Preprint
UCRL-JC-136015

Web-Based Tools for Environmental Data

G. Laguna, D. Lager, F. Colombini and P. Ottesen

This article was submitted to the
National Water Quality Monitoring Council National Conference
Austin, TX
April 25-27, 2000

U.S. Department of Energy

Lawrence
Livermore
National
Laboratory

March 28, 2000

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Web-Based Tools for Environmental Data

Gary Laguna, Darrel Lager, Francesca Colombini, Patricia Ottesen
Lawrence Livermore National Laboratory

BIOGRAPHICAL SKETCHES

Gary W. Laguna, BS in Computer Science, Abilene Christian University, 1981, and MS in Computer Science, University of California, Davis, 1983. Gary is a computer scientist at Lawrence Livermore National Laboratory, where he has worked since 1981. He is currently with the Environmental Restoration Division of the Environmental Protection Department, where he supports a wide variety of projects with an emphasis on web-based applications.

Darrel L. Lager, BSEE, California Polytechnic State University at San Luis Obispo, 1968. Since that time he has been at Lawrence Livermore National Laboratory (LLNL) as an Electronics Engineer. He is presently in the Environmental Restoration Division of the Environmental Protection Department acting as the World-Wide-Web site designer, manager, and administrator. His present professional interests revolve around the design and implementation of Web applications for access to the Division's large sample database and for the Division's real-time control of its remediation facilities.

Francesca M. Colombini, BS in Computer Science, University of the Pacific, Stockton, CA, 1985. In 1986, Francesca was hired as a computer scientist at Lawrence Livermore National Laboratory (LLNL) and for the last 10 years has supported LLNL's Environmental Protection Department (EPD). Currently, Francesca manages and develops custom applications for EPD's large environmental database. She also creates Web enabled data mining tools to deliver information from this data repository.

Patricia L. Ottesen, BA, State University of New York at Stony Brook, 1979. She has served as an environmental intern and scientist at Lawrence Livermore National Laboratory since 1984, specializing in information systems. Her current position is Group Leader of Information Systems for the Environmental Restoration Division of the Environmental Protection Department.

ABSTRACT

Lawrence Livermore National Laboratory (LLNL) has pursued an aggressive site characterization and remediation program since the early 1980's. The effort has required drilling and sampling over 1000 wells. The development of tools for interacting with the large volume of data is imperative. Working closely with interdisciplinary project scientists, we have developed a suite of web-based tools for facilitating many data-driven analysis and interpretation tasks.

LLNL tool development must meet the needs of several different groups: LLNL project staff, DOE project managers, and government regulators. The project managers and regulators require general tools, answering questions such as "what locations have had detectable amounts of a particular chemical." In addition to general inquiries, regulators want specific information, such as reports of volatile organic compound concentrations for an area over time. LLNL users need tools that support analysis and facility operations as well as general inquiry tools. We have developed web-based tools that allow each class of user to obtain much of the information they desire without the assistance of database specialists.

While these tools were created for particular classes of users, each tool has proven useful to other groups as well. Providing a web interface to these tools makes them easily accessible regardless of the user's location or computing platform. Cross-linking these tools increases their visibility and enables data exploration. In this paper, we will describe a selection of our web-based tools, illustrating the way we are using the web to facilitate easier and broader access to project data.

Web-Based Tools for Environmental Data

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Introduction

Lawrence Livermore National Laboratory (LLNL) has pursued an aggressive site characterization and remediation program since the early 1980's (Management Summary, 1998). The effort has required the drilling and sampling of over 1000 wells, resulting in a continuously growing database with millions of sample analysis and other environmental records. The development of tools to facilitate the active use of this large volume of data is imperative (Canales, 1996). Working closely with multi-disciplinary project scientists, we have developed a suite of web-based tools for facilitating many data-driven analysis and interpretation tasks. Needs must be met for several different customer groups: LLNL project staff and managers, DOE project managers, and government regulators.

The project managers and regulators require general tools, answering questions such as "what locations have had detectable amounts of a particular chemical" or "what chemicals have had detectable amounts reported for a particular location." In addition to general inquiries, regulators want specific information, such as reports of volatile organic compound concentrations for an area over time. LLNL users need tools that support conceptual model development, interpretation and analysis, and treatment facility operations as well as general inquiry tools. We have developed web-based tools that allow each class of user to obtain much of the information they desire without the assistance of database specialists.

Our Evolution to Web-Based Tools

Our approach to web-based tool development has been evolutional and iterative. LLNL began its environmental restoration activities in the early 1980's. At that time, personal computers were just being introduced and the Internet, as we know it today, was a decade away. Tools and procedures were developed for LLNL's remediation efforts using available technology prior to the widespread availability of the Internet. Our organization's primary goal is to remediate the site, so only a small portion of our resources can be devoted to developing tools.

The Internet has revolutionized many aspects of tool development and tool delivery. Our users work with a variety of computing platforms, including Macintosh, Unix, and numerous flavors of wintel PC compatibles. By developing tools compatible with web browsers, we are freed from many of the constraints of hardware platforms. Web-based tools can be run from almost any platform that can support a full-featured web browser. Project cost concerns are also addressed since using a web-based approach places the computational burden on the server, extending the life of older and slower desktop machines. Virtual teams and remote collaboration are facilitated: web-based tools free users from location constraints; tools do not have to be accessed from a particular machine or a particular local area network. In theory, any machine connected to the Internet can access our web-based tools (within our computer security constraints).

Some tasks do not lend themselves to the web. One such task that we have encountered is complex modeling programs. An attempt was made to develop a web-based front-end for one of our modeling simulations. The simulation had so many selectable controls that the web-based interface became complicated and cumbersome. Frequent users of the simulation preferred to run the simulation directly instead of through the web-based interface. Those users who did use the web-based interface were unfamiliar with all the controls, often creating simulations that were misleading or meaningless. Tasks that do not lend themselves to the web are time-consuming to develop and result in tools that do not get used.

Before developing a new tool, it must be clear that there is a savings to be gained. Most of the tools that we develop are designed to save time and effort. Other tools might generate savings that are harder to recognize. For

instance, a web-based tool that replaces a spreadsheet may in fact take more time to use and offer fewer features for manipulating the data. However, the web-based tool may offer better collaboration and allow easier integration of the data into a database for long-term storage. A sense of the value of the tool is determined by estimating the amount of time required to develop the tool and comparing that time to the savings or benefit the tool will generate.

Some proposed tools will never be developed. Due to resource constraints, we continually have a considerable backlog of requests from users for web-based tools. Our users' eagerness to suggest new tools is clear evidence that they have embraced the web as a tool delivery mechanism, and that they see web-based tools as a way to increase their efficiency and productivity.

Tool Presentation Approach

Web browsing can be a time-consuming activity. Most web pages contain links to other pages, and these pages contain links to still other pages, and so on, and so on. Ideally, a person starts out on a page about a topic, and the links on the page lead to more and more detailed information. But this is not always the case. In some instances, people get so lost following links that they forget what they were initially looking for. Other browsers peruse web pages not knowing exactly what they are looking for. However, by following links for some general topic, they eventually are presented specific information that is useful to them.

