

FINAL REPORT
CO-OCCURRENCE OF DRINKING WATER CONTAMINANTS

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EXECUTIVE SUMMARY

The purpose of this analysis is to determine whether specific primary (arsenic, sulfate, uranium, radium, radon, nitrate) and secondary (antimony, barium, beryllium, cadmium, chromium, cyanide, iron, manganese, mercury, nickel, nitrite, selenium, thallium, hardness, total dissolved solids) drinking water contaminants co-occur on a statistically significant basis or if the co-occurrence is purely a random phenomenon. The information on co-occurrence will be used by the Environmental Protection Agency (EPA) to determine the level of overlap in regulatory requirements, for example, in cases where treatment technologies applied for one regulation may resolve monitoring and/or additional treatment needs for another regulation. This information may also be used to show where specific levels of one contaminant may interfere with the treatment technology for another.

This study constitutes a follow-on effort to work performed in 1994 under Work Assignment (WA) 5 of EPA Contract 68-C3-0365 and 1998 under WA 0-25 of EPA Contract 68-C6-0059. Under the 1994 WA, SAIC supported EPA in analyzing the distribution of arsenic co-occurrence with other inorganic constituents.

The first step in the analysis was the selection of a database that contains all the constituents. The amount of data (sample size) for each constituent should be large enough for any meaningful statistical analysis to be valid. There exists several national level water quality databases that contain historical contaminant occurrence data. This work focused on the examination of three primary databases: (1) the USGS NWIS databases (surface and groundwater), (2) National Ambient Arsenic Occurrence database (consists of USGS groundwater data for arsenic samples and other constituents), and (3) the EPA State Radon Occurrence database. The conclusion of this assessment was to focus solely on the USGS NWIS database since it contained both ground and surface water data, it was national in scope, and provided latitude/longitude coordinates for monitoring stations that could be used in subsequent analyses to associate monitoring stations with public water supply systems. The NWIS database represents raw water samples.

The primary constituents of interest include: Arsenic, Sulfate, Radon, Radium, Uranium, and Nitrate. The secondary constituents include: Antimony, Barium, Beryllium, Cadmium, Chromium, Cyanide, Iron, Manganese, Mercury, Nickel, Nitrite, Selenium, Thallium, hardness and total dissolved solids.

The next step in this study was the determination of the level of analysis. In other words, whether the analysis should be performed at the observation point or at the observation station level? A single station may have more than one observation, based on the time at which these samples were taken. Some stations have only a single observation. The stations with multiple observations can be reduced to a single observation by making assumptions about how to aggregate the data. The application of these assumptions are part of the data normalization process to create a uniform co-occurrence database.

Many sets of analyses were performed to determine the best options for this analysis and to also develop a co-occurrence analysis protocol. The following steps describe the protocol;

- Single constituent counts: determines constituents with no detect data
- Histograms: determines constituents below minimum threshold level
- Co-occurrence counts: determines number of stations where both constituents co-occur
- Data reduction based on sample size: filter detect co-occurrence stations based on sample size.
- Correlation coefficients were calculated for all combinations of primary and secondary constituents at all threshold levels. Calculation of the correlation coefficient and associated P-value was used as a screening technique to filter out constituents which do not co-occur on a statistically significant basis. Calculations were made separately for ground water and surface water on both a national and regional basis.
- Statistical Analysis: bivariate or multivariate analysis based on the problem to be solved, i.e. is the co-occurrence of two constituents of concern or is the co-occurrence of multiple constituents the issue.

Based on this protocol, the following results were obtained;

- There were 862 possible co-occurring pairs for ground water and 780 possible co-occurring pairs for surface water, based on the available data in the NWIS database.
- Out of the above possible combinations, there are 44 co-occurring pairs for ground water and 26 pairs for surface water that have enough data for valid statistical analysis.
- Sulfate occurs most frequently with other constituents - 13 constituents each for ground water and surface water.
- On a percentage basis, for ground water, sulfate occurs most frequently with ferrous iron (54.72%) and Uranium-235 (50.47%).
- On a percentage basis, for surface water, sulfate occurs most frequently with ferrous iron (74.01%) and total manganese (54.28%)
- From a spatial perspective and where both constituents occur above their respective threshold levels, manganese and iron is the most wide spread co-occurring pair in ground water. This pair occurs in 537 counties. For surface water, sulfate and manganese is the most wide spread co-occurring pair. This pair occurs in 376 counties.
- For ground water, pairs with correlation coefficient greater than 0.8 occur in EPA Regions 1, 3, 4, 5, 7, 8, 10 (Table ES-1) and for surface water in the Regions 3, 5, 6, 8, 9, 10 (Table

ES-2). The results also show that usually metals and sulfate have very high correlation both in surface water and ground water.

Table ES-1: EPA Regions where Correlation Coefficients for Co-occurring Pairs are >0.8 (Ground Water)

Region	Constituent	Co-occurring Constituent
1	Total Arsenic	Total Iron
3	Diss. Sulfate Diss. Manganese	Total Manganese, Diss Manganese Diss. Nickel
4	Total Iron	Dissolved Manganese
5	Diss. Sulfate Total Iron Diss. Iron Diss. Manganese	Total Iron, Diss. Iron, Ferrous Iron, Total Manganese, Diss. Manganese, Diss. Nickel Total Manganese, Diss. Manganese Total Manganese, Diss. Manganese, Diss. Nickel Diss. Nickel
7	Diss. Sulfate	Diss. U-235
8	Diss. Sulfate Total Iron Diss. Manganese	Total Iron, Total Manganese Total Manganese Diss. Nickel
10	Diss. Sulfate Diss. Cadmium Diss. Iron Diss. Manganese	Diss. Cadmium, Diss. Manganese, Diss. Nickel Diss. Manganese Diss. Nickel Diss. Nickel

Table ES-2: EPA Regions where Correlation Coefficients for Co-occurring Pairs are >0.8 (Surface Water)

Region	Constituent	Co-occurring Constituent
3	Diss. Sulfate	Diss. Iron, Total Iron, Ferrous Iron
5	Total Iron Diss. Iron	Total Manganese, Diss. Manganese Total Manganese
6	Total Iron	Total Manganese
8	Ferrous Iron	Dissolved Manganese
9	Diss. Sulfate	Total Manganese
10	Total Iron	Total Manganese

1. INTRODUCTION

Constituents occur in ground water and surface water either naturally or by man-made activities. The fate and transport of these constituents is effected by various hydro-geochemical factors. The co-occurrence of these constituents is also dependent on different hydrogeochemical factors. This section discusses the purpose of this study, a summary of the previous work performed for co-occurrence, and background information on various parameters and the databases used for the study.

1.1 Purpose

The purpose of this analysis is to determine whether specific primary (arsenic, sulfate, uranium, radium, radon, nitrate), and secondary (antimony, barium, beryllium, cadmium, chromium, cyanide, iron, manganese, mercury, nickel, nitrite, selenium, thallium, hardness, total dissolved solids), drinking water contaminants co-occur on a statistically significant basis or if the co-occurrence is purely a random phenomenon. The information on co-occurrence will be used by the Environmental Protection Agency (EPA) to determine the level of overlap in regulatory requirements, for example, in cases where treatment technologies applied for one regulation may resolve monitoring and/or additional treatment needs for another regulation or where water supplies may incur costs for installing multiple treatments to address other co-occurring substances. This information may also be used to show where specific levels of one contaminant may interfere with the treatment technology for another.

For studying the question, "Is co-occurrence random with concentration?", there are different issues that need to be addressed. The main issue is the selection of a database that contains enough data for all the constituents of interest. There are different databases maintained by the EPA and the USGS. The selected database should have data in large enough size to support meaningful statistical analysis. To support this co-occurrence study, the following analyses were performed;

- The development of a protocol for the co-occurrence analysis.
- Level of analysis: observation points vs. observation stations.
- The sample size selection criteria.
- Data reduction methodology
- The effect of national level and regional level analysis on co-occurrence
- The effect of well depth on co-occurrence
- The spatial distribution of co-occurring pairs.
- Hydrogeochemical literature search for co-occurrence observations

1.2 Previous Work

This study constitutes a follow-on effort to work performed in 1994 under Work Assignment (WA) 5 of EPA Contract 68-C3-0365 and 1998 under WA 0-25 of EPA Contract 68-C6-0059. Under this 1994 WA, SAIC supported EPA in analyzing the distribution of arsenic co-occurrence with other inorganic constituents.

Under the 1998 WA, SAIC performed various analyses and the reports documenting this work have been previously submitted to EPA. The following is a summary of the work performed and the results in all the reports submitted.

SAIC September 1998 Report: This report contains analysis of three water-quality databases for use in co-occurrence analysis and initial statistical analyses for the primary constituents (arsenic, sulfate, uranium, radium, radon, and nitrate) of concern. Also, included in the report were a literature search to identify studies related to the co-occurrence of these constituents and hydrogeochemical description of the primary constituents..

SAIC January 1999 Report: In the follow-on analysis, documented in this report, the focus of the effort was on identifying, and locating actual co-occurrence data for the primary constituents and the determination of significant correlations of co-occurrence. The correlations were also performed for primary constituent concentrations versus well depth. The correlations were also calculated depending on national and regional level data. This was necessary to see any regional trends in the correlation and to document the difference between national and regional co-occurrence observations.

SAIC May 1999 Report: This report contains information on primary (arsenic, sulfate, uranium, radium, radon, nitrate), secondary (antimony, barium, beryllium, cadmium, chromium, cyanide, iron, manganese, mercury, nickel, nitrite, selenium, thallium), and ancillary (hardness, total dissolved solids) constituents of concern. All correlation analysis were performed for national and regional levels for all constituents together. In addition to the correlations, the following analysis were also performed;

- Frequency counts for observation points
- Single occurrence frequency counts (observation points)
- Co-occurrence frequency counts (observation points)
- Frequency counts for observation stations
- Constituent occurrence with depth
- Hydrogeochemical description of secondary constituents

In addition to these reports, two progress summary reports were also submitted in April 1999 and August 1999.

1.3 Background

1.3.1 Drinking Water Regulations

The 1996 Safe Drinking Water Act Amendments directed EPA's Office of Ground Water and Drinking Water (OGWDW) to meet several regulatory initiatives with near-term deadlines. This included final regulations for the Interim Enhanced Surface Water Treatment Rule (December 1998), Stage I Disinfectants and Disinfection Byproducts Rule (December 1998), and Ground Water Disinfection Rule (August 1999), and proposed regulations for Radon (August 1999) and Arsenic (January 1, 2000). EPA was already working from mandates from the 1986 amendments to regulate uranium and revise regulations for radium, gross alpha emitters, beta emitters, and photon emitters.

EPA must consider cost when establishing national primary drinking water regulations, and the amendments added several major stipulations. First, EPA must compare the reduction in health risks (benefits) against the cost of implementing the regulation. Second, EPA must consider any increase in health risks that occur in complying because of changes in co-occurring contaminants. Third, EPA must account for benefits of reducing co-occurring contaminants due to compliance with the new Maximum Contaminant Level (MCL). Finally, EPA must eliminate double counting benefits that result from compliance with other proposed or final regulations.

A National Primary Drinking Water Regulation (NPDWR) is an enforceable standard that controls the level of a specific contaminant that can adversely affect health and is known or anticipated to occur in drinking water. In order to achieve this standard, EPA first sets a non-enforceable Maximum Contaminant Level Goal (MCLG) at a level that protects against health risks. Then EPA establishes an MCL or a Treatment Technique under the NPDWR for a contaminant. A Treatment Technique can be established in lieu of an MCL for contaminants that cannot be measured accurately at levels of public health concern. EPA also develops requirements for monitoring, treatment technologies, and analytical methods for the contaminant as part of the NPDWR.

In deriving MCLs or treatment techniques, EPA evaluates the availability and performance of various technologies for removing the contaminant, the ability of laboratories to measure the contaminant accurately and consistently, the performance reliability of available analytical methods, and the health risks associated with various contaminant levels. These analyses require study of the occurrence of the contaminant in systems, the size of the systems, the range of the concentrations of the contaminant in systems, and the cost of adding treatment to achieve the MCL.

1.3.2 Constituents of Concern

The constituents analyzed have been partitioned into two groups (primary and secondary), based on EPA priorities. The primary constituents include: Arsenic, Sulfate, Radon, Radium, Uranium, and Nitrate. The secondary constituents include: Antimony, Barium, Beryllium, Cadmium, Chromium, Cyanide, Iron, Manganese, Mercury, Nickel, Nitrite, Selenium, Thallium, hardness, and total

dissolved solids. An additional set of ancillary parameters includes: Turbidity, Conductance, Dissolved Oxygen, pH, Alkalinity, Well Depth, Depth Below Land. These ancillary parameters were selected for use as indicators of hydrogeologic and geochemical conditions that could influence the co-occurrence of specific constituents.

1.3.3 Threshold Values

Based on technical direction provided by the EPA, the following threshold values were used in the statistical analysis of co-occurrence (Tables 1-1 and 1-2).

