	01/10/1991	91Q1	<5	<5	ug/L	EPA335.2
Cyanide	HSB115C	04/03/1991	91Q2	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	07/29/1991	91Q3	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	01/07/1992	92Q1	<5	5	ug/L	EPA9012
Cyanide	HSB115C	04/15/1992	92Q2	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	07/16/1992	92Q3	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	10/20/1992	92Q4	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	01/17/1993	93Q1	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	01/17/1993	93Q1	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	04/12/1993	93Q2	<10	<10	ug/L	EPA9012
Cyanide	HSB115C	04/12/1993	93Q2	<10	<10	ug/L	EPA9012
Cyanide	HSB115C	07/20/1993	93Q3	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	07/20/1993	93Q3	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	10/12/1993	93Q4	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	10/12/1993	93Q4	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	01/13/1994	94Q1	<5	<5	ug/L	EPA9012
Cyanide	HSB115C	07/11/1994	94Q3	<5	<5	ug/L	EPA335.3
Cyanide	HSB115C	01/10/1995	95Q1	<8.33	<8.33	ug/L	EPA335.3
Cyanide	HSB115C	07/24/1995	95Q3	<20	<20	ug/L	EPA335.3
Cyanide	HSB115C	02/15/1996	96Q1	<10	<10	ug/L	EPA335.3
Cyanide	HSB115C	08/09/1996	96Q3	<10	<10	ug/L	EPA335.3

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Figure 6. Example of Category 4 data.

Constituent	*Well*	*Sample Date*	*QTR*	*Filtered Result*	*Unfiltered Result*	*Units*	*Method*
Uranium-235	FSB122D	02/06/1991	91Q1	<1	<1	PCL	EERF0.07
Uranium-235	FSB122D	02/06/1991	91Q1	<58	<58	PCL	EPA900.0
Uranium-235	FSB122D	02/24/1993	93Q1	<1	<1	PCL	CTC0009
Uranium-235	FSB122D	02/24/1993	93Q1	<1	<1	PCL	CTC0009
Uranium-235	FSB122D	05/13/1993	93Q2	<1	<1	PCL	HASL300
Uranium-235	FSB122D	05/13/1993	93Q2	<1	<1	PCL	HASL300
Uranium-235	FSB122D	08/22/1993	93Q3	<1	<1	PCL	CTC0009
Uranium-235	FSB122D	08/22/1993	93Q3	<1	<1	PCL	CTC0009
Uranium-235	FSB122D	11/15/1993	93Q4	<1	<1	PCL	CTC0009
Uranium-235	FSB122D	11/15/1993	93Q4	<1	<1	PCL	CTC0009
Uranium-235	FSB122D	02/16/1994	94Q1	0	0	PCL	EPIA-011
Uranium-235	FSB122D	02/16/1994	94Q1	<0.00433	<0.00433	PCL	EPIA-011
Uranium-235	FSB122D	08/15/1994	94Q3	<0.169	<0.169	PCL	EPIA-011
Uranium-235	FSB122D	02/21/1995	95Q1	0	0	PCL	EPIA-011
Uranium-235	FSB122D	02/21/1995	95Q1	<0.09	<0.09	PCL	EMLU02MOD
Uranium-235	FSB122D	07/20/1995	95Q3	<0.117	<0.117	PCL	EPIA-011
Uranium-235	FSB122D	01/16/1996	96Q1	<0.0154	<0.0154	PCL	EPIA-011
Uranium-235	FSB122D	07/31/1996	96Q3	0.058	0.058	PCL	EPIA-011

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Figure 7. Example of Category 5 data.