We have attempted to support both approaches to information gathering as models for our web-based tools. For users who are familiar with our database and know the information they want, we provide links to details about that information. For other users we provide tools to help them identify what is of interest to them, then guide them to other tools that will provide specific information. We try to leverage all of our tools by cross-linking them. We have learned that our users often take the information obtained from one tool as the basis for using another tool. Where possible, we try to automate this tool-jumping process as much as possible.

Tools for Project Staff

Most of the tools that have been developed for LLNL's Environmental Restoration Project have been targeted to facilitate the activities required to choose, design, and deploy treatment strategies, as well as monitoring remediation progress. Web-based tools have been developed that help us manage our field activities, such as the "Sampling Water Level" and the "Well Specification" tool. Additionally, many web-based tools have been developed to help our project scientists characterize the site, then plan and refine remediation strategies. These include the "Lithology" tool, the "Geophysical Curves Display" tool (Figure 1), the "Piper" (Figure 2) and "Stiff" (Figure 3) diagramming tools, the "Multiple Well/Multiple Parameter Time Series Plot" tool (Figure 4), and the "Contour Plot" tool. In addition to the tools above, we have also developed many tools to streamline the information gathering required for the many regulatory reports we are required to submit.

Tools for Regulators and Project Managers

The governmental regulators charged with oversight of the cleanup at LLNL have been granted access to our environmental remediation database and database tools. Providing meaningful tools to these users is a challenge because most of the database tools have been developed for users with an intimate knowledge of our site as well as a working knowledge of our database structure.

The development of tools for these users is further complicated by the lack of context provided by many tools. One such situation would be a sample value for a chemical at a location, which was greater than recent previous samples at that location. Without also examining recent groundwater elevation and other related data, it would be very hard to accurately understand the significance of the high sample value. Another example would be off-site

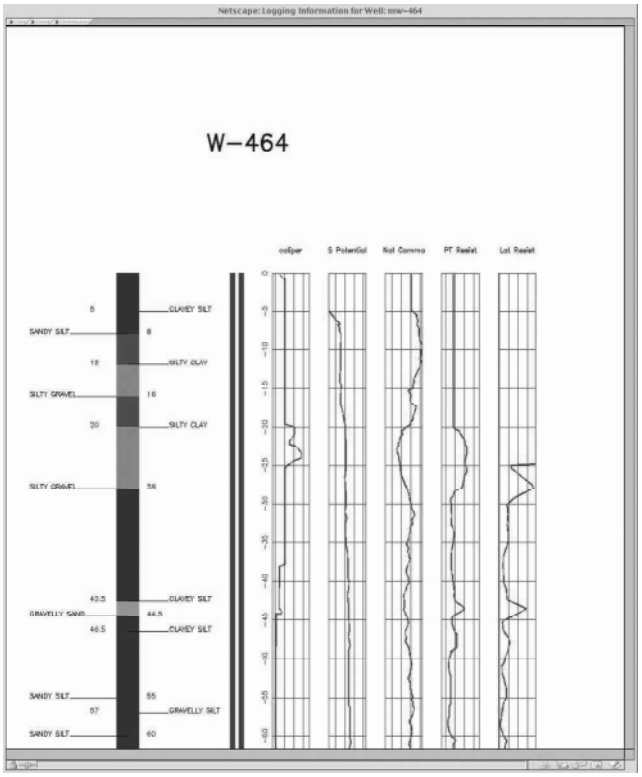

Figure 1. Output of the “Geophysical Curves Display” tool.

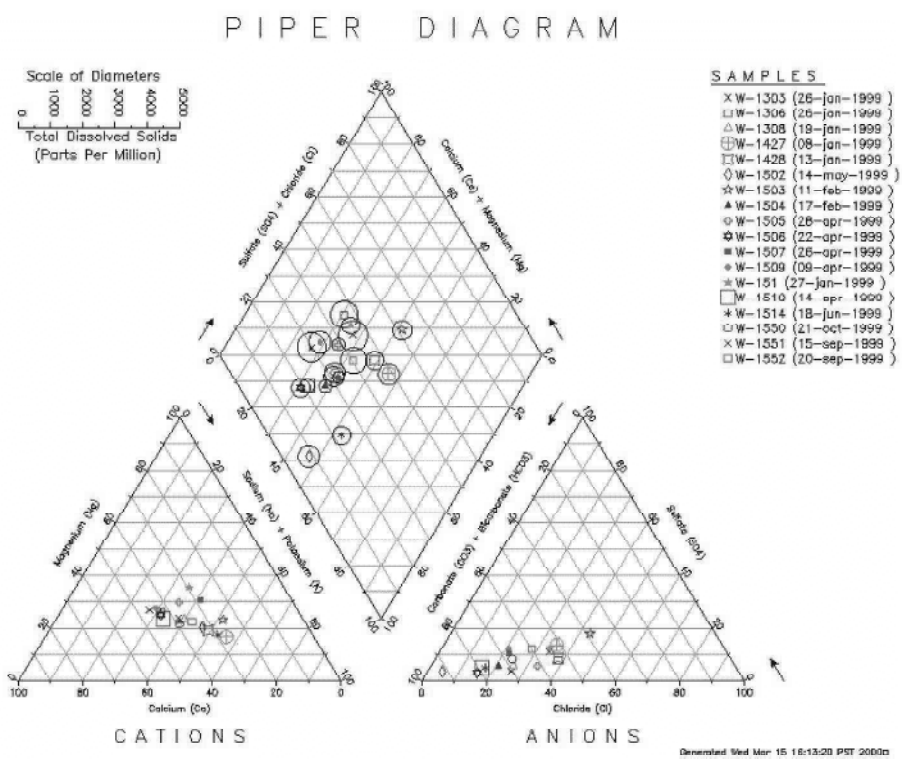

Figure 2. Output of the “Piper” tool.