Table 1-1. Primary Constituent Threshold Levels

Constituent	Threshold	Units
Arsenic – dissolved, total	2, 5, 10, 20	UG/L
Sulfate - dissolved	25, 120, 150, 250, 500	MG/L
Radium -226	3, 4	PCi/L
Radon - 222	100, 300, 500, 1000, 3000	PCi/L
Nitrate - N	8, 10	MG/L
Uranium 235	5, 20, 50, 60	PCi/L
Uranium 238	5, 20, 50, 60	PCi/L

Table 1-2. Secondary Constituent Threshold Levels

Constituent	Threshold	Units
Antimony - dissolved, total	6	UG/L
Barium - dissolved, suspended, total	2000	UG/L
Beryllium – dissolved, total	4	UG/L
Cadmium – dissolved, total	5	UG/L
Chromium – dissolved, hexaval, total	100	UG/L
Cyanide – total, dissolved	0.2	MG/L
Iron – suspended, total, dissolved, ferrous	300,500	UG/L
Manganese – suspended, total, dissolved	50	UG/L
Mercury – dissolved, total	2	UG/L
Nickel – dissolved, total	100	UG/L
Nitrite - N	1	MG/L
Selenium – total, dissolved	50	UG/L
Thallium – dissolved, total	2	UG/L
Hardness – total	300	MG/L
Total Dissolved solids	500	MG/L

1.3.4 Databases

Contaminant occurrence data are available from several sources. The U.S. Geological Survey (USGS) has extensive data from raw surface and ground water, along with documented analytical methodologies. These data are maintained in the National Stream Quality Accounting Network (NASQAN) and the National Water Information System (NWIS). EPA maintains the Storage and Retrieval System (STORET), which contains data from States, EPA, and other government agencies. EPA conducted the Rural Water Survey between 1978 and 1980, covering 648 supplies, 474 of which were ground water supplies. The National Organics Monitoring Survey (NOMS) was conducted by EPA from 1976 to 1977 and provides information on treated water data from 1976 and 1977. The National Inorganics and Radionuclides Survey (NIRS), conducted by EPA in 1984-1986, consists of finished drinking water samples. In addition, regulated contaminants are tracked for compliance purposes in the Safe Drinking Water System (SDWIS), indicating systems that exceed MCLs. Finally, States and other groups keep monitoring data. Quality of the data, detection levels, and reasons for sampling vary extensively among the databases. No single database provides all the data needed for regulatory analysis of co-occurrence of primary constituents.

1.3.4.1 USGS NWIS Database

As documented in the final draft report, "Co-occurrence of Drinking Water Contaminants" (January 27, 1999), under EPA contract Number 68-C6-0059, Work Assignment Number 1-25, there exists several national level water quality databases that contain historical contaminant occurrence data. Prior work, documented in the above mentioned report, focused on the examination of three primary databases:

- Extracts from the USGS NWIS databases (surface and ground water)
- National Ambient Arsenic Occurrence database (consists of USGS ground water data for arsenic samples and other constituents), and
- The EPA State Radon Occurrence database.

An assessment of each of these databases was previously conducted and reported on in the January, 1997 report. The conclusion of this assessment was to focus solely on the USGS NWIS database since it contained both ground and surface water data, it was national in scope, and provided latitude/longitude coordinates for monitoring stations that could be used in subsequent analyses to associate monitoring stations with public water supply systems. The NWIS data represents raw water samples across the U.S for both ground water and surface water.

There are several other occurrence databases, such as NIRS, NOMS, and STORET, which contain historical monitoring data. NIRS and NOMS databases were not used due to their limited sample size, limited ability to perform specific geographic analyses, lack of data currency, and lack of metadata. STORET data was not used because of the lack of metadata, variability in analytical

methods used across agencies contributing data, and the decrease in the frequency of USGS updates. In addition, USGS data were obtained directly, thus there was no need to extract it from STORET.

The NWIS contains a water quality data storage retrieval system developed by the USGS Water Resources Division. NWIS is a distributed water database in which data can be processed over a network of computers at USGS offices throughout the U.S. The system comprises the Automated Data Processing System, the Ground-Water Site Inventory System, the Water-Quality System, and the Water-Use Data System. Within NWIS, a logical water-quality database consists of a water-quality file (WQFILE), a station file (SITEFILE), and shared parameter reference files (USGS, 1997a). These three files were delivered, in ASCII format, by the USGS, for each of the fifty states. For each state, a set of NWIS ASCII files (WQFILE, SITEFILE, and parameter reference file) were processed through three Statistical Analysis Systems (SAS) programs to convert the ASCII files to dBase files based on the file layout listed in the January report.

2. METHODOLOGY

This section deals with the methodology used for performing the co-occurrence analysis. The methodology section is divided into three sub-sections as follows: Conventions Applied, Analysis Performed, and Literature Search. The convention sub-section describes the assumptions made to perform the analyses and interpret results. The analysis sub-section discusses the type of analysis performed for the observations points and observation stations.

2.1 Conventions Applied

The NWIS database contains data in a format that can not be used directly for the analysis. Several conventions, as described in this section, were applied to the database. There were separate conventions for observation points (section 2.1.1) and observation stations (section 2.1.2).

2.1.1 Observation Points

There are 146,529 observation point data for ground water and 339,043 observation point data for surface water in the NWIS database.

2.1.1.1 Average Data for More Than One Entry

All statistics were computed on the daily mean values rather than the original raw data. Daily mean values were used as some stations reported multiple measurements for a parameter in one day. The majority of these measurements were taken hours apart and sometimes minutes apart.

2.1.1.2 Sample Counts

As a preliminary data analysis step, counts of observations (observation data and observation stations) were made to determine the sample size of the various co-occurrence combinations. The purpose of these counts was to indicate the actual sample size available for statistical analysis. The following procedure was applied for the counts;

- Constituent 1 missing/constituent 2 present
- Constituent 1 present/ constituent 2 missing
- Constituent 1 present/ constituent 2 present.

Where both constituents are present, the observation counts were further subdivided into three categories:

- Both constituent detected
- One or the other constituents not detected
- Both constituents not detected.

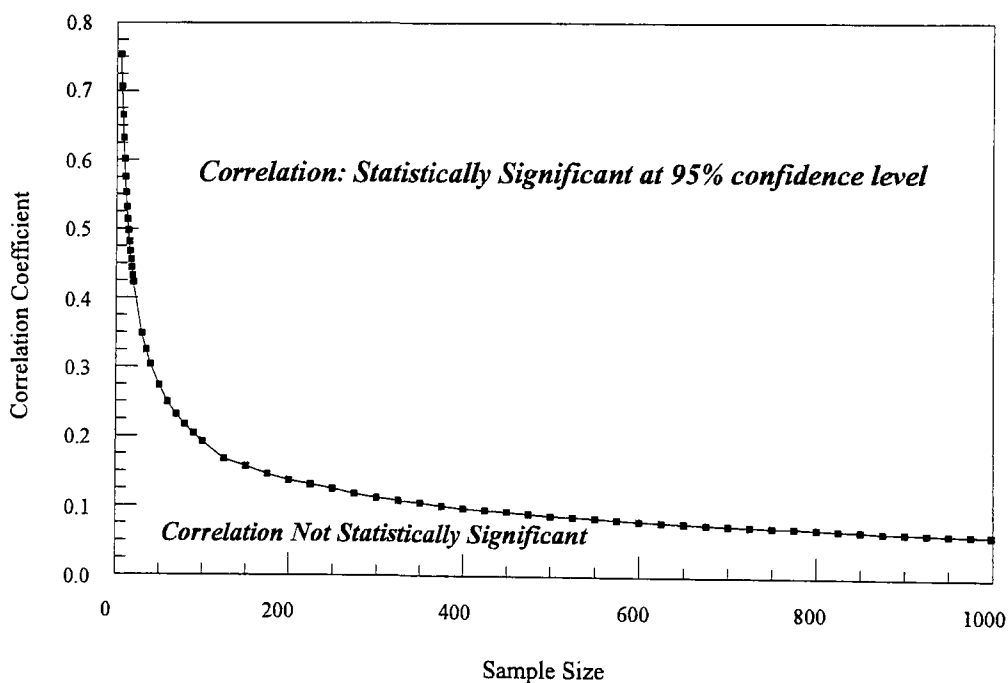
2.1.1.3 Pearson Correlation Coefficient (r)

The Pearson Correlation Coefficient is a measure of the degree of linear relationship between two variables (Hoel, 1971). Correlation calculations enable the identification of the degree of association between two measures.

The Pearson correlation coefficient ranges from -1 to 1 . -1 and 1 indicates the strongest amount of association. The sign of the correlation (+, -) defines the direction of the relationship, either positive or negative. A positive correlation coefficient means that as the value of one variable increases, the value of the other variable increases; a negative sign indicates the opposite effect.

In the correlation coefficient calculations, the first step is to determine when a value of r is large enough, numerically, to refute the possible claim that x and y are actually uncorrelated variables. The hypothesis of no correlation between x and y would be accepted unless the magnitude of r exceeded a critical value of r . The values plotted in Figure 2-1 are from Murdoch and Barnes, 1974. The data plotted in this Table is the critical value of r at the 95% confidence level. If the value of r for a sample size falls below the curve then r is not reliable. Reliable values of r lie above the curve.

Figure 2-1. Critical Value of r (95% confidence level)



2.1.1.4 Pearson Correlation Probability (P-value)

The Pearson Correlation Probability (P-value) associated with the Pearson Correlation Coefficient (r) indicates whether the coefficient may be deemed statistically significant from zero. P-value is checked prior to accepting the coefficient value. If the P-value is less than 0.05 then the correlation coefficient value is deemed to be meaningful (see the following web site for more information on P-value; <http://www.edsm.ulst.ac.uk/minitab/correlation.html>). If the P-value is large, it means that the correlation is essentially zero. All results are reported at the 95% confidence interval.

2.1.2 Observation Stations

The NWIS database contains monitoring data for each observation station. Some stations have more than one data point (different dates or different times in the same day).

2.1.2.1 Conversion of data to observation stations

The first step in the analysis was to convert observation points to observation stations. The data in the NWIS database occur in different combinations of parameters measured. The following assumptions (Table 2-1) address all the possible combinations. These assumptions were used to convert the data from observation points to observation stations. This yielded 27,760 observation stations for ground water and 13,930 observation stations for surface water.

Table 2-1. Assumptions for Conversion from Observation Points to Stations

Observation	Value	Action	Count as
Single observation	Detect		Detect
Single observation	Non-Detect		Non-Detect
Single observation	Missing		Missing
Homogeneous Measurements			
Multiple Observations	All values detect	Computes Average	Detect
Multiple Observations	All values non-detect		Non-Detect
Multiple Observations	All values missing		Missing
Mixed Measurements			
Multiple Observations	Detect & Missing	Average of detects	Detect
Multiple Observations	Non-detect & Missing		Non-detect
Multiple Observations	Detects & Non-detects	½ of Reporting Limit of Non-detects Average of detects and non-detects	Detect
Multiple Observations	Detect, Non-Detect, & Missing	½ of Reporting Limit of Non-detects Average of detects and non-detects	Detect

2.1.2.2 Sample Size

The sample size determination is often based on best professional judgement. The subjective answer will be based on an objective approach, dependent on a number of factors, including the desired statistical power and level of confidence in the final decision and the variability of the environmental attribute of interest (US EPA 1999). The selection of a sample size is influenced by a number of factors, including the purpose of the study, population size, the risk of selecting a “bad sample”, and the allowable sampling error.

Correlation is one of the principal forms of analysis to investigate co-occurrence of the constituents. It is important to detect a correlation that is considered to be a significant indicator of co-occurrence. Two types of errors must be considered when conducting a statistical test to examine co-occurrence, Type I (false positive) and Type II (false negative), with probabilities α and β respectively. Type I errors lead to mis-identifying co-occurrence when it does not exist. Type II errors lead to mis-identifying no co-occurrence when it does exist. The probability of Type I error, α , is specified by the investigator. However, the probability that a significant result will be obtained if a real difference exists (i.e. the power of the test, $1 - \beta$) depends largely on the total sample size.

In other words, the power of a test refers to its ability to detect what we are looking for, i.e., the co-occurrence of two constituents. The definition of statistical power is $1 - \beta$, i.e., the probability of correctly rejecting the null hypothesis (correctly identifying a correlation). To calculate the largest possible sample size necessary, we use a test value of 50% which produces the largest possible variance. This is also known as the “most pessimistic variance assumption”.

Given the test of $H_0: \rho=0$ versus $H_a: \rho=\rho_1$, the sample size required to ensure a power = $1 - \beta$ with Type I error = α can be computed by solving the following equation (Lachin, 1981):

$$[(N-3)^{0.5}] * C(\rho_1) = Z_{\alpha} + Z_{\beta}$$

where $C(\rho_1) = \frac{1}{2} \log_e[(1 + \rho_1)/(1 - \rho_1)]$

Z_{α} = 1.645 if α is equal to 0.05 (i.e. at 95% confidence interval)

Z_{β} = 1.645 if power is 0.95

N = Sample Size

Using this formula, the required sample size (N) can be computed with the ρ_1 value, Type I error and pre-defined power.

If it is desired to ensure a 95% chance of detecting (power = 0.95) a moderate correlation ($\rho_1 = 0.5$) with the 95% confidence interval ($\alpha = 0.05$), the sample size required is 39.

2.2 Analysis

2.2.1 Statistical Analysis for Observation Points (Previous Work)

There are approximately 500,000 data points in the NWIS database for primary and secondary constituents. This includes multiple entries for the same station. As discussed below three sets of analyses were performed for all primary and secondary constituents. The results for the observation points are documented in the May 1999 report to the EPA (SAIC May, 1999).

- **Single constituent count:** As per EPA's technical direction, single constituent counts were performed for all primary and secondary constituents. Threshold values used for these constituents are listed in Table 1-1 and 1-2. This analysis was performed as a screening level approach to determine the abundance and distribution of constituents prior to performing co-occurrence counts as described below. It gives information about the data available above or below a threshold level for that constituent. Examination of this data provides an initial screening technique to reduce the number of co-occurrence tables to be generated later.
- **Scatter Plot:** Scatter plots were generated for each constituent. These plots were generated to discern whether there is any pronounced relationship, and if so, whether the relationship is linear. These plots were delivered previously at the March 24, 1999 project meeting.
- **Calculation of Correlation Coefficient and P-value:** Pearson Correlation Coefficients and associated P-values for combinations of primary and secondary constituents were calculated. These analyses were done separately for ground water and surface water on both a national and regional level.
- **Co-occurrence frequency counts:** Co-occurrence counts of the primary constituents with other selected constituents were performed as per EPA's technical direction. This analysis was performed to see how much data lies above or below a particular range of values for the selected constituents. The ranges of values used for arsenic are shown in Table 2-3.