Constituent	*Well*	*Sample Date*	*QTR*	*Filtered Result*	*Unfiltered Result*	*Units*	*Method*
Barium, total recoverable	FSB108D	11/19/1992	92Q4	14.3	14.3	ug/L	EPA6010
Barium, total recoverable	FSB108D	01/12/1993	93Q1	16.1	16.1	ug/L	EPA6010
Barium, total recoverable	FSB108D	02/25/1993	93Q1	14.5	14.5	ug/L	EPA6010
Barium, total recoverable	FSB108D	03/11/1993	93Q1	15.6	15.6	ug/L	EPA6010
Barium, total recoverable	FSB108D	04/08/1993	93Q2	15.1	15.1	ug/L	EPA6010
Barium, total recoverable	FSB108D	05/05/1993	93Q2	15.2	15.2	ug/L	EPA6010
Barium, total recoverable	FSB108D	06/07/1993	93Q2	15.1	15.1	ug/L	EPA6010
Barium, total recoverable	FSB108D	07/18/1993	93Q3	12.0	12.0	ug/L	EPA6010
Barium, total recoverable	FSB108D	08/12/1993	93Q3	10.0	10.0	ug/L	EPA6010
Barium, total recoverable	FSB108D	09/06/1993	93Q3	10.4	10.4	ug/L	EPA6010
Barium, total recoverable	FSB108D	10/10/1993	93Q4	9.8	9.8	ug/L	EPA6010
Barium, total recoverable	FSB108D	10/10/1993	93Q4	9.8	9.8	ug/L	EPA6010
Barium, total recoverable	FSB108D	11/04/1993	93Q4	9.8	9.8	ug/L	EPA6010
Barium, total recoverable	FSB108D	11/04/1993	93Q4	9.8	9.8	ug/L	EPA6010
Barium, total recoverable	FSB108D	12/07/1993	93Q4	10.2	10.2	ug/L	EPA6010
Barium, total recoverable	FSB108D	12/07/1993	93Q4	10.2	10.2	ug/L	EPA6010
Barium, total recoverable	FSB108D	01/12/1994	94Q1	10.7	10.7	ug/L	EPA6010
Barium, total recoverable	FSB108D	02/07/1994	94Q1	10.4	10.4	ug/L	EPA6010
Barium, total recoverable	FSB108D	03/08/1994	94Q1	9.8	9.8	ug/L	EPA6010
Barium, total recoverable	FSB108D	03/20/1994	94Q1	<9.75	9.8	ug/L	EPA6010
Barium, total recoverable	FSB108D	03/20/1994	94Q1	9.3	9.3	ug/L	EPA6010
Barium, total recoverable	FSB108D	03/20/1994	94Q1	9.3	9.3	ug/L	EPA6010
Barium, total recoverable	FSB108D	06/01/1994	94Q2	9.3	9.3	ug/L	EPA6010
Barium, total recoverable	FSB108D	08/19/1994	94Q3	9.5	9.5	ug/L	EPA6010
Barium, total recoverable	FSB108D	11/15/1994	94Q4	9.1	9.1	ug/L	EPA6010
Barium, total recoverable	FSB108D	02/13/1995	95Q1	10.4	10.4	ug/L	EPA6010
Barium, total recoverable	FSB108D	02/13/1995	95Q1	10.0	10.0	ug/L	EPA6010
Barium, total recoverable	FSB108D	04/12/1995	95Q2	10.5	10.5	ug/L	EPA6010
Barium, total recoverable	FSB108D	01/10/1996	96Q1	8.9	8.9	ug/L	EPA6010 A

Figure 8. Example of Category 6 data.

Constituent	*Well*	*Sample Date*	*QTR*	*Filtered Result*	*Unfiltered Result*	*Units*	*Method*
Tritium	FSB 89D	10/25/1987	87Q4	2890	2890	PCM	.
Tritium	FSB 89D	10/25/1987	87Q4	2306	2306	PCM	8Z
Tritium	FSB 89D	12/01/1987	87Q4	5840	5840	PCM	.
Tritium	FSB 89D	02/13/1988	88Q1	1310	1310	PCM	.
Tritium	FSB 89D	02/13/1988	88Q1	1070	1070	PCM	8Z
Tritium	FSB 89D	04/01/1988	88Q2	1540	1540	PCM	.
Tritium	FSB 89D	04/01/1988	88Q2	1410	1410	PCM	8Z
Tritium	FSB 89D	07/10/1988	88Q3	1710	1710	PCM	.
Tritium	FSB 89D	07/10/1988	88Q3	1506	1506	PCM	8Z
Tritium	FSB 89D	10/22/1988	88Q4	2680	2680	PCM	.
Tritium	FSB 89D	10/22/1988	88Q4	2532	2532	PCM	8Z
Tritium	FSB 89D	02/26/1989	89Q1	3400	3400	PCM	8Z
Tritium	FSB 89D	02/26/1989	89Q1	3350	3350	PCM	.
Tritium	FSB 89D	05/20/1989	89Q2	2460	2460	PCM	.
Tritium	FSB 89D	05/20/1989	89Q2	2300	2300	PCM	LA9763M
Tritium	FSB 89D	07/02/1989	89Q3	2650	2650	PCM	.
Tritium	FSB 89D	07/02/1989	89Q3	2300	2300	PCM	LA9763M
Tritium	FSB 89D	10/14/1989	89Q4	1300	1300	PCM	TI052-2
Tritium	FSB 89D	10/14/1989	89Q4	1100	1100	PCM	LA9763M
Tritium	FSB 89D	01/16/1990	90Q1	1300	1300	PCM	TI052-2
Tritium	FSB 89D	01/16/1990	90Q1	1290	1290	PCM	EPA906.0
Tritium	FSB 89D	05/02/1990	90Q2	1400	1400	PCM	TI052-2
Tritium	FSB 89D	05/02/1990	90Q2	1300	1300	PCM	LA9763M
Tritium	FSB 89D	07/11/1990	90Q3	740	740	PCM	LA9763M
Tritium	FSB 89D	10/03/1990	90Q4	1500	1500	PCM	LA9763M
Tritium	FSB 89D	01/08/1991	91Q1	2200	2200	PCM	LA9763M
Tritium	FSB 89D	04/03/1991	91Q2	3000	3000	PCM	EPA906.0
Tritium	FSB 89D	07/15/1991	91Q3	1420	1420	PCM	EPA906.0
Tritium	FSB 89D	01/19/1992	92Q1	1850	1850	PCM	EPA906.0
Tritium	FSB 89D	04/02/1992	92Q2	1320	1320	PCM	EPA906.0
Tritium	FSB 89D	07/08/1992	92Q3	1810	1810	PCM	EPA906.0
Tritium	FSB 89D	11/12/1992	92Q4	1200	1200	PCM	EPA906.0
Tritium	FSB 89D	02/20/1993	93Q1	1080	1080	PCM	EPA906.0
Tritium	FSB 89D	02/20/1993	93Q1	1080	1080	PCM	EPA906.0
Tritium	FSB 89D	05/04/1993	93Q2	1030	1030	PCM	EPA906.0
Tritium	FSB 89D	05/04/1993	93Q2	1030	1030	PCM	EPA906.0
Tritium	FSB 89D	08/05/1993	93Q3	810	810	PCM	EPA906.0
Tritium	FSB 89D	08/05/1993	93Q3	810	810	PCM	EPA906.0
Tritium	FSB 89D	11/07/1993	93Q4	1040	1040	PCM	EPA906.0
Tritium	FSB 89D	11/07/1993	93Q4	1040	1040	PCM	EPA906.0