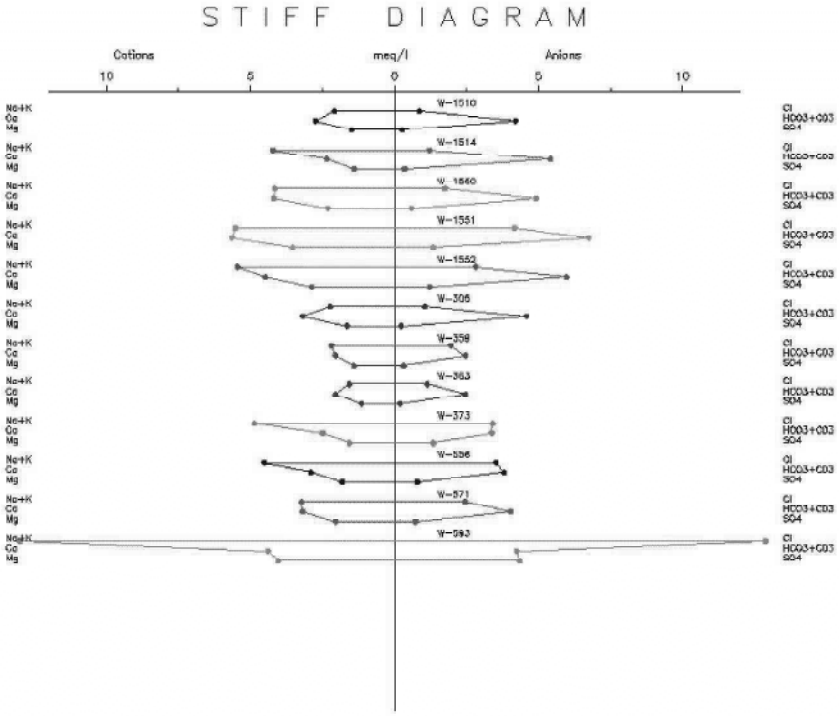

Figure 3. Output of the “Stiff” tool.

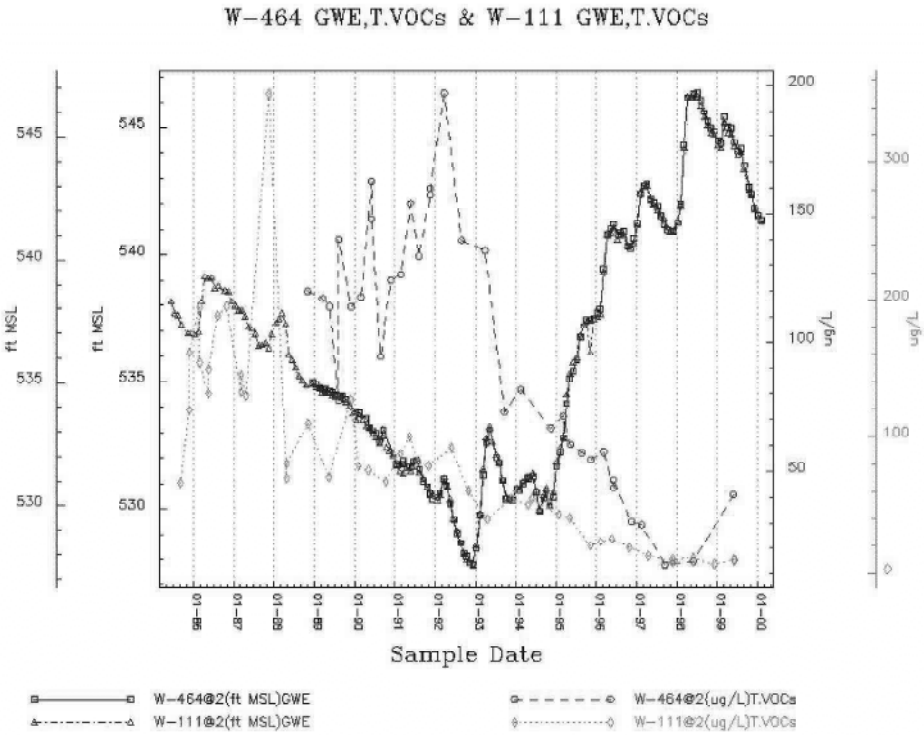

Figure 4. Output of the “Multiple Well/Multiple Parameter Time Series Plot” tool.

wells that are monitored as part of our project. Some of the samples from these wells could be misleading to our regulators because they are influenced by the activities of organizations other than the laboratory.

While it is probably impossible for any tool to completely address these challenges, our approach has been to provide our regulators with tools that help them find the types of information they are interested in while preserving some of the information's context. It should be noted that we do not limit our regulators to using only the tools we have developed for them. Instead, it is our aim to give them tools to find areas of interest within the "big picture" which will allow them to use our other tools with "understanding."

Project managers, like regulators, are also interested in the "big picture" as well as summary information. Of course, project managers have all of the project staff at their disposal to interpret and analyze retrieved information. While welcoming the regulators to use tools and access data, we are demonstrating that they have become a real part of the project team. As team members, they are expected to raise questions or data for examination, discussion and interpretation.

We will present here three tools developed to address the needs of users such as our regulators and project managers. Two of the tools are known as the "Hit Hunters." The "Hit Hunters" allow users to find samples where chemicals have been detected above a reporting, or detection, limit. A third tool is a reporting tool, which has been customized for these users to retrieve information about any selected well.

Hit Hunter – Search for Locations

The first of our "Hit Hunter" tools finds all positive detections, or "hits", for a selected chemical. A user of this tool is first presented a page with one entry box and two sets of radio buttons (Figure 5). The entry box is used to enter the first few characters of a chemical name or nickname. These characters will be used to pare down the list of over 1400 names and nicknames of chemicals recognized by our database. The first set of radio buttons allows the user to choose the matrix for the samples they are interested in. Currently, this tool allows users to select "Groundwater", "Aqueous", "Soil" or "Groundwater and Aqueous." The second set of radio buttons allows the user to select between LLNL's two physical plant locations.

After making the choices described above, the user clicks on the "Find It" button and is taken to a second page (Figure 6), presenting the user with more choices. All chemical names and nicknames containing the string entered on the first page are retrieved and displayed as a pop-up list. The user then must select the desired chemical from the displayed list. The user must also narrow the geographical area of interest. On the first page, the user selected one of LLNL's two physical sites. Within each site, there are several sub-areas, each with a number of wells, and possibly other types of sample locations. After selecting the chemical and area of interest, the user can click on the "Submit Query" button to process the request and go to the results page.

The results of the user's request are presented as a series of tables (Figure 7). Each table contains the following summary information: the location identifier, the matrix for the samples, the sample type, the number of hits, the maximum sample result returned for this location, the sample result units, the reporting limit for the samples, and the date associated with the maximum sample result. The headers of the columns are links that allow the user to view a definition of that item from the database data dictionary.

This summary result information allows users to quickly assess which locations should receive further examination. Locations with no hits for the requested chemical are not displayed. Someone looking for current TCE areas of concern might first start by eliminating locations with a small number of hits and sample dates older than a few years. Next, one might decide to only view samples with concentrations greater than 100 ug/L. In the example shown, that would leave four locations. Of the four remaining locations, a user might choose the location with the most recent sample date for the maximum sample result. In this example, that would be location W-464. Additional information about W-464 can be obtained by following the "plot" link (Figure 8).