In addition, a set of co-occurrence counts was created separately for ground and surface water. for the following sets of constituent pairs using the threshold values indicated above;

- SO₄ – Uranium, Radium, Radon, Nitrate, Iron, Manganese, Hardness, Total Dissolved Solids (TDS), Nitrite.
- Uranium – Radium, Radon, Nitrate, Iron, Manganese, Hardness, TDS, Nitrite.
- Radium – Radon, Nitrate, Iron, Manganese, Hardness, TDS, Nitrite.
- Radon - Nitrate, Iron, Manganese, Hardness, TDS, Nitrite

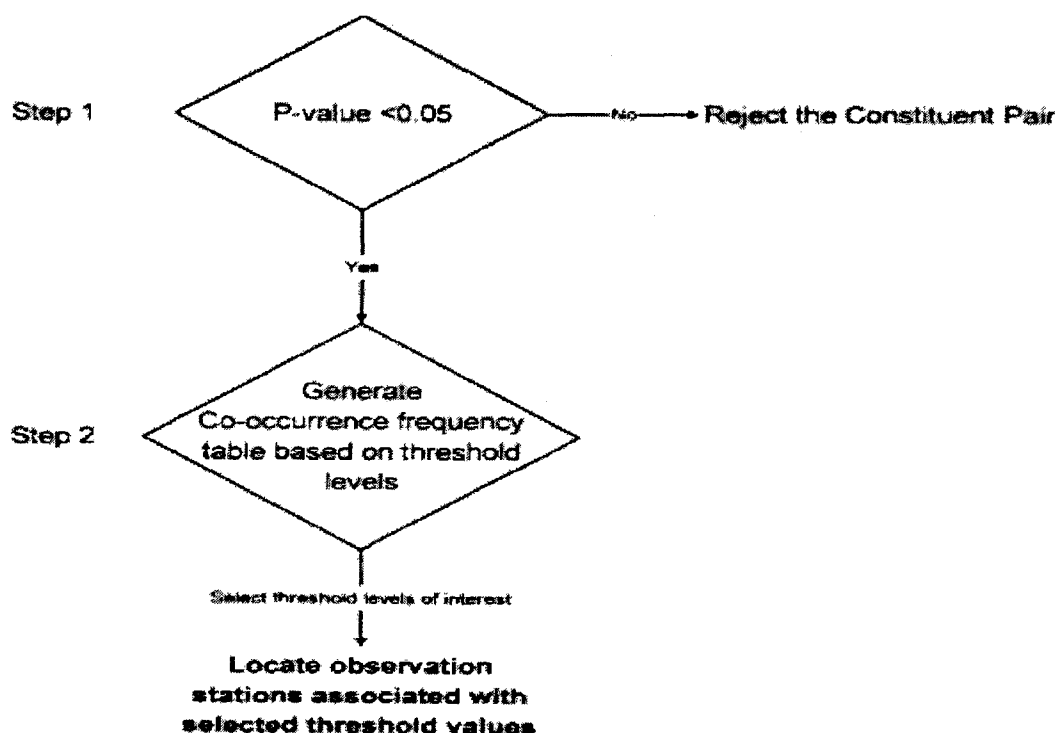
Table 2-2: Parameters and threshold intervals used in the co-occurrence frequency tables

Arsenic Threshold Levels	Constituent	Constituent Threshold Levels
ND, D-2, 2-5, 5-10, 10-20, >20 ug/L	Sulfate	ND, -25, 25-120, 120-250, 250-500, >500 MG/l)
	Uranium	ND, D-5, 5-20, 20-50, 50-60, >60 Pci/l
	Radium-226	ND, D-2, 2-3, 3-4, 4-5, >5 Pci/l
	Radon	ND, D-100, 100-300, 300-1000, 1000-3000, >3000 Pci/l
	Nitrate	ND, D-5, 5-8, 8-10, >10 MG/l
	Iron	ND, D-.3, .3-1.5, 1.5-2.5, >2.5 MG/l
	Manganese	ND, D-20, 20-50, >50 ug/l
	Hardness	ND, D-300, >300 MG/l
	T.S.	ND, D-500, >500 MG/l
	Nitrite	ND, D-1, >1 MG/l
	Antimony	ND, D-.006, >.006 MG/l
	Barium	ND, D-2, >2 MG/l
	Beryllium	ND, D-.004, >.004 MG/l
	Cadmium	ND, D-.005, >.005 MG/l
	Chromium	ND, D-.1, >.1 MG/l
	Cyanide	ND, D-.2, >.2 MG/l
	Mercury	ND, D-.002, >.002 MG/l
	Nickel	ND, D-.05, >.05 MG/l
	Selenium	ND, D-.05, >.05 MG/l
	Thallium	ND, D-.002, >.002 MG/l

Note: ND = non-detect (value below detection level),
D = detect (value above detection level)

An analysis flow chart, as shown below (see Figure 2-2), was developed to ultimately determine systems impacted by different threshold values. Data are filtered through each step, and in the end gives number of drinking water systems impacted by a threshold value. In step 1, constituent co-occurrence is filtered based on significant correlation coefficients. If a constituent pair passes through this filter, then a co-occurrence frequency table is generated. These frequency tables show the percentage of observations in various threshold categories. These tables were delivered in the SAIC May 1999 report.

Figure 2-2. Co-occurrence Analysis Flow Chart



2.2.2 Frequency Counts for Observation Stations

There are 27,760 observation stations for ground water and 13,930 stations for surface water in the NWIS database. This current report focuses on two types of analysis;

- Single constituent counts
- Pairwise constituent counts

Three types of analysis were performed on the observation stations.

2.2.2.1 Histograms

Histograms were generated to see the distribution of contaminants in stations for different percentages. Histograms were created to see a distribution of detect stations for 10%, 25%, 50%, 75%, 90%, and >90% intervals. In other words, what is the concentration of constituents for 0-10% of the detect stations. This gives a complete distribution of concentration of contaminants for various station percentages.

2.2.2.2 Sample Size Determination

Using the methodology discussed in the section 2.1.2.2, a minimum sample size of 39 was used for the analysis. This sample size was used for data reduction as discussed in the sub-section 2.2.2.3. Any co-occurring pair with sample size <39 was not considered for further analysis.

2.2.2.3 Data Reduction

Data reduction is necessary to focus on those constituents which have a proper sample size. Further analysis for these constituents may yield meaningful results. Data in the analysis were reduced by the following three factors;

- If the number of stations in the single constituent count is zero then do not use these constituents for further analysis.
- In co-occurring pairs, if all the stations are below the minimum threshold values of the constituents or the station count is zero, then do not use these constituents for further analysis.
- If the co-occurring constituent pair has a station count less than 39 stations, then do not use those constituents for further analysis.

2.3 Literature Search

An automated literature search was performed using the DIALOG database search engine. The databases searched are listed in table 2-3.

Table 2-3. Databases Used for Literature Search

Databases	Period of Analysis	Copyright and Publisher
Ei Compendex(R)	1970-1998/Jul W2	© 1998 Engineering Info. Inc
<i>CAB Abstracts</i>	1972-1998/May	© 1998 CAB International
<i>BIOSIS PREVIEWS(R)</i>	1969-1998/JUN W2	© 1998 BIOSIS
<i>Water Resour. Abs.</i>	1967-1998/Apr	© 1998 Cambridge Scientific Abs.
<i>WATERNET(TM)</i>	1971-1998/Q2	© 1998 American Water Works Association
<i>Wilson Appl. Sci & Tech</i>	1983-1998/May	Abs© 1998 The HW Wilson Co.
<i>AGRICOLA</i>	1970-1998/May	© format only 1998 The Dialog Corp.
<i>Toxline(R)</i>	1965-1998/Apr	© format only 1998 The Dialog Corp.
<i>EMBASE</i>	1974-1998/Jun W1	© 1998 Elsevier Science B.V.
<i>Enviroline(R)</i>	1975-1998/May	© 1998 Congressional Information Service
<i>Pollution Abs</i>	1970-1998/May	© 1998 Cambridge Scientific Abstracts
<i>Energy SciTec</i>	1974-1998/May B2	© 1998 Contains copyrighted material
<i>NTIS</i>	64-1998/Jul W1	Comp&distr 1998 NTIS, Intl Copyright All Right
<i>GEOBASE(TM)</i>	1980-1998/Apr	© 1998 Elsevier Science Ltd.
<i>Pascal</i>	1973-1998/May	© 1998 INIST/CNRS

The key words used in the literature search are shown in the table 2-4. The numbers shown to the left of the keyword are the number of hits associated with the keyword combination. A list of titles was generated and scanned for potentially relevant articles. Abstracts were obtained for these articles. These abstracts were filtered for relevance and full articles were obtained for each pertinent document. Each of these articles were reviewed. Information was extracted into a MS Access database. A hardcopy of this database was previously delivered to the EPA (SAIC 1998 Report)

Table 2-4. Key Words and Number of Hits Found in Database Literature Search

Search #	Number of Hits	Key Words
S1	13291	<i>CO(1W)OCCUR? OR COOCCUR</i>
S2	286	<i>SI AND (CONTAMINANT OR POLLUTANT)</i>
S3	25	<i>SI AND (DRINKING OR POTABLE)(2N)WATER</i>
S4	11	<i>SI AND ANTIMONY</i>
S5	6	<i>SI AND ASBESTOS</i>
S6	12	<i>SI AND BARIUM</i>
S8	39	<i>SI AND CADMIUM</i>
S9	43	<i>SI AND CHROMIUM</i>
S10	21	<i>SI AND MERCURY</i>
S11	1437	<i>SI AND NICKEL</i>
S12	17	<i>SI AND NITRITE</i>
S13	123	<i>SI AND NITRATE</i>
S14	2	<i>SI AND RADIUM</i>
S15	8	<i>SI AND SELENIUM</i>
S16	1	<i>SI AND THALLIUM</i>
S17	29	<i>SI AND CYANIDE</i>
S18	2	<i>SI AND RADON</i>
S19	37	<i>SI AND ARSENIC</i>
S20	13	<i>SI AND RADIONUCLIDE</i>
S21	123	<i>SI AND SULFATE</i>
S22	18	<i>SI AND URANIUM</i>
S23	43	<i>SI AND MICROBES</i>
S24	3	<i>SI AND CRYPTOSPORIDIUM</i>
S25	1	<i>SI AND BERYLLIUM</i>

3. RESULTS

This section presents the statistical results for the co-occurrence of the primary and secondary constituents. The discussion includes the results based on observation points and the stations. The detailed results for the observation points covering a total of 22 constituents (7 primary and 15 secondary) were discussed in the May 21 report submitted to the EPA. Each constituent was analyzed at one or more threshold levels. The SAIC May 1999 report contained results for the following analyses;

- Single occurrence frequency counts for observation stations
- Co-occurrence frequency counts for observation stations
- Co-occurrence frequency counts for observation stations
- Constituent occurrence with depth
- Correlation coefficient calculations for observation points

National Level

- Overall correlation coefficient results for ground water and surface water
- Overall correlation coefficient results for ground water and surface water at different threshold values
- Statistically significant correlation coefficient results for ground water and surface water

Regional Level

- Overall correlation coefficient results for ground water and surface water
- Overall correlation coefficient results for ground water and surface water at different threshold values
- Statistically significant correlation coefficient results for ground water and surface water

3.1 Observation Stations

This section covers results not previously documented in past reports. It covers analyses related to observation stations. A key point about each observation station is there is variability in the number of parameters and values associated with each station. Some stations have single values and others have more than one value. To be consistent, all the stations should have some uniformity. To achieve this, multiple observations were reduced to single observations. This reduction methodology and assumptions were explained in sub-section 2.2.1. Two types of analysis, single constituent counts and co-occurring pair counts were performed for the observation station data. The main objective of this analysis was to see:

- Which constituents co-occur together and what is there spatial distribution?
- Is the sample size of the co-occurring pair large enough for statistical tests?

3.1.1 Single Constituent Counts:

Single constituent counts were performed to yield a first look at the data and also tell us which constituents should be considered for pair-wise analysis. It reveals the sample size of the constituents and whether it is large enough to warrant further analysis. Table 3-1 and 3-2 describe the single count results. Table 3-1 lists results for ground water and Table 3-2 for surface water. Each table gives the number of detect, non-detect, and missing stations for a particular constituent. There are a total of 27,760 stations for ground water and 13,930 stations for surface water. The largest number of detect stations are for sulfate for both ground water (15,214) and surface water (6,823). The largest number of non-detect stations are for nitrite-N dissolved for ground water (10,740) and for dissolved cadmium for surface water (1,897). The constituents with zero detect stations were not used for further analysis in the pairwise counts.

Table 3-1 and 3-2 also gives the concentrations of constituents for different percentages of detect stations only. The percentage distribution ranges are 0-10%, 10-25%, 25-50%, 50-75%, 75-90%, and 90-100% of the detect stations. These percentages show how many constituents have stations below a particular threshold or how many stations are in a quartile. This distribution also shows the constituents with all the detect stations below a minimum threshold value. This is part of the screening criteria for further statistical analysis.

There were a total of 51 constituents (primary and secondary) in ground water and surface water. Out of these 51 constituents, 9 constituents in ground water and 11 constituents in surface water have no detect stations. In other words there is no data. As shown in Table 3-1 and 3-2, these constituents with zero detect stations were in suspended mode (e.g. suspended arsenic). There were 4 constituents in ground water and 9 constituents in surface water where all the stations were below the minimum threshold value even though data was present as detected values for these constituents. It was observed that all the stations had maximum concentration of the constituent lower than the minimum threshold value. The threshold values are given in Table 1-1 and Table 1-2. Table 3-3 summarizes the results from these initial observations of the data in table 3-1 and 3-2.