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Tritium	FSB 89D	02/08/1994	94Q1	15.2	15.2	PCM	EPIA-002
Tritium	FSB 89D	05/17/1994	94Q2	4110	4110	PCM	EPA906.0
Tritium	FSB 89D	08/04/1994	94Q3	4020	4020	PCM	EPIA-002
Tritium	FSB 89D	11/17/1994	94Q4	6360	6360	PCM	EPIA-002
Tritium	FSB 89D	02/09/1995	95Q1	1750	1750	PCM	EPIA-002
Tritium	FSB 89D	08/04/1995	95Q3	1290	1290	PCM	EPIA-002
Tritium	FSB 89D	10/11/1995	95Q4	777	777	PCM	EPIA-002
Tritium	FSB 89D	02/08/1996	96Q1	849	849	PCM	EPA906.0
Tritium	FSB 89D	04/29/1996	96Q2	916	916	PCM	EPA906.0
Tritium	FSB 89D	08/01/1996	96Q3	818	818	PCM	EPA906.0
Tritium	FSB 89D	10/03/1996	96Q4	1410	1410	PCM	EPA906.0

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Figure 9. Example of Category 7 data.

Constituent	*Well*	*Sample Date*	*QTR*	*Filtered Result*	*Unfiltered Result*	*Units*	*Method*
Mercury, total recoverable	HSB 71C	10/08/1992	92Q4	<0.2	<0.2	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	01/28/1993	93Q1	<0.2	<0.2	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	04/20/1993	93Q2	0.55	0.55	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	07/08/1993	93Q3	0.232	0.232	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	11/16/1993	93Q4	0.2	0.2	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	11/16/1993	93Q4	0.2	0.2	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	11/16/1993	93Q4	<0.2	<0.2	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	11/16/1993	93Q4	<0.2	<0.2	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	01/05/1994	94Q1	<0.2	0.204	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	04/28/1994	94Q2	<0.2	<0.2	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	07/13/1994	94Q3	<0.2	<0.2	ug/L	EPA245.1
Mercury, total recoverable	HSB 71C	10/19/1994	94Q4	<0.2	<0.2	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	01/13/1995	95Q1	<0.28	0.28	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	04/06/1995	95Q2	0.239	0.239	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	07/25/1995	95Q3	0.3	0.3	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	10/06/1995	95Q4	<0.28	<0.28	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	02/22/1996	96Q1	0.359	0.359	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	04/16/1996	96Q2	0.207	0.207	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	07/18/1996	96Q3	1.19	1.19	ug/L	EPA7470
Mercury, total recoverable	HSB 71C	10/21/1996	96Q4	<0.13	0.125	ug/L	EPA7470