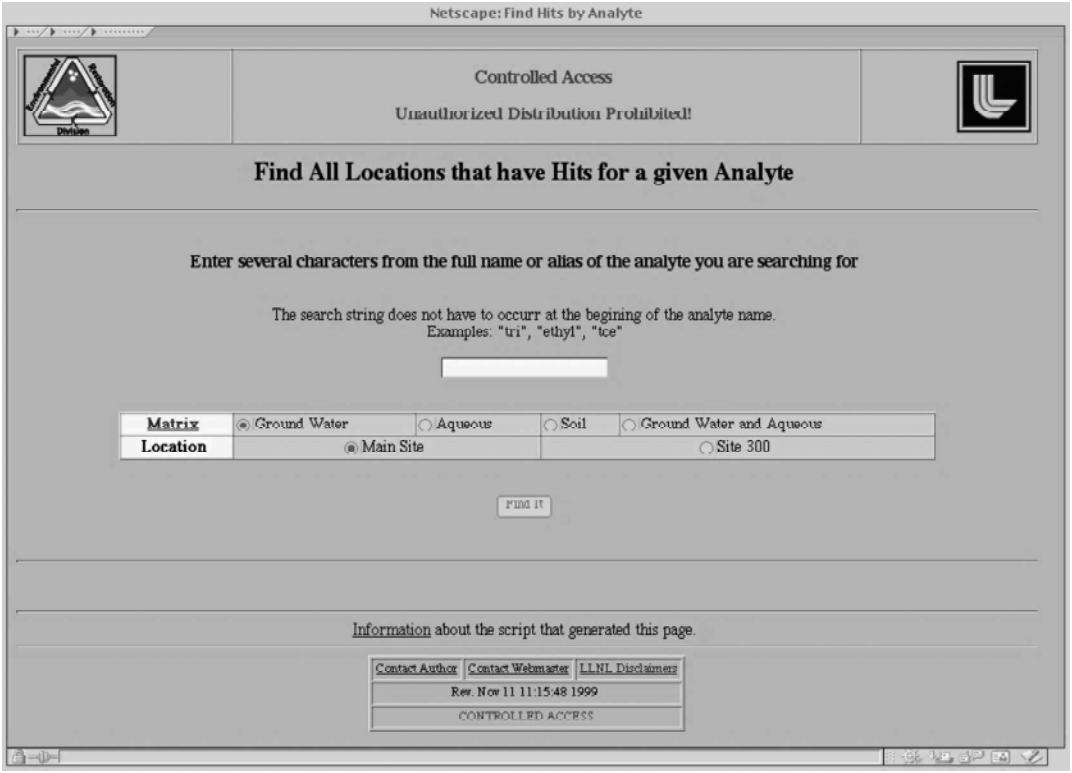

Figure 5. “Hit Hunter” – “Find All Locations” tool, first page.

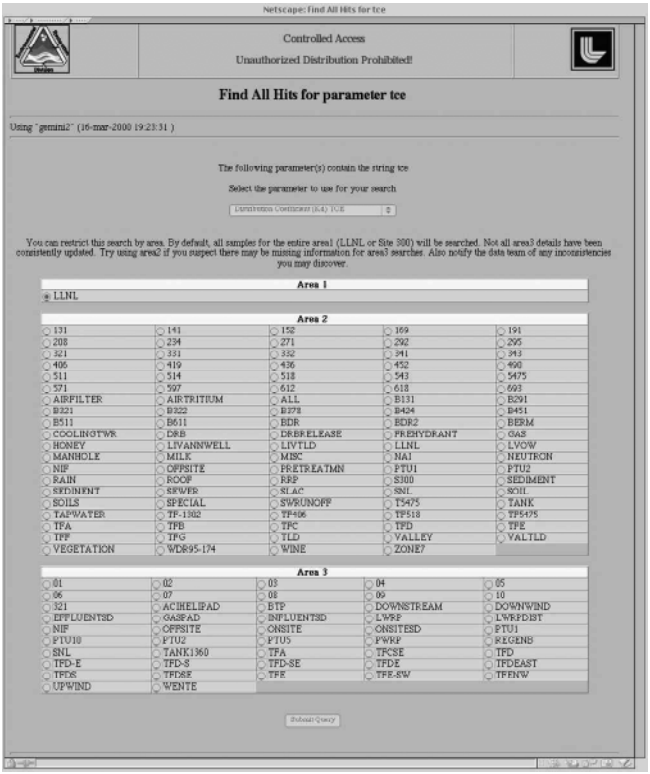

Figure 6. “Hit Hunter” – “Find All Locations” tool, second page.

Netscape: Find All Hits for 8650

Gemini Access

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Using "gemini2" (16-mar-2000 19:23:31)

Find All Hits for Trichloroethene

Area1 = LLNL and area2 = TFG

See the database query below

The following locations have sample results for **Trichloroethene** above the non-detect limit

loc_id	matrix	type		Num Hits	max result	units	los_value	Sample Date of Max Result
SIP-212-101	GW	RTN	plot	10	4.6	ug/L	0.5	02-dec-1996
SIP-331-001	GW	RTN	plot	3	2.9	ug/L	0.5	25-sep-1997
TW-11	GW	DUP		1	17	ug/L	0.5	27-aug-1996
TW-11	GW	RTN	plot	42	170	ug/L	0	01-dec-1987
TW-11A	GW	DUP	plot	3	6.7	ug/L	0.5	30-nov-1989
TW-11A	GW	RTN	plot	32	27	ug/L	0	16-may-1984
W-111	GW	DUP	plot	2	3.9	ug/L	0.5	20-nov-1997
W-111	GW	RTN	plot	42	32	ug/L	0	27-may-1992
W-146	GW	DUP	plot	4	28	ug/L	0	20-nov-1991
W-146	GW	RTN	plot	36	25	ug/L	0	20-nov-1991
W-147	GW	RTN	plot	25	7.2	ug/L	0	27-oct-1999
W-148	GW	DUP	plot	2	1.7	ug/L	0.3	22-may-1991
W-148	GW	RTN	plot	23	19	ug/L	0	20-may-1987
W-223	GW	RTN		1	0.5	ug/L	0	03-nov-1986
W-252	GW	DUP	plot	2	20	ug/L	0.5	30-nov-1990
W-252	GW	RTN	plot	32	39	ug/L	0	24-mar-1992
W-253	GW	DUP	plot	2	28	ug/L	0.5	30-jul-1991
W-253	GW	RTN	plot	30	38	ug/L	0	26-aug-1992
W-307	GW	DUP	plot	6	190	ug/L	1	01-dec-1989
W-307	GW	RTN	plot	33	200	ug/L	0	26-aug-1987
W-464	GW	DUP	plot	2	84	ug/L	0.5	20-nov-1991
W-464	GW	RTN	plot	32	110	ug/L	0	24-mar-1992
W-551	GW	DUP	plot	5	17	ug/L	0.5	11-sep-1996
W-551	GW	RTN	plot	30	21	ug/L	0	24-mar-1992
W-618	GW	RTN		1	2.5	ug/L	0.5	08-aug-1991

Figure 7. "Hit Hunter" – "Find All Locations" tool, results page.