Table 3-3: Summary Table for Single Counts

Counts	Ground Water	Surface Water
Total Constituents	51	51
Constituents with zero detect stations	9	11
Constituents with all stations below the minimum threshold value	4	9
Remaining Constituents	38	31

3. Results

Table 3-1: Single Station Counts for Groundwater

Parameter		Distribution Percentage						Station Counts			Thres hold
Code	Name	0%-10%	10%-25%	25%-50%	50%-75%	75%-90%	90%-100%	Detects	Non- detects	Missing	Values
00613	Nitrite-N Diss, mg/l as N	.0006-.006	.006-.01	.01-.012	.012-.022	.02-.06	.06-5.4	3307	10740	13713	1
00615	Nitrite-N Total, mg/l as N	.001-.0057	.0057-.0075	.0075-.01	.01-.02	.02-.043	.043-.26	101	351	27308	1
00618	Nitrate mg/l	.001-.08	.08-.4	.4-1.65	1.65-5.14	5.14-12.55	12.55-1600	3392	91	24277	8
00720	Total Cyanide, mg/l	.001-.001	.001-.0075	.0075-.0075	.0075-.0125	.0125-.021	.021-.03	22	287	27451	0.2
00723	Diss. Cyanide, mg/l	0-0	0-.001	.001-.113	.113-3.4	3.4-31	31-280	31	1144	26585	0.2
00945	Diss. Sulfate, mg/l	0-2.4	2.4-8.13	8.13-26	26-87.5	87.5-310	310-37000	15214	443	12103	25
01000	Diss. Arsenic, ug/l	.525-1	1-2	2-4	4-10	10-25	25-3800	4028	3095	20637	2
01001	Susp. Arsenic, ug/l	-	-	-	-	-	-	0	0	27760	2
01002	Total, Arsenic, ug/l	.531-1	1-2	2-3	3-16	16-51	51-1400	329	442	26989	2
01005	Dissol. Barium, ug/l	1-7.55	7.55-19	19-42	42-91	91-193	193-10000	5478	381	21901	2000
01006	Susp Barium, ug/l	100	-	-	-	-	-	1	1	27758	2000
01007	Total Barium, ug/l	0-0	0-0	0-100	100-200	200-400	400-10000	377	212	27171	2000
01010	Diss Beryllium, ug/l	.1-.342	.342-.5	.5-.7	.7-1.1	1.1-3.5	3.5-388	279	4086	23395	4
01012	Total Beryllium, ug/l	.346-.36	.36-.5	.5-.66	.66-1	1-2.4	2.4-9.6	36	313	27411	4
01025	Diss Cadmium, ug/l	.066-.562	.562-.875	.875-1.1	1.1-2.58	2.58-7.15	7.15-5675	569	5816	21373	5
01026	Susp Cadmium, ug/l	-	-	-	-	-	-	0	0	27760	5
01027	Total Cadmium, ug/l	0-.6	.6-1	1-2	2-9.75	9.75-30	30-80	70	612	27078	5
01030	Diss chromium, ug/l	.571-1	1-1.7	1.7-3	3-5.1	5.1-9.5	9.5-27300	2428	3991	21341	100
01031	Susp chromium, ug/l	-	-	-	-	-	-	0	0	27760	100
01032	Hexval chromium, ug/l	.562-1	1-1.8	1.8-3.58	3.58-8.71	8.71-18	18-234.57	167	208	27385	100
01034	Total chromium, ug/l	.75-1	1-2	2-4	4-10.08	10.08-43.78	43.78-420	328	351	27081	100
01044	Susp Iron ug/l	140	-	-	-	-	1100	2	0	27758	300
01045	Total Iron, ug/l	0-22.5	22.5-80	80-560	560-4006.6	4006.6-19000	19000-910000	1184	112	26464	300
01046	Diss Iron, ug/l	0-4	4-8	8-29	29-370	370-2600	2600-2040000	10399	3810	13551	300

3. Results

01047	Ferrous Iron, ug/l	0-.1	.1-20	20-810	810-2600	2600-66500	66500-500212	140	10	27610	300
01054	Susp Manganese, ug/l	1.33	-	1.66	-	-	55	3	1	27756	50
01055	Total manganese, ug/l	0-10	10-30	30-110	110-500	500-1900	1900-160000	919	294	26547	50
01056	Diss manganese, ug/l	.14-2	2-6	6-36.66	36.66-200	200-758	758-1065000	9833	4222	13705	50
01057	Diss Thallium, ug/l	1.1-1.2	1.2-1.5	1.5-7.875	7.875-11	11-14.01	14.01-18	20	535	27205	2
01059	Total Thallium, ug/l	.83-1	1	1	1	2	2	8	186	27566	2
01065	Diss Nickel, ug/l	.56-1	1-2	2-3	3-7	7-20	20-23800	1927	2595	23238	100
01066	Susp Nickel, ug/l	0	0	0	0	0	0	0	0	27760	100
01067	Total Nickel, ug/l	.625-.93	.93-2	2-6	6-23.33	23.33-82	82-590	160	213	27387	100
01095	Diss Antimony, ug/l	.625-1	1-1	1-2	2-3	3-6	6-198	87	2528	25145	6
01097	Total Antimony, ug/l	.56-.625	.625-.75	.75-1	1-2	2-18.1	18.1-94	35	204	27521	6
01145	Diss Selenium, ug/l	0-1	1-1	1-2	2-5	5-18.8	18.8-27000	1309	4249	22202	50
01146	Susp Selenium, ug/l	0	0	0	0	0	0	0	0	27760	50
01147	Total Selenium, ug/l	.53-.678	.678-1	1-2	2-3	3-6	6-31	122	420	27218	50
04106	Radium-228 pci/g	0	0	0	0	0	0	0	0	27660	3
04107	Radium-226 pci/g	0	0	0	0	0	0	0	0	27660	3
09507	Radium-226, total, pci/l	0	0	0	0	0	0	0	0	27660	3
09510	Radium-226, diss, pci/l	.1-.1	.1-2	.2-9	.9-2.2	2.2-6.2	6.2-31	45	54	27661	3
09511	Radium-226, diss, pci/l	.06-.08	.08-.17	.17-.52	.52-2	2-3.9	3.9-14	118	2	27640	3
22603	U-238, diss, pci/l	.1-.33	.33-1	1-7.5	7.5-20	20-160	160-75333.3	97	12	27651	5
22620	U-235, diss, pci/l	.1-2	.2-3	.3-6	.6-1.3	1.3-40	40-587.4	63	46	27651	5
71890	Hg, diss, ug/l	0-.05	.05-.1	.1-.1	.1-2	.2-.6	.6-5.5	233	1806	25721	2
71895	Hg, susp, ug/l	0	0	0	0	0	0	0	0	27760	2
71900	Hg, Tot. Rec., ug/l	.01-.075	.075-.1	.1-.154	.154-.75	.75-1.3	1.3-3.4	78	445	27237	2
76001	Radium-226, diss, pci/l	.003-.03	.03-.053	.053-.105	.105-.34	.34-.64	.64-6.14	215	2	27543	3
76002	Radon-222, pci/l	7-18	18-21	21-27	27-37	37-50	50-250	4506	2	23252	100
82303	Radon-222, total, pci/l	7-150	150-277	277-500	500-978	978-2100	2100-82082	4519	69	23172	100

3. Results

Table 3-2: Single Station Counts for Surface water

Parameter		Distribution Percentage						Station Counts			Thres hold
Code	Name	0%-10%	10%-25%	25%-50%	50%-75%	75%-90%	90%-100%	Detects	Non- detects	Missing	Values
00613	Nitrite-N Diss, mg/l as N	.0007-.006	.006-.008	.008-.0137	.0137-.03	.03-.063	.063-2.48	4187	1696	8047	1
00615	Nitrite-N Total, mg/l as N	.0007-.006	.006-.001	.001-.017	.017-.03	.03-.07	.07-8.73	1406	395	12129	1
00618	Nitrate mg/l	.001-.071	.071-.21	.21-.63	.63-2.01	2.01-5.05	5.05-365	4070	45	9815	8
00720	Total Cyanide, mg/l	.0006-.001	.001-.0038	.0038-.0055	.0055-.007	.007-.01	.01-1.204	155	360	13415	0.2
00723	Diss. Cyanide, mg/l	.01-.01	.01-3.5	53.5-7	7-10.5	10.5-12.6	12.6-35	14	57	13859	0.2
00945	Diss. Sulfate, mg/l	.009-3.45	3.45-8.18	8.18-28	28-120	120-520	520-64000	6823	14	7093	25
01000	Diss. Arsenic, ug/l	.51-.83	.83-1.25	1.25-2.75	2.75-6	6-21	21-32000	1314	566	12050	2
01001	Susp. Arsenic, ug/l	-	-	-	-	-	-	0	0	13930	2
01002	Total, Arsenic, ug/l	.52-.71	.71-1.	1.-2.08	2.08-4.5	4.5-11	11-256.5	944	400	12586	2
01005	Diss. Barium, ug/l	1-13	13-23.5	23.5-41	41-66	66-99	99-475	2183	36	11711	2000
01006	Susp Barium, ug/l	-	-	-	-	-	-	0	0	13930	2000
01007	Total Barium, ug/l	0-0	0-42.6	42.6-74.2	74.2-100	100-200	200-3000	482	176	13272	2000
01010	Diss Beryllium, ug/l	.26-.295	.295-.386	.386-.55	.55-.8	.8-3.46	3.46-176	251	1349	12330	4
01012	Total Beryllium, ug/l	.37-.5	.5-.52	.52-.56	.56-.701	.701-1.01	1.01-55.71	187	699	13044	4
01025	Diss Cadmium, ug/l	.022-.15	.15-.537	.537-.75	.75-1.61	1.61-4	4-2000	563	1897	11470	5
01026	Susp Cadmium, ug/l	-	-	-	-	-	-	0	0	13930	5
01027	Total Cadmium, ug/l	0-.5	.5-.58	.58-1	1-1.75	1.75-4.47	4.47-80	407	1359	12164	5
01030	Diss chromium, ug/l	.22-.6	.6-.81	.81-1.49	1.49-2.67	2.67-4	4-325.2	760	1498	11672	100
01031	Susp chromium, ug/l	-	-	-	-	-	-	0	0	13930	100
01032	Hexval chromium, ug/l	.51-.52	.52-.54	.54-.57	.57-.66	.66-.68	.68-.88	18	30	13882	100
01034	Total chromium, ug/l	.52-.75	.75-1.31	1.31-3	3-5.2	5.2-12	12-240	1009	550	12371	100
01044	Susp Iron ug/l	-	-	-	-	-	-	0	0	13930	300
01045	Total Iron, ug/l	0-110	110-313.33	313.33-823	822.9-2445	2445-9300	9300-2750000	1963	7	11960	300
01046	Diss Iron, ug/l	.1-6.8	6.8-17	17-45.625	45.625-158	158-750	750-2480000	5001	419	8510	300

3. Results

01047	Ferrous Iron, ug/l	0-130	130-290	290-990	990-10000	10000-49300	49300-2280000	125	2	13803	300
01054	Susp Manganese, ug/l	1.25	-	-	-	-	1.75	2	0	13928	50
01055	Total manganese, ug/l	0-20.5	20.5-54.58	54.58-150	150-565	565-3527	3527-160000	1805	39	12086	50
01056	Diss manganese, ug/l	.048-3	3-8.1	8.1-26	26-103.5	103.5-485.4	485.4-151000	5052	296	8582	50
01057	Diss Thallium, ug/l	.39	-	-	-	-	.4	2	75	13853	2
01059	Total Thallium, ug/l	.54-.58	.58-.75	.75-1	1-1	1-1.33	1.33-1.5	29	254	13647	2
01065	Diss Nickel, ug/l	.53-.687	.687-1.035	1.035-2.1	2.1-5.52	5.52-12	12-12560.9	1148	959	11823	100
01066	Susp Nickel, ug/l	-	-	-	-	-	-	0	0	13930	100
01067	Total Nickel, ug/l	.54-.83	.83-1.75	1.75-4	4-10.3	10.3-18.5	18.5-790	1021	274	12635	100
01095	Diss Antimony, ug/l	.22-.64	.64-1	1-2	2-4	4-8	8-281	121	753	13056	6
01097	Total Antimony, ug/l	.25-.5	.5-.75	.75-1	1-2	2-3.3	3.3-12	114	157	13659	6
01145	Diss Selenium, ug/l	0-.625	.625-.875	.875-2	2-5.33	5.33-22	22-2833.3	907	1426	11597	50
01146	Susp Selenium, ug/l	-	-	-	-	-	-	0	0	13930	50
01147	Total Selenium, ug/l	.3-.6	.6-.78	.78-1.625	1.625-4.5	4.5-21	21-5800	330	903	12697	50
04106	Radium-228 pci/g	-	-	-	-	-	-	0	0	13930	
04107	Radium-226 pci/g	-	-	-	-	-	-	0	0	13930	3
09507	Radium-226, total, pci/l	-	-	-	-	-	-	0	0	13930	3
09510	Radium-226, diss, pci/l	.1	-	-	-	-	.11	2	6	13922	3
09511	Radium-226, diss, pci/l	.01-.03	.03-.045	.045-.072	.072-.12	.12-.2	.2-2.3	129	2	13799	3
22603	U-238, diss, pci/l	.12-.17	.17-.6	.6-1.1	1.1-3.7	3.7-5	5-12	17	4	13909	5
22620	U-235, diss, pci/l	.1	.2	.2	.2	.5	.6	6	15	13909	5
71890	Hg, diss, ug/l	0-.056	.056-.062	.062-.075	.075-.112	.112-.2	.2-25.02	378	764	12788	2
71895	Hg, susp, ug/l	-	-	-	-	-	-	0	0	13930	2
71900	Hg, Tot. Rec., ug/l	.025-.052	.052-.06	.06-.075	.075-.1	.1-.2	.2-6.65	477	785	12668	2
76001	Radium-226, diss, pci/l	.005-.01	.01-.014	.014-.02	.02-.03	.03-.049	.049-.375	133	2	13795	3
76002	Radon-222, pci/l	15.6-18	18-21	21-31	31-37	37-55.5	55.5-330	65	0	13865	100
82303	Radon-222, total, pci/l	36.5-64.5	64.5-152	152-271	271-420	420-679.5	679.5-3300	64	1	13865	100

3.1.2 Co-occurring Pairwise Counts

For the co-occurring pair counts only those constituents that had non zero detect stations in the single constituent counts were used. Appendix A (ground water) and B (surface water) show the distribution of co-occurring pairs counts. Co-occurrence counts show the amount of data available for statistical analyses. At this point, it does not mean that there is a significant statistical co-occurrence. Both the appendices have three columns;

- Column 1 (Co-occurring pairs): This column lists the number of stations where two constituents co-occur.
- Column 2 (Pairs above the threshold values): This column lists the number of stations where both the constituents are above the threshold value. The threshold values are given in table 1 and 2. Only non-zero station counts are listed.
- Column 3 (Pairs above count): This column lists the pairs with station count greater than 39. The selection of 39 as sample size is described in the section 2.1.2.2.