Figure 10: H-Area Permit Modification Recommendations

1995 Permit Constituent	Limit	Unit	Recommendations: RCRA = CA, UIC = Y	RCRA = CA, UIC = N	RCRA = M, UIC = N	RCRA = N, UIC = N	More Analysis
Antimony	0.006	mg/L				X	
Benzene	0.005	mg/L				X	
Bis(2-ethylhyxyl) phthalate	10.0	u g/L				X	
Cyanide	40.0	u g/L				X	
Methylene Chloride	0.005	mg/L				X	
Selenium	0.05	mg/L				X	
Silver	0.05	mg/L				X	
Trichlorofluoromethane	1.0	u g/L				X	
Curium-246	SOA	pCi/L				X	
Plutonium-238	SOA	pCi/L				X	
Plutonium-239/240	SOA	pCi/L				X	
Thorium-228	SOA	pCi/L				X	
Thorium-232	SOA	pCi/L				X	
Barium	2	mg/L			X		
Chromium	0.1	mg/L			X		
Copper	1.3	mg/L			X		
Cobalt	2.94	u g/L		X			
Tin	2.63	u g/L		X			X
Curium-243/244	SOA	pCi/L		X			
Thorium-230	SOA	pCi/L		X			
Uranium-234	SOA	pCi/L		X			
Lead	0.015	mg/L	X				
Mercury	0.002	mg/L	X				
Tetrachloroethylene	0.005	mg/L	X				X
Cobalt-60	SOB	pCi/L	X				
Iodine-129	SOB	pCi/L	X				
Gross Alpha	15	pCi/L	X				
Gross Beta	50	pCi/L	X				
Nitrate	10	mg/L	X				
Total Radium (226+228)	5	pCi/L	X				
Tritium	20000	pCi/L	X				
Radium-226	SOR	pCi/L	X				
Radium-228	SOR	pCi/L	X				
Strontium-90	SOB	pCi/L	X				
Technetium-99	SOB	pCi/L	X				
Arsenic	0.05	mg/L					X
Cadmium	0.005	mg/L					X
Nickel	0.1	mg/L					X
Trichloroethylene	0.005	mg/L					X
Vanadium	4.06	u g/L					X
Zinc	5	mg/L					X
Americium-241	SOA	pCi/L					X
Carbon-14	SOB	pCi/L					X
Curium-242	SOA	pCi/L					X
Nickel-63	SOB	pCi/L					X
Uranium-235	SOA	pCi/L					X
Uranium-238	SOA	pCi/L					X

Figure 11: F-Area Permit Modification Recommendations

1995 Permit Constituent	Limit	Unit	Recommendations: RCRA = CA UIC = Y	RCRA = CA UIC = N	RCRA = M UIC = N	RCRA = N UIC = N	More Analysis
Antimony	0.006	mg/L				X	
Arsenic	0.05	mg/L				X	
Benzene	0.005	mg/L				X	
Bis(2-ethylhyxyl) phthalate	10.0	ug/L				X	
Cyanide	40.0	ug/L				X	
Phenols	5.0	ug/L				X	
Selenium	0.05	mg/L				X	
Silver	0.05	mg/L				X	
Thallium	0.002	mg/L				X	
Vanadium	BG	mg/L				X	
Curium-242	SOA	pCi/L				X	
Plutonium-239/240	SOA	pCi/L				X	
Thorium-232	SOA	pCi/L				X	
Barium	2	mg/L			X		
Chromium	0.1	mg/L			X		
Copper	1.3	mg/L			X		
Zinc	5	mg/L			X		
Cobalt-60	SOB	pCi/L			X		
Trichlorofluoromethane	1.0	ug/L		X			
Curium-246	SOA	pCi/L		X			
Thorium-228	SOA	pCi/L		X			
Thorium-230	SOA	pCi/L		X			
Cadmium	0.005	mg/L	X				
Cobalt	2.96	ug/L	X				
Lead	0.015	mg/L	X				
Mercury	0.002	mg/L	X				
Nickel	0.1	mg/L	X				
Gross Alpha	15	pCi/L	X				
Gross Beta	50	pCi/L	X				
Nitrate	10	mg/L	X				
Total Radium (226+228)	5	pCi/L	X				
Tritium	20	pCi/L	X				
Americium-241	SOA	pCi/L	X				
Cesium-137	SOB	pCi/L	X				
Curium-243/244	SOA	pCi/L	X				
Iodine-129	SOB	pCi/L	X				
Radium-226	SOR	pCi/L	X				
Radium-228	SOR	pCi/L	X				
Strontium-90	SOB	pCi/L	X				
Technetium-99	SOB	pCi/L	X				
Uranium-234	SOA	pCi/L	X				
Uranium-235	SOA	pCi/L	X				
Uranium-238	SOA	pCi/L	X				
Methylene Chloride	0.005	mg/L					X
Tetrachloroethylene	0.005	mg/L					X
Trichloroethylene	0.005	mg/L					X
Plutonium-238	SOA	pCi/L					X