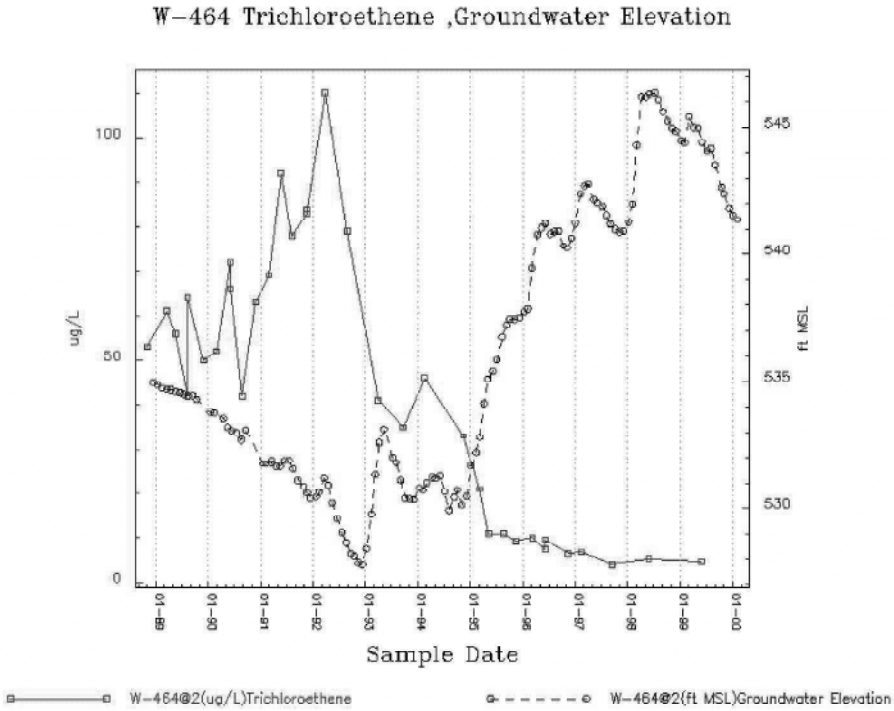


Figure 8. Output of the "Multiple Well/Multiple Parameter Time Series Plot" tool for TCE at W-464.

The “plot” link generates a request to the “Multiple Well/Multiple Parameter Time Series Plot” tool. This tool can plot multiple chemicals from multiple wells against time on a single plot. However, in the “Hit Hunter” context, it will only plot a single chemical and groundwater elevation against time. In this plot, we see that TCE concentrations for W-464 were increasing through the early 1990’s, but since 1994 have steadily decreased to the current level of less than 10 ug/L. In addition to the plot, this tool also lists each sample date, sample result, and the associated log number in a table. The log number is a link, which can be used to gain still more information about the sample, such as the sample type, the requested analysis, the analysis method, the laboratory that performed the analysis, and various quality control parameters.

The “Hit Hunter” result page also contains links to our mapping tools. Each of the location identifiers on the result page is linked to a mapping tool, which displays that location on our site map (Figure 9). Clicking anywhere on the map zooms in about that point. Clicking on the label for the location generates a request to our other “Hit Hunter” tool, the “Search for Chemicals” tool.

Hit Hunter – Search for Chemicals

Our second “Hit Hunter” tool searches for any chemical that has had a positive detection, or hit, for one selected well. This tool can be accessed directly or from other tools as described above. The top page of the “Search for Chemicals” tool requires the user to enter a location identifier and to select the matrix to be searched (Figure 10). After setting these values and clicking the “Get Info” button, the web-tool displays the results page (Figure 11). The results page for the “Search for Chemicals” tool is very similar to that of the “Search for Locations” tool. The data is presented as a series of tables containing the following information: the name of the chemical found, the matrix for the samples, the sample type, the number of hits, the maximum sample result returned for this chemical, the sample result units, the reporting limit for the samples, and the date associated with the maximum sample result. Similar to the “Search for Locations” tool, the “Search for Chemicals” tool contains links to the database data dictionary and the “Multiple Well/Multiple Parameter Time Series Plot” tool. However, instead of a link to the mapping tool, the “Search for Chemicals” tool links the chemical name to our third tool, the “List Results” tool.

List Results Tool

The “List Results” tool provides users with an easy way to retrieve the sample analysis results for up to eight chemicals in one well. The first page of the “Sample Results” tool allows the user to select the location identifier and the chemicals for the search (Figure 12). The results are presented in a table (Figure 13). The table contains columns for the sample date, the analytical lab, the sample type, the sample method, the sampling depth, the validation code, and one column for each requested chemical. Additionally, the results page also has a link to allow the results to be downloaded as a tab-separated-values file for use with spreadsheet programs.

Conclusions

While these tools were created for particular classes of users, each tool has proven useful to other groups as well. Providing a web interface to these tools makes them easily accessible regardless of the user’s location or computing platform. Cross-linking these tools increases their visibility and enables data exploration. In this paper, we have described our approach to tool development and provided examples of several of our web-based tools that are helping us perform a successful remediation. However, even the most ingenious and effective tools are only as useful as the underlying database. Our project has a well thought out and rigorously maintained database. Our organization considers keeping the database up to date and accurate a top priority. Together, the database and our web-based tools have become a vital part of our project infrastructure, contributing to efficiency and successful remediation.

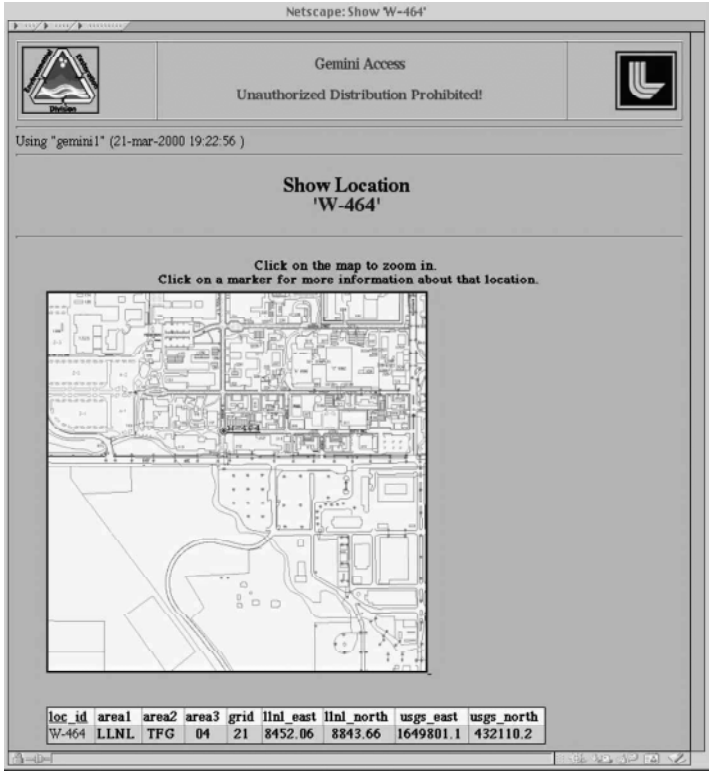


Figure 9. “Map” tool showing the location of W-464.