Appendices A and B shows that sulfate occurs most frequently with other constituents. Sulfate co-occurs with 13 constituents in ground water and 13 constituents in surface water. On a percentage basis, for ground water, sulfate occurs most frequently with ferrous iron (54.72%) and Uranium-235 (50.47%). On a percentage basis, for surface water, sulfate occurs most frequently with ferrous iron (74.01%) and total manganese (54.28%) The table 3-4 summarizes the results from Appendices A and B.

Table 3-4: Summary Table for Co-occurrence Counts

Pairs	Ground Water	Surface Water
Total Co-occurring Pairs	862	780
Pairs with zero detect stations	232	164
Pairs with zero stations above threshold value	353	435
Pairs with station count <39	233	155
Remaining Co-occurring Pairs	44	26

Table 3-5: Percentage of Detect Co-occurring Constituents (Ground Water)

Constituent X	Constituent Y	# of Measured Stations	# of Detect Stations	Percentage of Detect Stations
P00618 Nitrate	P00945 Diss. Sulfate	2859	301	10.5
	P01000 Diss. Arsenic	1353	69	5.09
	P01056 Diss. Manganese	2449	133	5.43
	P82303 Total Radon-222	615	113	18.37
P00945 Diss. Sulfate	P01000 Diss. Arsenic	6818	2004	29.39
	P01002 Total Arsenic	469	77	16.41
	P01025 Diss. Cadmium	6104	72	1.17
	P01045 Total Iron	1020	282	27.64
	P01046 Diss. Iron	13522	1299	9.60
	P01047 Ferrous Iron	148	81	54.72
	P01055 Total Manganese	941	249	26.46
	P01056 Diss. Manganese	13352	2280	17.07
	P01065 Diss. Nickel	4249	67	1.57
	P01145 Diss. Selenium	5348	50	0.93
	P22620 Diss. U-235	105	53	50.47
	P82303 Total Radon-222	4085	1764	43.18
P01000 Diss. Arsenic	P01002 Total Arsenic	184	56	30.43
	P01046 Diss. Iron	6812	453	6.65
	P01056 Diss Manganese	6879	854	12.41
	P82303 Total Radon-222	2578	1013	39.29
P01002 Total Arsenic	P01045 Total Iron	541	107	19.77
	P01046 Diss. Iron	269	57	21.18
	P01055 Total Manganese	543	99	18.23
	P01056 Diss. Manganese	330	67	20.30
P01025 Diss. Cadmium	P01046 Diss. Iron	6131	50	0.81
	P01056 Diss. Manganese	6245	63	1.00
P01045 Total Iron	P01046 Diss. Iron (300)	682	223	32.69
	P01047 Ferrous Iron	109	78	71.55
	P01055 Total Manganese	1182	488	41.28
	P01056 Diss. Manganese	724	216	29.83
	P82303 Total Radon-222	168	52	30.95
P01046 Diss. Iron	P01047 Ferrous iron	148	86	58.18
	P01055 Total Manganese	656	181	27.59
	P01056 Diss. Manganese	13907	2082	14.97
	P01065 Diss Nickel	4348	52	1.19
	P82303 Total Radon-222	4045	533	13.17
P01047 Ferrous Iron	P01056 Diss. Manganese	90	60	66.67
	P01065 Diss Nickel	148	70	47.29
P01055 Total Manganese	P01056 Diss. Manganese	709	261	36.81
	P82303 Total Radon-222	187	49	26.20
P01056 Diss. Manganese	P01065 Diss Nickel	4441	64	1.44
	P82303 Total Radon-222	4047	854	21.10
P22620 Diss. U-235	P82303 Total Radon-222	87	46	52.87
P76002 Radon -222 Diss	P82303 Total Radon-222	4507	44	0.97

Table 3-6: Percentage of Detect Co-occurring Constituents (Surface Water)

Constituent X	Constituent Y	# of Measured Stations	# of Detect Stations	Percentage of Detect Stations
P00618 Nitrate	P00945 Diss Sulfate	3114	66	2.11
P00945 Diss Sulfate	P01000 Diss. Arsenic	1702	624	36.66
	P01002 Total Arsenic	1173	342	29.15
	P01025 Diss Cadmium	2195	39	1.77
	P01045 Total Iron	1700	845	49.70
	P01046 Diss. Iron	5139	401	7.80
	P01047 Ferrous Iron	127	94	74.01
	P01055 Total Manganese	1612	875	54.28
	P01056 Diss. Manganese	5046	1179	23.36
P01000 Diss. Arsenic	P01002 Total Arsenic	498	195	39.15
	P01045 Total Iron	450	106	23.55
	P01055 Total Manganese	412	101	24.51
	P01056 Diss. Manganese	1590	248	15.59
P01002 Total Arsenic	P01045 Total Iron	982	304	30.95
	P01055 Total Manganese	896	256	28.57
	P01056 Diss. Manganese	754	118	15.64
P01045 Total Iron	P01046 Diss. Iron	1504	399	26.52
	P01047 Ferrous Iron	115	88	76.52
	P01055 Total Manganese	1802	1216	67.48
	P01056 Diss. Manganese	1493	705	47.22
P01046 Diss. Iron	P01047 Ferrous Iron	127	94	74.01
	P01055 Total Manganese	1458	378	25.92
	P01056 Diss. Manganese	5255	659	12.54
P01047 Ferrous Iron	P01055 Total Manganese	118	89	75.42
	P01056 Diss Manganese	127	94	74.01
P01055 Total Manganese	P01056 Diss. Manganese	1459	799	54.76

As shown in Table 3-4, out of 862 co-occurring pairs for ground water only 44 pairs co-occur above threshold levels and with station counts above the statistically acceptable level. For surface water, out of 780 pairs only 26 pairs meet this criteria. These pairs were selected based only on the number of detect stations.

Percentage detect stations with respect to measured stations is given in table 3-5 (ground water) and 3-6 (surface water). For ground water, the maximum detect percentage is for total iron and ferrous iron (71.55%) and minimum percentage is for sulfate and dissolved selenium (1%). There are only six constituent pairs (dissolved sulfate and ferrous iron, dissolved sulfate and dissolved U-235, total iron and ferrous iron, dissolved iron and ferrous iron, ferrous iron and dissolved manganese, and dissolved U-235 and total radon-222) that have detect percentage above 50%. Similarly, for surface water, the maximum detect percentage is for total iron and ferrous iron (76.52%) and the minimum is for sulfate and dissolved cadmium (1.77%). There are only seven constituent pairs (dissolved

sulfate and ferrous iron, dissolved sulfate and total manganese, total iron and ferrous iron, total iron and total manganese, dissolved iron and ferrous iron, ferrous iron and total manganese, ferrous iron and dissolved manganese) having detect percentage above 50%.

3.1.3 Distribution of Constituents:

Table 3-7 (ground water) and 3-8 (surface water) summarize the distribution of the constituent pairs on a county basis. Only the selected co-occurring pairs, based on the data reduction steps applied, (shown in Table 3-5 and 3-6) were used for the county distribution analysis. These tables show the number of counties where both the co-occurring pairs are above minimum threshold. From a spatial perspective and where both constituents occur above their respective threshold levels, manganese and iron is the most wide spread co-occurring pair. This pair occurs in 537 counties in ground water and 308 counties in surface water. This distribution is the first step in understanding the linkage of data with the public water systems.

Table 3-9 (ground water) and 3-10 (surface water) show measured, detect, and percentage detect of co-occurring pairs on a county basis. When computing percentages on a county basis, the detect percentage is very high for both ground water and surface water. For ground water, there are only four (dissolved sulfate and dissolved cadmium, dissolved sulfate and dissolved selenium, dissolved cadmium and dissolved iron, and dissolved cadmium and dissolved manganese) co-occurring constituent pairs below 50% detect and only one co-occurring constituent pair (dissolved sulfate and dissolved cadmium) for surface water. The probability of detection is very high in the counties where these co-occurring constituent pairs are measured.

3.1.4 Statistical Analysis

A detailed correlation coefficient analysis was performed for the co-occurring constituents selected from the data reduction steps previously outlined. Tables 3-11 (ground water, national), 3-12 (surface water, national), 3-13 (ground water, regional), and 3-14 (surface water, regional) show statistically significant co-occurring pairs based on the Pearson correlation coefficients for the observation points associated with the observation stations.

**Table 3-7: Spatial Distribution Summary of Co-occurring Constituents by County
(Ground Water)***

Constituent X	Constituent Y	Thresh- hold level	Total # of Detect Counties	# of counties with both constituent above threshold value	# of counties with both constituents below threshold value	# of counties with only X above threshold value & Y below	# of counties with only Y above threshold value & X below
P00618 Nitrate(8)	P00945 Diss. Sulfate	25	454	125	126	29	174
	P01000 Diss. Arsenic	2	145	35	14	3	93
	P01002 Total Arsenic	2	16	2	6	1	7
	P01025 Diss. Cadmium	5	48	4	31	6	7
	P01027 Total Cadmium	5	3	0	1	0	2
	P01045 Total Iron	300	30	4	8	3	15
	P01046 Diss. Iron	300	401	43	178	67	113
	P01055 Total Manganese	50	23	2	7	2	12
	P01056 Diss. Manganese	50	424	97	120	31	176
	P22620 Diss. U-235	5	2	0	0	2	0
	P82303 Total Radon-222	100	206	60	2	0	144
P00945 Diss. Sulfate (25)	P01000 Diss. Arsenic	2	325	227	15	21	62
	P01002 Total Arsenic	2	58	33	1	8	16
	P01025 Diss. Cadmium	5	111	27	29	53	2
	P01027 Total Cadmium	5	15	5	3	5	2
	P01045 Total Iron	300	124	58	22	14	30
	P01046 Diss. Iron	300	970	437	206	203	124
	P01055 Total Manganese	50	107	45	20	17	25
	P01056 Diss. Manganese	50	934	502	160	128	144
	P22620 Diss. U-235	5	12	1	0	11	0
	P82303 Total Radon-222	100	561	312	17	4	228
P01000 Diss. Arsenic (2)	P01002 Total Arsenic	2	23	18	2	2	1
	P01025 Diss. Cadmium	5	54	13	9	31	1
	P01027 Total Cadmium	5	3	1	0	2	0
	P01045 Total Iron	300	16	10	0	4	2
	P01046 Diss. Iron	300	303	167	14	102	20
	P01055 Total Manganese	50	13	9	1	2	1
	P01056 Diss. Manganese	50	306	195	17	70	24
	P22620 Diss. U-235	5	10	1	0	9	0
	P82303 Total Radon-222	100	179	154	1	1	23
P01002 Total Arsenic (2)	P01025 Diss. Cadmium	5	8	3	2	2	1
	P01027 Total Cadmium	5	12	5	2	4	1
	P01045 Total Iron	300	47	34	2	7	4
	P01046 Diss. Iron	300	36	21	5	7	3
	P01055 Total Manganese	50	42	29	3	7	3
	P01056 Diss. Manganese	50	36	18	5	10	3
	P22620 Diss. U-235	5	1	0	0	1	0

3. Results

Constituent X	Constituent Y	Thresh- hold level	Total # of Detect Countries	# of counties with both constituent above threshold value	# of counties with both constituents below threshold value	# of counties with only X constituent above threshold value & Y below	# of counties with only Y constituent above threshold value & X below
	P82303 Total Radon-222	100	10	8	0	0	2
P01025 Diss. Cadmium (5)	P01027 Total Cadmium	5	6	2	4	0	0
	P01045 Total Iron	300	11	2	2	0	7
	P01046 Diss. Iron	300	111	21	51	7	32
	P01055 Total Manganese	50	12	3	3	0	6
	P01056 Diss. Manganese	50	107	26	30	2	49
	P22620 Diss. U-235	5	3	1	1	1	0
	P82303 Total Radon-222	100	29	7	0	0	22
P01027 Total Cadmium (5)	P01045 Total Iron	300	14	8	2	0	4
	P01046 Diss. Iron	300	9	2	5	0	2
	P01055 Total Manganese	50	13	7	3	0	3
	P01056 Diss. Manganese	50	10	3	4	0	3
	P22620 Diss. U-235	5	0	0	0	0	0
	P82303 Total Radon-222	100	2	0	0	0	2
P01045 Total Iron (300)	P01046 Diss. Iron (300)	300	67	35	19	13	0
	P01055 Total Manganese	50	126	74	22	20	10
	P01056 Diss. Manganese	50	63	32	12	15	4
	P22620 Diss. U-235	5	0	0	0	0	0
	P82303 Total Radon-222	100	28	9	1	0	18
P01046 Diss. Iron (300)	P01055 Total Manganese	50	58	28	18	5	7
	P01056 Diss. Manganese	50	944	537	207	66	134
	P22620 Diss. U-235	5	6	1	5	0	0
	P82303 Total Radon-222	100	489	225	12	13	239
P01055 Total Manganese (50)	P01056 Diss. Manganese	50	56	35	18	3	0
	P22620	5	1	0	0	1	0
	P82303 Total Radon-222	100	29	12	1	0	16
P01056 Diss. Manganese (50)	P22620 Diss. U-235	5	8	1	5	2	0
	P82303 Total Radon-222	100	480	267	12	10	191
P22620 Diss. U-235 (5)	P82303 Total Radon-222	100	10	1	0	0	9

* Number in parenthesis indicates the minimum threshold level.

**Table 3-8: Spatial Distribution Summary of Co-occurring Constituents by County
(Surface Water)***

Constituent X	Constituent Y	Thresh- hold level	Total # of detect Counties	# of counties with both constituents above threshold value	# of counties with both constituents below threshold value	# of counties with only X constituent above threshold value & Y below	# of counties with only Y constituent above threshold value & X below
P00618 Nitrate (8)	P00945 Diss. Sulfate	25	1050	41	424	5	580
P00945 Diss Sulfate (25)	P01000 Diss. Arsenic	2	370	216	44	79	31
	P01002 Total Arsenic	2	278	149	35	66	28
	P01025 Diss. Cadmium	5	239	16	72	150	1
	P01045 Total Iron	300	368	244	21	27	76
	P01046 Diss. Iron	300	1245	100	332	637	176
	P01047 Ferrous Iron	300	5	5	0	0	0
	P01055 Total Manganese	50	350	238	33	13	66
	P01056 Diss. Manganese	50	1241	376	335	359	171
P01000 Diss. Arsenic (2)	P01002 Total Arsenic	2	134	76	33	2	23
	P01045 Total Iron	300	118	56	9	9	44
	P01055 Total Manganese	50	106	54	8	3	41
	P01056 Diss. Manganese	50	351	115	74	114	48
P01002 Total Arsenic (2)	P01045 Total Iron	300	241	137	12	13	79
	P01055 Total Manganese	50	215	123	12	9	71
	P01056 Diss. Manganese	50	212	68	45	64	35
P01045 Total Iron (300)	P01046 Diss. Iron	300	335	60	46	229	0
	P01047 Ferrous Iron	300	3	3	0	0	0
	P01055 Total Manganese	50	374	308	20	26	20
	P01056 Diss. Manganese	50	330	175	27	117	11
P01046 Diss. Iron (300)	P01047 Ferrous Iron	300	5	5	0	0	0
	P01055 Total Manganese	50	328	50	34	9	235
	P01056 Diss. Manganese	50	1262	200	604	85	373
P01047 Ferrous Iron (300)	P01055 Total Manganese	50	4	4	0	0	0
	P01056 Diss. Manganese	50	5	5	0	0	0
P01055 Total Manganese (50)	P01056 Diss. Manganese	50	327	183	42	102	0

* Number in parenthesis indicates the minimum threshold level

3. Results

Table 3-9 Percentage of Detected Stations for Co-occurring Constituents by County (Ground Water)

Constituent X	Constituent Y	# of Counties Measured	# of Counties Detected	Percentage of Detected
P00618 Nitrate	P00945 Diss. Sulfate	458	454	99.12
	P01000 Diss. Arsenic	239	145	60.66
	P01056 Diss. Manganese	453	424	93.59
	P82303 Total Radon-222	208	206	99.03
P00945 Diss. Sulfate	P01000 Diss. Arsenic	522	325	62.26
	P01002 Total Arsenic	90	58	64.44
	P01025 Diss. Cadmium	491	111	22.60
	P01045 Total Iron	128	124	96.87
	P01046 Diss. Iron	1041	970	93.17
	P01047 Ferrous Iron	8	8	100.0
	P01055 Total Manganese	119	107	89.91
	P01056 Diss. Manganese	1033	934	90.41
	P01065 Diss. Nickel	424	326	76.88
	P01145 Diss. Selenium	478	197	41.21
	P22620 Diss. U-235	18	12	66.66
	P82303 Total Radon-222	570	561	98.42
P01000 Diss. Arsenic	P01002 Total Arsenic	30	23	76.66
	P01046 Diss. Iron	521	303	58.15
	P82303 Total Radon-222	322	179	55.59
P01002 Total Arsenic	P01045 Total Iron	80	47	58.75
	P01046 Diss. Iron	50	36	72.00
	P01055 Total Manganese	78	42	53.84
	P01056 Diss. Manganese	49	36	73.46
P01025 Diss. Cadmium	P01046 Diss. Iron	512	111	21.67
	P01056 Diss. Manganese	515	107	20.77
P01045 Total Iron	P01046 Diss. Iron (300)	67	67	100.0
	P01047 Ferrous Iron	4	4	100.0
	P01055 Total Manganese	137	126	91.97
	P01056 Diss. Manganese	64	63	98.43
	P82303 Total Radon-222	29	28	96.55
P01046 Diss. Iron	P01047 Ferrous iron	8	8	100.0
	P01055 Total Manganese	61	58	95.08
	P01056 Diss. Manganese	1071	944	88.14
	P01065 Diss Nickel	450	285	63.33
	P82303 Total Radon-222	558	489	87.63
P01055 Total Manganese	P01056 Diss. Manganese	60	56	93.33
	P82303 Total Radon-222	32	29	90.62
P01056 Diss. Manganese	P01065 Diss Nickel	453	274	60.48
	P82303 Total Radon-222	558	480	86.02
P22620 Diss. U-235	P82303 Total Radon-222	12	10	83.33
P76002 Radon-222 PE	P82303 Total Radon-222	592	589	99.49

Table 3-10: Percentage of Detected Stations for Co-occurring Constituents by County (Surface Water)

Constituent X	Constituent Y	# of Counties Measured	# of Counties Detected	Percentage of Detected Counties
P00618 Nitrate	P00945 Diss Sulfate	1053	1050	99.71
P00945 Diss Sulfate	P01000 Diss. Arsenic	478	370	77.40
	P01002 Total Arsenic	332	278	83.73
	P01025 Diss Cadmium	619	239	38.61
	P01045 Total Iron	369	368	99.72
	P01046 Diss. Iron	1266	1245	98.34
	P01047 Ferrous Iron	5	5	100.0
	P01055 Total Manganese	353	350	99.15
	P01056 Diss. Manganese	1255	1241	98.88
P01000 Diss. Arsenic	P01002 Total Arsenic	178	134	75.28
	P01045 Total Iron	159	118	74.21
	P01055 Total Manganese	153	106	69.28
	P01056 Diss. Manganese	466	351	75.32
P01002 Total Arsenic	P01045 Total Iron	294	241	81.97
	P01055 Total Manganese	269	215	79.92
	P01056 Diss. Manganese	256	212	82.81
P01045 Total Iron	P01046 Diss. Iron	339	335	98.80
	P01047 Ferrous Iron	3	3	100.0
	P01055 Total Manganese	377	374	99.20
	P01056 Diss. Manganese	335	330	98.50
P01046 Diss. Iron	P01047 Ferrous Iron	5	5	100.0
	P01055 Total Manganese	335	328	97.91
	P01056 Diss. Manganese	1286	1262	98.13
P01047 Ferrous Iron	P01055 Total Manganese	4	4	100.0
	P01056 Diss Manganese	5	5	100.0
P01055 Total Manganese	P01056 Diss. Manganese	333	327	98.19

3. Results

Table 3-11: Statistically Significant Co-occurring Pairs for Ground Water - National Level Results

Constituent	Nitrate	Sulfate Diss	Arsenic Diss	Arsenic Total	Cadmium Diss	Iron Total	Iron Diss	Iron Ferrous	Manganese Total	Manganese Diss	Nickel Diss	Selenium Diss	U-235 Diss	Radon-222	Radon-222 Total
Nitrate															
Sulfate Diss	*														
Arsenic Diss															
Arsenic Total															
Cadmium Diss		*													
Iron Total		*													
Iron Diss		*			*										
Iron Ferrous		*													
Manganese Total		*				*	*	*							
Manganese Diss		*			*	*	*	*							
Nickel Diss		*								*					
Selenium Diss		*													
U-235 Diss		*													
Radon-222		*													
Radon-222 Total		*								*					

3. Results

Table 3-12: Statistically Significant Co-occurring Pairs for Surface Water - National Level Results

Constituent	Nitrate	Sulfate Diss.	Arsenic Diss.	Arsenic Total	Cadmium Diss	Iron Total	Iron Diss.	Iron Ferrous	Manganese Total	Manganese Diss.
Nitrate										
Sulfate Diss	*									
Arsenic Diss		*								
Arsenic Total		*								
Cadmium Diss		*								
Iron Total		*		*						
Iron Diss		*								
Iron Ferrous		*								
Manganese Total		*		*		*	*			
Manganese Diss		*	*			*	*			

3. Results

Table 3-13: Statistically Significant Co-occurring Constituents Ground Water in EPA Regions

Constituent X	Constituent Y	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
P00618 Nitrate(8)	P00945 Diss. Sulfate				*				*	*	*
	P01000 Diss. Arsenic										*
	P01056 Diss. Manganese									*	
	P82303 Total Radon-222				*						
P00945 Diss. Sulfate	P01000 Diss. Arsenic	*			*					*	
	P01002 Total Arsenic										
	P01025 Diss. Cadmium		*	*	*	*	*	*		*	*
	P01045 Total Iron		*			*			*		
	P01046 Diss. Iron			*		*	*		*		*
	P01047 Ferrous Iron					*					
	P01055 Total Manganese		*	*		*			*		
	P01056 Diss. Manganese	*		*		*	*		*	*	*
	P01065 Diss. Nickel		*	*	*	*	*	*	*		*
	P01145 Diss Selenium			*	*	*		*	*	*	*
	P22620 Diss. U-235							*	*		*
	P82303 Total Radon-222										*
P01000 Diss. Arsenic	P01002 Total Arsenic										
	P01046 Diss. Iron							*			
	P82303 Total Radon-222						*				
P01002 Total Arsenic	P01045 Total Iron	*			*	*		*			
	P01046 Diss. Iron										
	P01055 Total Manganese				*	*					
	P01056 Diss. Manganese			*			*				
P01025 Diss. Cadmium	P01046 Diss. Iron	*			*	*		*		*	*
	P01056 Diss. Manganese			*	*	*	*	*	*	*	*
P01045 Total Iron	P01046 Diss. Iron										

3. Results

Constituent X	Constituent Y	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
	P01047 Ferrous Iron										
	P01055 Total Manganese	*	*		*	*	*	*	*		*
	P01056 Diss. Manganese		*		*	*	*	*	*		*
	P82303 Total Radon-222										*
P01046 Diss. Iron	P01047 Ferrous iron										
	P01055 Total Manganese			*		*	*	*	*	*	
	P01056 Diss. Manganese		*	*	*	*	*	*	*	*	*
	P01065 Diss Nickel			*	*	*			*		*
	P82303 Total Radon-222										*
P01055 Total	P01056 Diss. Manganese										
	P82303 Total Radon-222										
P01056 Diss.	P01065 Diss Nickel		*	*	*	*	*		*	*	*
	P82303 Total Radon-222										*
P22620 Diss. U-235	P82303 Total Radon-222										
P76002 Radon-222	P82303 Total Radon-222										

3. Results

Table 3-14: Statistically Significant Co-occurring Constituents Surface Water in EPA Regions

Constituent X	Constituent Y	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
P00618 Nitrate (8)	P00945 Diss Sulfate	*	*		*	*			*	*	*
P00945 Diss Sulfate	P01000 Diss. Arsenic	*						*	*	*	
	P01002 Total Arsenic	*								*	*
	P01025 Diss Cadmium				*	*	*		*	*	*
	P01045 Total Iron		*	*		*					
	P01046 Diss. Iron			*		*			*	*	
	P01047 Ferrous Iron			*					*		
	P01055 Total	*	*	*	*	*			*	*	
	P01056 Diss.	*		*		*			*	*	*
P01000 Diss. Arsenic	P01002 Total Arsenic										
	P01045 Total Iron							*			
	P01055 Total		*					*	*		
	P01056 Diss.							*			
P01002 Total Arsenic	P01045 Total Iron										
	P01055 Total										
	P01056 Diss.										
P01045 Total Iron	P01046 Diss. Iron										
	P01047 Ferrous Iron										
	P01055 Total	*		*	*	*	*	*	*	*	*
	P01056 Diss.	*	*	*	*	*			*		*
P01046 Diss. Iron	P01047 Ferrous Iron										
	P01055 Total		*	*	*	*		*	*		
	P01056 Diss.	*	*	*	*	*	*	*	*	*	*
P01047	P01055 Total										
	P01056 Diss								*		
P01055 Total	P01056 Diss.										

4. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this analysis was to determine whether specific primary (arsenic, sulfate, uranium, radium, radon, nitrate) and secondary (antimony, barium, beryllium, cadmium, chromium, cyanide, iron, manganese, mercury, nickel, nitrite, selenium, thallium, hardness, total dissolved solids) drinking water contaminants co-occur on a statistically significant basis or if the co-occurrence is purely a random phenomenon. This section deals with the conclusions of this study based on the interpretation of analytical results and also recommendations for future work.

4.1 Conclusions

All the data for analysis was extracted from the USGS NWIS (surface and ground water) database. The conclusions in this report mainly focus on the statistical analysis of the NWIS observations as aggregated into station.

The following conclusions were drawn from the analysis;

4.1.1 Databases

- The NWIS is a good repository of information that can be used for co-occurrence analysis. It covers all the inorganic constituents of interest.
- For specific constituents of concern, there is enough data to draw meaningful conclusions about co-occurrence. and has enough data for any meaningful statistical analysis.
- For this project a total of 22 constituents (7 primary and 15 secondary) were analyzed. Several constituents had both total and dissolved forms. Thus, there were total 51 constituents analyzed both for ground water and surface water.

4.1.2 Datasets

All the analyses were performed at two levels of details: observation points and observation stations. A single station may have more than one observation point based on time. These observations were made independent of time as discussed in sub-section 2.1.2.1 by aggregating them on a station basis. The main advantage of aggregating the observation points into stations was to allow each station to be treated equally, since the sampling efforts at each station were not the same.

4. Conclusions and Recommendations

4.1.3 Observation Points

The details of the observation point analyses are documented in the previous reports submitted to the EPA. These analyses included; national and regional correlation coefficient calculations, well depth analysis, distribution of ancillary parameters, generation of scatter plots, and calculation of co-occurrence frequency tables.

- A total of 9,912 co-occurrence combinations (based on multiple threshold levels) were analyzed on a national level using observation points data. The screening techniques applied to the correlation coefficients resulted in 1860 statistically significant pairs (based on P-value < 0.05). The screening results for the regional analysis showed the following statistics: 98,185 combinations (based on a multiple threshold levels considered in each of 10 EPA Regions) and 7,152 statistically significant pairs based on P-value.

4.1.4 Observation Stations

The following conclusions have been drawn from the analysis of the observation station data.

- There were 862 possible co-occurring pairs for ground water and 780 possible co-occurring pairs for surface water, based on the available data in the NWIS database.
- Out of the above possible combinations, there are 44 co-occurring pairs for ground water and 26 pairs for surface water that have enough data for valid statistical analysis. Table 4-1 and 4-2 show the co-occurring pairs for ground water and surface water respectively.
- Sulfate occurs most frequently with other constituents - 13 constituents each for ground water and surface water.
- On a percentage basis, for ground water, sulfate occurs most frequently with ferrous iron (54.72%) and Uranium-235 (50.47%). For surface water, sulfate occurs most frequently with ferrous iron (74.01%) and total manganese (54.28%)
- From a spatial perspective and where both constituents occur above their respective threshold levels, manganese and iron is the most wide spread co-occurring pair in ground water. This pair occurs in 537 counties. For surface water, sulfate and manganese is the most wide spread co-occurring pair. This pair occurs in 376 counties.
- For ground water, pairs with correlation coefficient greater than 0.8 occurs in EPA Region 1, 3, 4, 5, 7, 8, 10 and for surface water in the Regions 3, 5, 6, 8, 9, 10 as shown in Table 4-3 and 4-4. It also shows that usually metals and sulfate have very high correlation both in surface water and ground water.