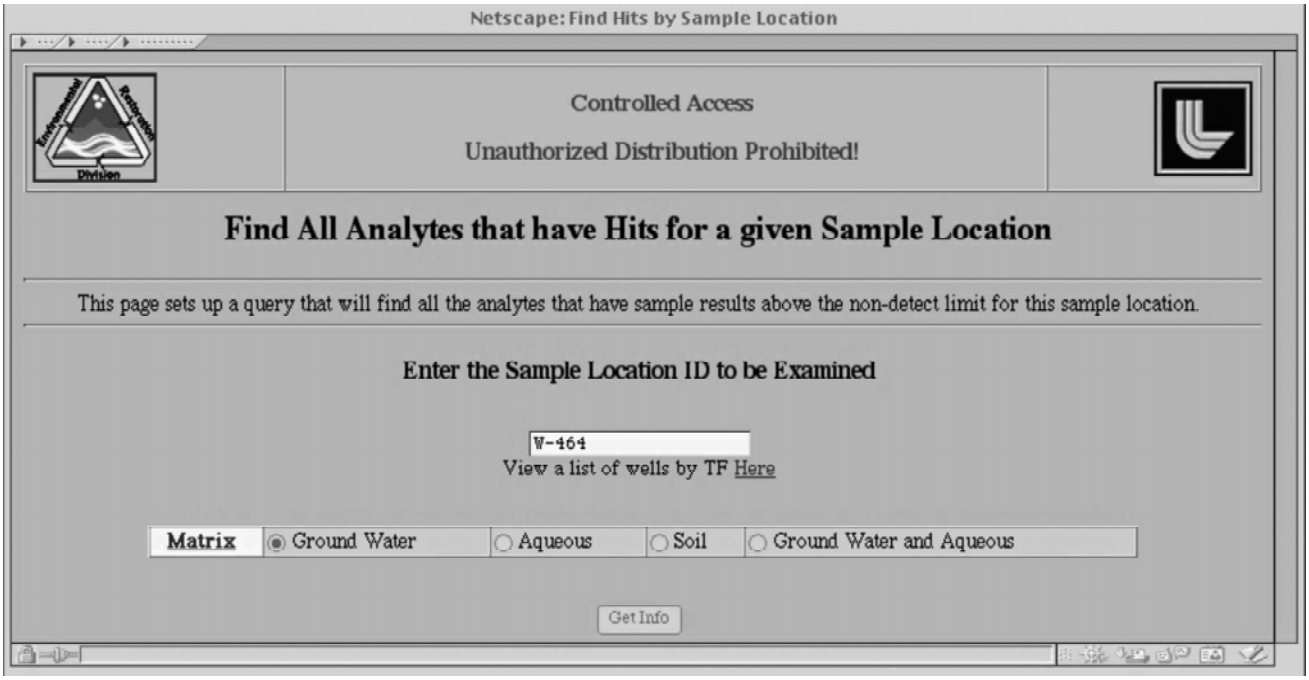
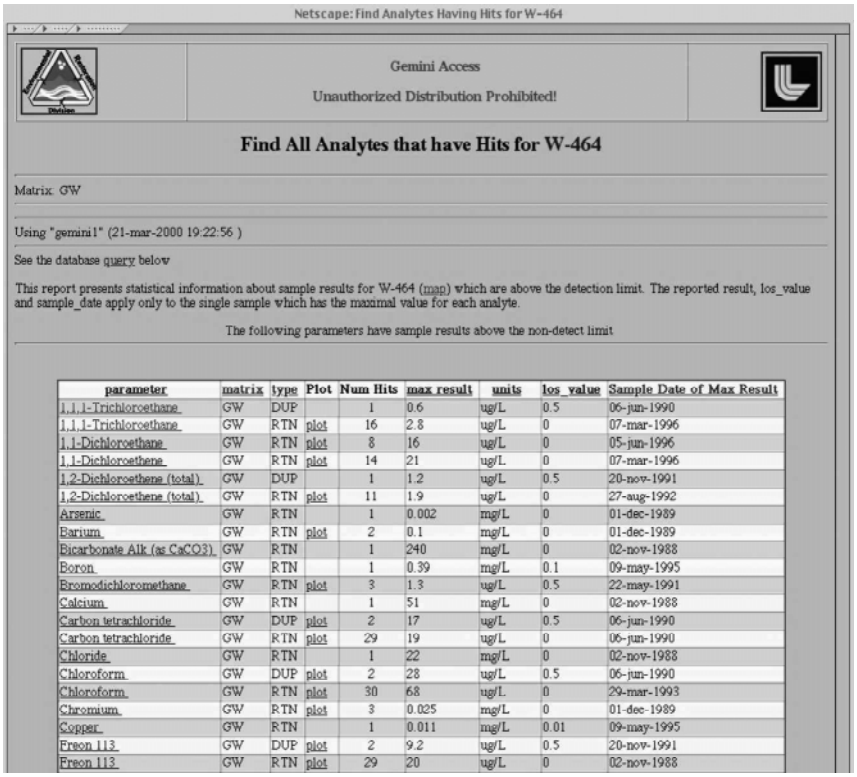


Figure 10. “Hit Hunter” – “Find All Chemicals” tool, first page.



Netscape: Find Analytes Having Hits for W-464

Gemini Access

Unauthorized Distribution Prohibited!

Find All Analytes that have Hits for W-464

Matrix: GW

Using "gemini1" (21-mar-2000 19:22:56)

See the database query below

This report presents statistical information about sample results for W-464 (map) which are above the detection limit. The reported result, los_value and sample_date apply only to the single sample which has the maximal value for each analyte.

The following parameters have sample results above the non-detect limit

parameter	matrix	type	Plot	Num Hits	max result	units	los_value	Sample Date of Max Result
1,1,1-Trichloroethane	GW	DUP		1	0.6	ug/L	0.5	06-jun-1990
1,1,1-Trichloroethane	GW	RTN	plot	16	2.8	ug/L	0	07-mar-1996
1,1-Dichloroethane	GW	RTN	plot	8	16	ug/L	0	05-jun-1996
1,1-Dichloroethene	GW	RTN	plot	14	21	ug/L	0	07-mar-1996
1,2-Dichloroethene (total)	GW	DUP		1	1.2	ug/L	0.5	20-nov-1991
1,2-Dichloroethene (total)	GW	RTN	plot	11	1.9	ug/L	0	27-aug-1992
Arsenic	GW	RTN		1	0.002	mg/L	0	01-dec-1989
Barium	GW	RTN	plot	2	0.1	mg/L	0	01-dec-1989
Bicarbonate Alk (as CaCO3)	GW	RTN		1	240	mg/L	0	02-nov-1988
Boron	GW	RTN		1	0.39	mg/L	0.1	09-may-1995
Bromodichloromethane	GW	RTN	plot	3	1.3	ug/L	0.5	22-may-1991
Calcium	GW	RTN		1	51	mg/L	0	02-nov-1988
Carbon tetrachloride	GW	DUP	plot	2	17	ug/L	0.5	06-jun-1990
Carbon tetrachloride	GW	RTN	plot	29	19	ug/L	0	06-jun-1990
Chloride	GW	RTN		1	22	mg/L	0	02-nov-1988
Chloroform	GW	DUP	plot	2	28	ug/L	0.5	06-jun-1990
Chloroform	GW	RTN	plot	30	68	ug/L	0	29-mar-1993
Chromium	GW	RTN	plot	3	0.025	mg/L	0	01-dec-1989
Copper	GW	RTN		1	0.011	mg/L	0.01	09-may-1995
Freon 113	GW	DUP	plot	2	9.2	ug/L	0.5	20-nov-1991
Freon 113	GW	RTN	plot	29	20	ug/L	0	02-nov-1988

Figure 11. “Hit Hunter” – “Find All Chemicals” tool, results page.