4. Conclusions and Recommendations

Table 4-1: Final Co-occurring Pairs Selected based on the data reduction steps (Ground Water)*

	Nitrate	Sulfate Diss.	Arsenic Diss.	Arsenic Total	Cadmium Diss.	Iron Total	Iron Diss.	Iron Ferrous	Manganese Total	Manganese Diss.	Nickel Diss.	Selenium Diss.	U-235 Diss.	Radon- 222	Radon- 222 Total
Nitrate		301	69							133					113
Sulfate Diss	301		2004	77	72	282	1299	81	249	2280	67	50	53		1764
Arsenic Diss	69	2004		56			453			854					1013
Arsenic Total		77	56			107	57		99	67					
Cadmium Diss		72					50			63					
Iron Total		282		107			223	78	488	216					52
Iron Diss		1299	453	57	50	223		86	181	2082	52				533
Iron Ferrous		81				78	86		60	70					
Manganese Total		249		99		488	181	60		261					49
Manganese Diss	133	2280	854	67	63	216	2082	70	261		64				854
Nickel Diss		67					52			64					
Selenium Diss		50													
U-235 Diss		53													46
Radon-222															44
Radon-222 Total	113	1764	1013			52	533		49	854			46	44	

* Number of stations where both constituents were detected above the minimum threshold level

4. Conclusions and Recommendations

Table 4-2: Final Co-occurring Pairs Selected based on the data reduction steps (SurfaceWater)*

	Nitrate	Sulfate Diss.	Arsenic Diss.	Arsenic Total	Cadmium Diss.	Iron Total	Iron Diss.	Iron Ferrous	Manganese Total	Manganese Diss.
Nitrate		66								
Sulfate Diss	66		624	342	39	845	401	94	875	1179
Arsenic Diss		624		195		106			101	248
Arsenic Total		342	195			304			256	118
Cadmium Diss		39								
Iron Total		845	106	304			399	88	1216	705
Iron Diss		401				399		94	378	659
Iron Ferrous		94				88	94		89	94
Manganese Total		875	101	256		1216	378	89		799
Manganese Diss		1179	248	118		705	659	94	799	

* Number of stations where both constituents were detected above the minimum threshold level

4. Conclusions and Recommendations

**Table 4-3 EPA Regions Where Correlation Coefficients for Co-occurring Pairs are >0.8
(Ground Water)**

Region	Constituent	Co-occurring Constituent
1	Total Arsenic	Total Iron
3	Diss. Sulfate Diss. Manganese	Total Manganese, Diss. Manganese Diss. Nickel
4	Total Iron	Dissolved Manganese
5	Diss. Sulfate Total Iron Diss. Iron Diss. Manganese	Total Iron, Diss. Iron, Ferrous Iron, Total Manganese, Diss. Manganese, Diss. Nickel Total Manganese, Diss. Manganese Total Manganese, Diss. Manganese, Diss. Nickel Diss. Nickel
7	Diss. Sulfate	Diss. U-235
8	Diss. Sulfate Total Iron Diss. Manganese	Total Iron, Total Manganese Total Manganese Diss. Nickel
10	Diss. Sulfate Diss. Cadmium Diss. Iron Diss. Manganese	Diss. Cadmium, Diss. Manganese, Diss. Nickel Diss. Manganese Diss. Nickel Diss. Nickel

**Table 4-3 EPA Regions Where Correlation Coefficients for Co-occurring Pairs are >0.8
(Surface Water)**

Region	Constituent	Co-occurring Constituent
3	Diss. Sulfate	Diss. Iron, Total Iron, Ferrous Iron
5	Total Iron Diss. Iron	Total Manganese, Diss. Manganese Total Manganese
6	Total Iron	Total Manganese
8	Ferrous Iron	Dissolved Manganese
9	Diss. Sulfate	Total Manganese
10	Total Iron	Total Manganese

4.2 Recommendations

The present analysis was limited to inorganic constituents. The statistical analysis was bivariate (correlation between two constituents) in nature. The number of public water systems that will be impacted by co-occurrence and the cost of co-occurrence for treatment was not analyzed. The following recommendations are made for future work.

4.2.1 Organic Constituents

The present work focuses only on the inorganic constituents (ground water and surface water). But both these sources contain organic constituents too. Organic constituents effect water treatment. A complete analysis of co-occurrence should include both, organic and inorganic constituents. The protocol of co-occurrence pair selection that was developed for this study can be used for organic constituents too.

The NWIS database contains information on 230 organic constituents, that covers all the constituents mandated by the EPA and other State regulations.

4.2.2 Multivariate Analysis

All constituents can co-occur with more than one other constituent. Common for all data analysis is to collect data about many samples where the characteristics vary. Traditional analysis is based on one or two variables at the time. But usually the variables interact, that is why analysis of all the variables simultaneously is necessary to reveal their relationships. This is called multivariate analysis. Multivariate analysis means using many variables to forecast, predict, or understand a situation.

Multivariate analysis is data dependent. By focusing on the constituents of interest and for which there is enough data is available, a multivariate analysis can be performed. The constituents can also be picked based on the EPA Regions.

4.2.3 Linking Public Water System

The ultimate objective of the co-occurrence analysis is to find out how many drinking water systems may be impacted by the abundance and distributions of the co-occurring constituents. This objective can be achieved by linking public water system locations with the co-occurrence data using a geographic information system (GIS). All the spatial analysis can be performed in the GIS environment. For example, GIS can be used to answer how many systems (based on the size) are impacted by the co-occurrence.

Spatial distribution of co-occurring pairs is the first step for linking PWS with the data. The second step involves the spatial distribution of PWS. The SDWIS database contains various the information

4. Conclusions and Recommendations

components needed for PWS spatial distribution. In the SDWIS database, each PWS has a latitude and longitude to link it with the co-occurrence data in GIS system

4.2.4 Cost

Once co-occurring constituents and the PWS impacted by them are known, then the cost of co-treatment can be calculated. The cost to an individual water supply for installing or upgrading a treatment technology to treat co-occurring contaminants in drinking water includes both capital costs and operation and maintenance (O&M) costs. Capital costs generally include the costs of process equipment and related structural, building, site preparation, and other construction costs (labor and material). O&M costs include direct costs of labor for operating the treatment system, the costs of chemicals, and other necessary and related indirect (overhead) costs (equipment and material). For unit treatment cost estimates, upgraded versions of the three models: the Very Small System (VSS); the WATER Model (SAIC, 1996); and the W/W COSTS Model (Culp/Wesner/Culp, 1986-1994 versions) can be used. The results of these models will be validated by careful comparison with actual constructed projects, vendor estimates, and outputs from other models.

The upgraded versions of the three models account for certain cost elements that historically have not been included in the development of unit costs. These include elements such as the availability and cost of land on which to place the treatment systems, permitting fees and pilot studies.

5. REFERENCES

Hoel, P. G., Elementary Statistics, Wiley Series in Probability and Mathematical Statistics, 1971.

Lachin, J.M., Introduction to sample size determination and power analysis for clinical trials, Controlled Clinical Trials, 2, 93-113, 1981.

Murdoch, J. and J.A. Barnes., Statistical Tables for Science, Engineering, Management and Business Studies, John Wiley and Sons, New York, 1974.

US EPA 1999, Sample size and sampling frequency estimator documentation, Beta Test (Version 0.7.2.2).

SAIC, Co-occurrence of Drinking Water Contaminants, Preliminary Draft Report, September 23, 1999.

SAIC, Co-occurrence of Drinking Water Contaminants, Final Draft Report, January 27, 1999.

SAIC, Co-occurrence of Drinking Water Contaminants, Progress Summary Report, April 12, 1999.

SAIC, Co-occurrence of Drinking Water Contaminants, Primary and Secondary Constituents Draft Report, May 21, 1999.

SAIC, Co-occurrence of Drinking Water Contaminants, Progress Summary Report, August 16, 1999.

Appendix A: Number of Stations with Co-occurring Pairs for Groundwater

(Shading shows pairs above sample size threshold)

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
P00613	00615	Nitrite-N Total, mg/l as N	13	
	00618	Nitrate mg/l	2885	8
	00720	Total Cyanide, mg/l	9	
	00723	Diss. Cyanide, mg/l	10	2
	00945	Diss. Sulfate, mg/l	2737	17
	01000	Diss. Arsenic, ug/l	780	3
	01002	Total, Arsenic, ug/l	48	
	01005	Dissol. Barium, ug/l	1057	
	01006	Susp Barium, ug/l	0	
	01007	Total Barium, ug/l	38	
	01010	Diss Beryllium, ug/l	94	3
	01012	Total Beryllium, ug/l	0	
	01025	Diss Cadmium, ug/l	160	2
	01027	Total Cadmium, ug/l	6	
	01030	Diss chromium, ug/l	519	1
	01032	Hexval chromium, ug/l	57	
	01034	Total chromium, ug/l	70	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	179	
	01046	Diss Iron, ug/l	1984	3
	01047	Ferrous Iron, ug/l	26	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	154	
	01056	Diss manganese, ug/l	2032	6
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	486	3
	01067	Total Nickel ug/L	22	
	01095	Diss Antimony, ug/l	17	
	01097	Total Antimony, ug/l	2	
	01145	Diss Selenium, ug/l	274	3
	01147	Total Selenium, ug/l	51	
	09510	Radium-226, diss, pci/l	6	
	09511	Radium-226, diss, pci/l	35	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	22603	U-238, diss, pci/l	14	
	22620	U-235, diss, pci/l	7	
	71890	Hg, diss, ug/l	78	3
	71900	Hg, Tot. Rec., ug/l	15	
	76001	Radium-226, diss, pci/l	43	
	76002	Radon-222, pci/l	633	
	82303	Radon-222, total, pci/l	623	4
P00615	00618	Nitrate mg/l	12	
	00720	Total Cyanide, mg/l	2	
	00723	Diss. Cyanide, mg/l	0	
	00945	Diss. Sulfate, mg/l	87	
	01000	Diss. Arsenic, ug/l	9	
	01002	Total, Arsenic, ug/l	25	
	01005	Dissol. Barium, ug/l	28	
	01006	Susp Barium, ug/l	0	
	01007	Total Barium, ug/l	24	
	01010	Diss Beryllium, ug/l	0	
	01012	Total Beryllium, ug/l	19	
	01025	Diss Cadmium, ug/l	5	
	01027	Total Cadmium, ug/l	17	
	01030	Diss chromium, ug/l	4	
	01032	Hexval chromium, ug/l	0	
	01034	Total chromium, ug/l	23	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	32	
	01046	Diss Iron, ug/l	35	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	25	
	01056	Diss manganese, ug/l	21	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	3	
	01065	Diss Nickel, ug/l	11	
	01067	Total Nickel ug/L	23	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	12	
	01145	Diss Selenium, ug/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01147	Total Selenium, ug/l	14	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	16	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P00618	00720	Total Cyanide, mg/l	7	
	00723	Diss. Cyanide, mg/l	17	2
	00945	Diss. Sulfate, mg/l	2715	301
	01000	Diss. Arsenic, ug/l	792	69
	01002	Total, Arsenic, ug/l	46	1
	01005	Dissol. Barium, ug/l	1092	
	01006	Susp Barium, ug/l	0	
	01007	Total Barium, ug/l	61	
	01010	Diss Beryllium, ug/l	83	2
	01012	Total Beryllium, ug/l	0	
	01025	Diss Cadmium, ug/l	144	3
	01027	Total Cadmium, ug/l	8	
	01030	Diss chromium, ug/l	481	1
	01032	Hexval chromium, ug/l	56	
	01034	Total chromium, ug/l	87	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	187	5
	01046	Diss Iron, ug/l	1843	12
	01047	Ferrous Iron, ug/l	23	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	157	4
	01056	Diss manganese, ug/l	1847	133
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	2	
	01065	Diss Nickel, ug/l	473	3
	01067	Total Nickel ug/L	26	
	01095	Diss Antimony, ug/l	19	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01097	Total Antimony, ug/l	2	
	01145	Diss Selenium, ug/l	324	15
	01147	Total Selenium, ug/l	51	
	09510	Radium-226, diss, pci/l	5	
	09511	Radium-226, diss, pci/l	26	1
	22603	U-238, diss, pci/l	8	3
	22620	U-235, diss, pci/l	6	
	71890	Hg, diss, ug/l	76	3
	71900	Hg, Tot. Rec., ug/l	15	
	76001	Radium-226, diss, pci/l	33	
	76002	Radon-222, pci/l	571	1
	82303	Radon-222, total, pci/l	599	113
P00720	00723	Diss. Cyanide, mg/l	4	
	00945	Diss. Sulfate, mg/l	19	
	01000	Diss. Arsenic, ug/l	4	
	01002	Total, Arsenic, ug/l	9	
	01005	Dissol. Barium, ug/l	4	
	01006	Susp Barium, ug/l	0	
	01007	Total Barium, ug/l	11	
	01010	Diss Beryllium, ug/l	1	
	01012	Total Beryllium, ug/l	2	
	01025	Diss Cadmium, ug/l	0	
	01027	Total Cadmium, ug/l	3	
	01030	Diss chromium, ug/l	1	
	01032	Hexval chromium, ug/l	0	
	01034	Total chromium, ug/l	13	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	21	
	01046	Diss Iron, ug/l	4	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	19	
	01056	Diss manganese, ug/l	4	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	3	
	01067	Total Nickel ug/L	5	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	1	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	5	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	3	
	71900	Hg, Tot. Rec., ug/l	3	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P00723	00945	Diss. Sulfate, mg/l	25	7
	01000	Diss. Arsenic, ug/l	23	8
	01002	Total. Arsenic, ug/l	10	4
	01005	Dissol. Barium, ug/l	28	
	01006	Susp Barium, ug/l	0	
	01007	Total Barium, ug/l	10	
	01010	Diss Beryllium, ug/l	5	
	01012	Total Beryllium, ug/l	0	
	01025	Diss Cadmium, ug/l	9	1
	01027	Total Cadmium, ug/l	2	
	01030	Diss chromium, ug/l	3	
	01032	Hexval chromium, ug/l	0	
	01034	Total chromium, ug/l	1	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	9	2
	01046	Diss Iron, ug/l	21	5
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	11	
	01056	Diss manganese, ug/l	23	
	01057	Diss Thallium, ug/l	1	
	01059	Total Thallium, ug/l	2	
	01065	Diss Nickel, ug/l	18	
	01067	Total Nickel ug/L	7	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	1	
	01145	Diss Selenium, ug/l	6	
	01147	Total Selenium, ug/l	4	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	16	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	1	
	82303	Radon-222, total, pci/l	1	
P00945	01000	Diss. Arsenic, ug/l	3797	2004
	01002	Total, Arsenic, ug/l	209	77
	01005	Dissol. Barium, ug/l	4950	2
	01006	Susp Barium, ug/l	1	
	01007	Total Barium, ug/l	292	
	01010	Diss Beryllium, ug/l	263	24
	01012	Total Beryllium, ug/l	34	
	01025	Diss Cadmium, ug/l	545	72
	01027	Total Cadmium, ug/l	66	14
	01030	Diss chromium, ug/l	2304	12
	01032	Hexval chromium, ug/l	137	4
	01034	Total chromium, ug/l	272	3
	01044	Susp Iron ug/l	1	
	01045	Total Iron, ug/l	922	282
	01046	Diss Iron, ug/l	9630	1299
	01047	Ferrous Iron, ug/l	139	81
	01054	Susp Manganese, ug/l	3	
	01055	Total manganese, ug/l	701	249
	01056	Diss manganese, ug/l	9003	2280
	01057	Diss Thallium, ug/l	19	12
	01059	Total Thallium, ug/l	8	2
	01065	Diss Nickel, ug/l	1813	67
	01067	Total Nickel ug/L	141	9
	01095	Diss Antimony, ug/l	85	9