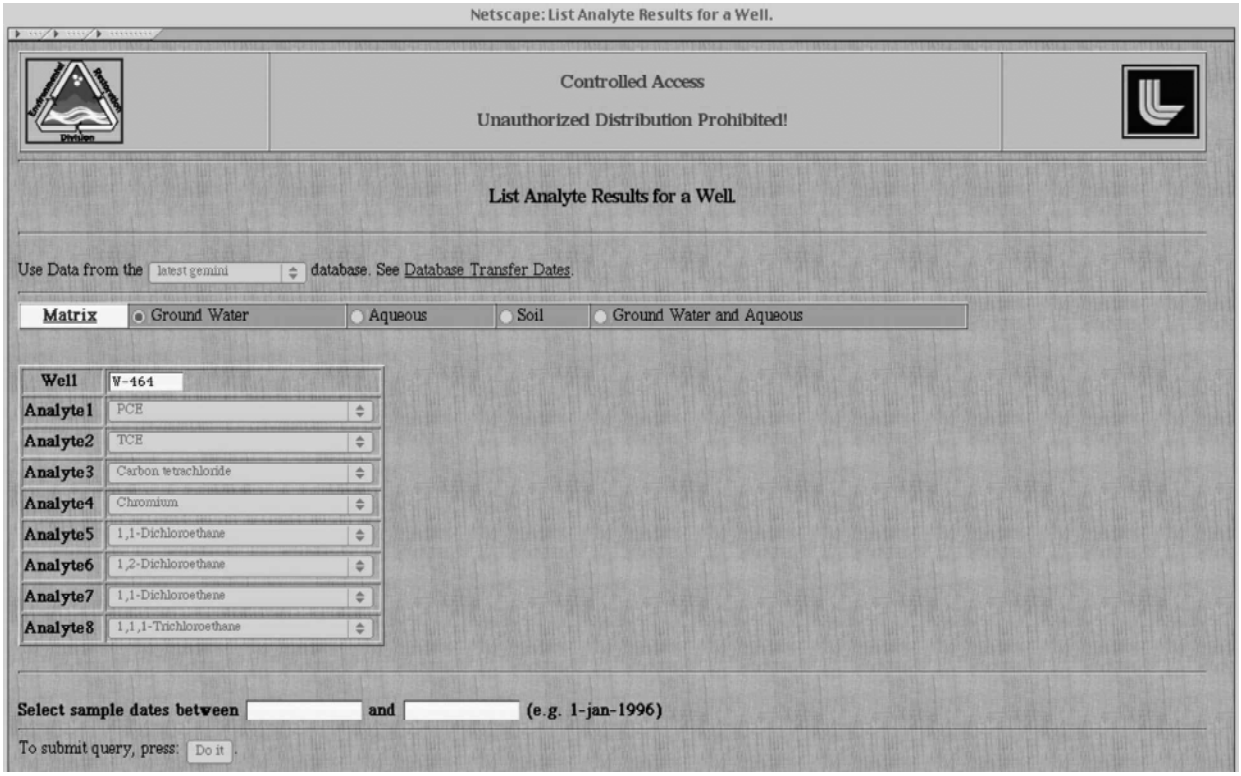
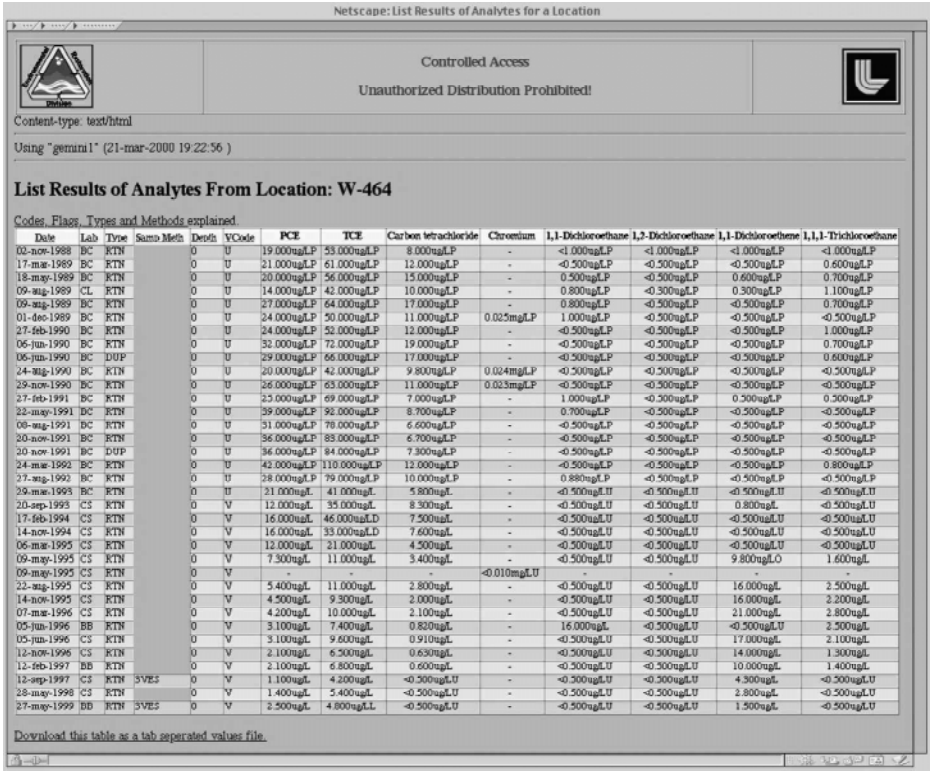


Figure 12. “List Results” tool, first page.



Netscape: List Results of Analytes for a Location

Controlled Access

Unauthorized Distribution Prohibited!

Content-type: text/html

Using "gemini1" (21-mar-2000 19:22:56)

List Results of Analytes From Location: W-464

Codes, Flags, Types and Methods explained.

Date	Lab	Type	Samp Meth	Depth	VCode	PCE	TCE	Carbon tetrachloride	Chromium	1,1-Dichloroethane	1,2-Dichloroethane	1,1-Dichloroethene	1,1,1-Trichloroethane
02-nov-1988	BC	RTN		0	U	19.000ug/LP	53.000ug/LP	8.000ug/LP	-	<1.000ug/LP	<1.000ug/LP	<1.000ug/LP	<1.000ug/LP
17-mar-1989	BC	RTN		0	U	21.000ug/LP	61.000ug/LP	12.000ug/LP	-	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	0.600ug/LP
18-may-1989	BC	RTN		0	U	20.000ug/LP	56.000ug/LP	15.000ug/LP	-	0.500ug/LP	<0.500ug/LP	0.600ug/LP	0.700ug/LP
09-aug-1989	CL	RTN		0	U	14.000ug/LP	42.000ug/LP	10.000ug/LP	-	0.800ug/LP	<0.500ug/LP	0.300ug/LP	1.100ug/LP
09-aug-1989	BC	RTN		0	U	27.000ug/LP	64.000ug/LP	17.000ug/LP	-	0.800ug/LP	<0.500ug/LP	<0.500ug/LP	0.700ug/LP
01-dec-1989	BC	RTN		0	U	24.000ug/LP	50.000ug/LP	11.000ug/LP	0.025mg/LP	1.000ug/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP
27-feb-1990	BC	RTN		0	U	24.000ug/LP	52.000ug/LP	12.000ug/LP	-	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	1.000ug/LP
06-jun-1990	BC	RTN		0	U	32.000ug/LP	72.000ug/LP	19.000ug/LP	-	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	0.700ug/LP
06-jun-1990	BC	DUP		0	U	29.000ug/LP	66.000ug/LP	17.000ug/LP	-	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	0.600ug/LP
24-aug-1990	BC	RTN		0	U	20.000ug/LP	42.000ug/LP	9.800ug/LP	0.024mg/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP
29-nov-1990	BC	RTN		0	U	26.000ug/LP	63.000ug/LP	11.000ug/LP	0.023mg/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP
27-feb-1991	BC	RTN		0	U	23.000ug/LP	69.000ug/LP	7.000ug/LP	-	1.000ug/LP	<0.500ug/LP	0.500ug/LP	0.500ug/LP
22-may-1991	BC	RTN		0	U	39.000ug/LP	92.000ug/LP	8.700ug/LP	-	0.700ug/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP
08-aug-1991	BC	RTN		0	U	31.000ug/LP	78.000ug/LP	6.600ug/LP	-	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP
20-nov-1991	BC	RTN		0	U	36.000ug/LP	83.000ug/LP	6.700ug/LP	-	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP
20-nov-1991	BC	DUP		0	U	36.000ug/LP	84.000ug/LP	7.300ug/LP	-	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP
24-mar-1992	BC	RTN		0	U	42.000ug/LP	110.000ug/LP	12.000ug/LP	-	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP	0.800ug/LP
27-aug-1992	BC	RTN		0	U	28.000ug/LP	79.000ug/LP	10.000ug/LP	-	0.880ug/LP	<0.500ug/LP	<0.500ug/LP	<0.500ug/LP
29-mar-1993	BC	RTN		0	U	21.000ug/L	41.000ug/L	5.800ug/L	-	<0.500ug/LU	<0.500ug/LU	<0.500ug/LU	<0.500ug/LU
20-sep-1993	CS	RTN		0	V	12.000ug/L	35.000ug/L	8.300ug/L	-	<0.500ug/LU	<0.500ug/LU	0.800ug/L	<0.500ug/LU
17-feb-1994	CS	RTN		0	V	16.000ug/L	46.000ug/LD	7.500ug/L	-	<0.500ug/LU	<0.500ug/LU	<0.500ug/LU	<0.500ug/LU
14-nov-1994	CS	RTN		0	V	16.000ug/L	33.000ug/LD	7.600ug/L	-	<0.500ug/LU	<0.500ug/LU	<0.500ug/LU	<0.500ug/LU
06-mar-1995	CS	RTN		0	V	12.000ug/L	21.000ug/L	4.500ug/L	-	<0.500ug/LU	<0.500ug/LU	<0.500ug/LU	<0.500ug/LU
09-may-1995	CS	RTN		0	V	7.300ug/L	11.000ug/L	3.400ug/L	-	<0.500ug/LU	<0.500ug/LU	9.800ug/LO	1.600ug/L
09-may-1995	CS	RTN		0	V	-	-	-	<0.010mg/LU	-	-	-	-
22-aug-1995	CS	RTN		0	V	5.400ug/L	11.000ug/L	2.800ug/L	-	<0.500ug/LU	<0.500ug/LU	16.000ug/L	2.500ug/L
14-nov-1995	CS	RTN		0	V	4.500ug/L	9.300ug/L	2.000ug/L	-	<0.500ug/LU	<0.500ug/LU	16.000ug/L	2.200ug/L
07-mar-1996	CS	RTN		0	V	4.200ug/L	10.000ug/L	2.100ug/L	-	<0.500ug/LU	<0.500ug/LU	21.000ug/L	2.800ug/L
05-jun-1996	BB	RTN		0	V	3.100ug/L	7.400ug/L	0.820ug/L	-	16.000ug/L	<0.500ug/LU	<0.500ug/LU	2.500ug/L
05-jun-1996	CS	RTN		0	V	3.100ug/L	9.600ug/L	0.910ug/L	-	<0.500ug/LU	<0.500ug/LU	17.000ug/L	2.100ug/L
12-nov-1996	CS	RTN		0	V	2.100ug/L	6.500ug/L	0.630ug/L	-	<0.500ug/LU	<0.500ug/LU	14.000ug/L	1.300ug/L
12-feb-1997	BB	RTN		0	V	2.100ug/L	6.800ug/L	0.600ug/L	-	<0.500ug/LU	<0.500ug/LU	10.000ug/L	1.400ug/L
12-sep-1997	CS	RTN	SVES	0	V	1.100ug/L	4.200ug/L	<0.500ug/LU	-	<0.500ug/LU	<0.500ug/LU	4.500ug/L	<0.500ug/LU
28-may-1998	CS	RTN		0	V	1.400ug/L	5.400ug/L	<0.500ug/LU	-	<0.500ug/LU	<0.500ug/LU	2.800ug/L	<0.500ug/LU
27-may-1999	BB	RTN	SVES	0	V	2.500ug/L	4.800ug/LL	<0.500ug/LU	-	<0.500ug/LU	<0.500ug/LU	1.500ug/L	<0.500ug/LU

Download this table as a tab seperated values file.

Figure 13. “List Results” tool, results page.

References

Management Summary - Environmental Restoration at Lawrence Livermore National Laboratory Livermore Site, Livermore, California U.S. Department of Energy September 1998 (available at http://www-erd.llnl.gov/library/), UCRL-AR-122289(Rev. 3).

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Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48. (UCRL-JC-136015)