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01097	Total Antimony, ug/l	35	6
	01145	Diss Selenium, ug/l	1216	50
	01147	Total Selenium, ug/l	101	
	09510	Radium-226, diss, pci/l	39	6
	09511	Radium-226, diss, pci/l	110	4
	22603	U-238, diss, pci/l	93	53
	22620	U-235, diss, pci/l	62	8
	71890	Hg, diss, ug/l	201	2
	71900	Hg, Tot. Rec., ug/l	61	1
	76001	Radium-226, diss, pci/l	201	
	76002	Radon-222, pci/l	3965	16
	82303	Radon-222, total, pci/l	3946	1764
P01000	01002	Total, Arsenic, ug/l	71	56
	01005	Dissol. Barium, ug/l	2007	5
	01006	Susp Barium, ug/l	0	
	01007	Total Barium, ug/l	27	
	01010	Diss Beryllium, ug/l	87	3
	01012	Total Beryllium, ug/l	1	
	01025	Diss Cadmium, ug/l	181	19
	01027	Total Cadmium, ug/l	5	1
	01030	Diss chromium, ug/l	1221	4
	01032	Hexval chromium, ug/l	66	
	01034	Total chromium, ug/l	55	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	49	22
	01046	Diss Iron, ug/l	2563	453
	01047	Ferrous Iron, ug/l	9	1
	01054	Susp Manganese, ug/l	2	
	01055	Total manganese, ug/l	46	25
	01056	Diss manganese, ug/l	2226	854
	01057	Diss Thallium, ug/l	11	8
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	692	8
	01067	Total Nickel ug/L	24	1
	01095	Diss Antimony, ug/l	78	9
	01097	Total Antimony, ug/l	6	3
	01145	Diss Selenium, ug/l	845	7

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01147	Total Selenium, ug/l	8	
	09510	Radium-226, diss, pci/l	11	1
	09511	Radium-226, diss, pci/l	28	1
	22603	U-238, diss, pci/l	51	28
	22620	U-235, diss, pci/l	37	2
	71890	Hg, diss, ug/l	101	2
	71900	Hg, Tot. Rec., ug/l	2	
	76001	Radium-226, diss, pci/l	83	
	76002	Radon-222, pci/l	1277	3
	82303	Radon-222, total, pci/l	1284	1013
P01002	01005	Dissol. Barium, ug/l	84	
	01006	Susp Barium, ug/l	0	
	01007	Total Barium, ug/l	140	6
	01010	Diss Beryllium, ug/l	8	
	01012	Total Beryllium, ug/l	29	2
	01025	Diss Cadmium, ug/l	19	4
	01027	Total Cadmium, ug/l	39	7
	01030	Diss chromium, ug/l	21	1
	01032	Hexval chromium, ug/l	8	
	01034	Total chromium, ug/l	100	1
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	193	107
	01046	Diss Iron, ug/l	125	57
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	179	99
	01056	Diss manganese, ug/l	132	67
	01057	Diss Thallium, ug/l	8	
	01059	Total Thallium, ug/l	6	
	01065	Diss Nickel, ug/l	42	4
	01067	Total Nickel ug/L	108	4
	01095	Diss Antimony, ug/l	3	
	01097	Total Antimony, ug/l	28	3
	01145	Diss Selenium, ug/l	13	
	01147	Total Selenium, ug/l	69	
	09510	Radium-226, diss, pci/l	2	1
	09511	Radium-226, diss, pci/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	22603	U-238, diss, pci/l	4	1
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	13	
	71900	Hg, Tot. Rec., ug/l	33	
	76001	Radium-226, diss, pci/l	3	
	76002	Radon-222, pci/l	13	
	82303	Radon-222, total, pci/l	14	11
P01005	01006	Susp Barium, ug/l	1	
	01007	Total Barium, ug/l	133	
	01010	Diss Beryllium, ug/l	273	
	01012	Total Beryllium, ug/l	23	
	01025	Diss Cadmium, ug/l	490	2
	01027	Total Cadmium, ug/l	35	
	01030	Diss chromium, ug/l	1730	
	01032	Hexval chromium, ug/l	63	
	01034	Total chromium, ug/l	104	
	01044	Susp Iron ug/l	2	
	01045	Total Iron, ug/l	298	
	01046	Diss Iron, ug/l	3703	7
	01047	Ferrous Iron, ug/l	50	
	01054	Susp Manganese, ug/l	3	
	01055	Total manganese, ug/l	240	
	01056	Diss manganese, ug/l	3724	10
	01057	Diss Thallium, ug/l	20	
	01059	Total Thallium, ug/l	8	
	01065	Diss Nickel, ug/l	1849	
	01067	Total Nickel ug/L	97	
	01095	Diss Antimony, ug/l	79	
	01097	Total Antimony, ug/l	28	
	01145	Diss Selenium, ug/l	792	
	01147	Total Selenium, ug/l	36	
	09510	Radium-226, diss, pci/l	9	
	09511	Radium-226, diss, pci/l	102	
	22603	U-238, diss, pci/l	82	
	22620	U-235, diss, pci/l	57	
	71890	Hg, diss, ug/l	165	
	71900	Hg, Tot. Rec., ug/l	31	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	76001	Radium-226, diss, pci/l	155	
	76002	Radon-222, pci/l	1787	
	82303	Radon-222, total, pci/l	1785	
P01006	01007	Total Barium, ug/l	1	
	01010	Diss Beryllium, ug/l	0	
	01012	Total Beryllium, ug/l	0	
	01025	Diss Cadmium, ug/l	0	
	01027	Total Cadmium, ug/l	0	
	01030	Diss chromium, ug/l	0	
	01032	Hexval chromium, ug/l	0	
	01034	Total chromium, ug/l	0	
	01044	Susp Iron ug/l	1	
	01045	Total Iron, ug/l	1	
	01046	Diss Iron, ug/l	1	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	1	
	01055	Total manganese, ug/l	1	
	01056	Diss manganese, ug/l	1	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	0	
	01067	Total Nickel ug/L	0	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	0	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01007	01010	Diss Beryllium, ug/l	16	
	01012	Total Beryllium, ug/l	34	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01025	Diss Cadmium, ug/l	28	
	01027	Total Cadmium, ug/l	57	
	01030	Diss chromium, ug/l	16	
	01032	Hexval chromium, ug/l	4	
	01034	Total chromium, ug/l	153	1
	01044	Susp Iron ug/l	1	
	01045	Total Iron, ug/l	361	8
	01046	Diss Iron, ug/l	110	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	1	
	01055	Total manganese, ug/l	332	8
	01056	Diss manganese, ug/l	105	
	01057	Diss Thallium, ug/l	11	
	01059	Total Thallium, ug/l	8	
	01065	Diss Nickel, ug/l	57	
	01067	Total Nickel ug/L	125	
	01095	Diss Antimony, ug/l	1	
	01097	Total Antimony, ug/l	27	
	01145	Diss Selenium, ug/l	14	
	01147	Total Selenium, ug/l	68	
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	1	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	13	
	71900	Hg, Tot. Rec., ug/l	51	
	76001	Radium-226, diss, pci/l	1	
	76002	Radon-222, pci/l	22	
	82303	Radon-222, total, pci/l	20	
P01010	01012	Total Beryllium, ug/l	0	
	01025	Diss Cadmium, ug/l	125	11
	01027	Total Cadmium, ug/l	3	
	01030	Diss chromium, ug/l	89	6
	01032	Hexval chromium, ug/l	4	
	01034	Total chromium, ug/l	5	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	35	8

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01046	Diss Iron, ug/l	230	19
	01047	Ferrous Iron, ug/l	17	8
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	34	8
	01056	Diss manganese, ug/l	238	21
	01057	Diss Thallium, ug/l	9	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	107	19
	01067	Total Nickel ug/L	10	
	01095	Diss Antimony, ug/l	6	1
	01097	Total Antimony, ug/l	2	
	01145	Diss Selenium, ug/l	42	1
	01147	Total Selenium, ug/l	6	
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	6	
	22603	U-238, diss, pci/l	10	6
	22620	U-235, diss, pci/l	9	5
	71890	Hg, diss, ug/l	29	1
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	8	
	76002	Radon-222, pci/l	21	2
	82303	Radon-222, total, pci/l	21	4
P01012	01025	Diss Cadmium, ug/l	8	1
	01027	Total Cadmium, ug/l	26	2
	01030	Diss chromium, ug/l	0	
	01032	Hexval chromium, ug/l	0	
	01034	Total chromium, ug/l	26	1
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	34	2
	01046	Diss Iron, ug/l	22	1
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	33	2
	01056	Diss manganese, ug/l	18	1
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	6	
	01065	Diss Nickel, ug/l	8	1

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01067	Total Nickel ug/L	33	2
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	17	
	01145	Diss Selenium, ug/l	1	
	01147	Total Selenium, ug/l	15	
	09510	Radium-226, diss. pci/l	0	
	09511	Radium-226, diss. pci/l	0	
	22603	U-238, diss. pci/l	0	
	22620	U-235, diss. pci/l	0	
	71890	Hg, diss. ug/l	1	
	71900	Hg, Tot. Rec., ug/l	21	
	76001	Radium-226, diss. pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01025	01027	Total Cadmium, ug/l	16	2
	01030	Diss chromium, ug/l	141	6
	01032	Hexval chromium, ug/l	4	
	01034	Total chromium, ug/l	25	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	48	2
	01046	Diss Iron, ug/l	470	50
	01047	Ferrous Iron, ug/l	2	1
	01054	Susp Manganese, ug/l	2	
	01055	Total manganese, ug/l	54	8
	01056	Diss manganese, ug/l	485	63
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	3	
	01065	Diss Nickel, ug/l	229	24
	01067	Total Nickel ug/L	22	2
	01095	Diss Antimony, ug/l	8	2
	01097	Total Antimony, ug/l	10	1
	01145	Diss Selenium, ug/l	54	1
	01147	Total Selenium, ug/l	3	
	09510	Radium-226, diss. pci/l	1	
	09511	Radium-226, diss. pci/l	11	
	22603	U-238, diss. pci/l	16	7
	22620	U-235, diss. pci/l	14	6

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	71890	Hg, diss. ug/l	48	2
	71900	Hg, Tot. Rec., ug/l	8	
	76001	Radium-226, diss, pci/l	13	
	76002	Radon-222, pci/l	81	2
	82303	Radon-222, total, pci/l	81	12
P01027	01030	Diss chromium, ug/l	1	
	01032	Hexval chromium, ug/l	0	
	01034	Total chromium, ug/l	43	3
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	64	19
	01046	Diss Iron, ug/l	35	3
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	63	20
	01056	Diss manganese, ug/l	33	4
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	7	
	01065	Diss Nickel, ug/l	17	2
	01067	Total Nickel ug/L	44	3
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	18	
	01145	Diss Selenium, ug/l	3	
	01147	Total Selenium, ug/l	13	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss. ug/l	4	
	71900	Hg, Tot. Rec., ug/l	22	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	2	
	82303	Radon-222, total, pci/l	2	
P01030	01032	Hexval chromium, ug/l	112	4
	01034	Total chromium, ug/l	27	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	64	1
	01046	Diss Iron, ug/l	1499	7

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01047	Ferrous Iron, ug/l	20	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	51	1
	01056	Diss manganese, ug/l	1354	8
	01057	Diss Thallium, ug/l	8	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	1122	7
	01067	Total Nickel ug/L	14	
	01095	Diss Antimony, ug/l	25	1
	01097	Total Antimony, ug/l	3	
	01145	Diss Selenium, ug/l	541	3
	01147	Total Selenium, ug/l	17	
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	32	
	22603	U-238, diss, pci/l	37	5
	22620	U-235, diss, pci/l	36	4
	71890	Hg, diss, ug/l	55	1
	71900	Hg, Tot. Rec., ug/l	2	
	76001	Radium-226, diss, pci/l	38	
	76002	Radon-222, pci/l	1271	2
	82303	Radon-222, total, pci/l	1246	5
P01032	01034	Total chromium, ug/l	24	
	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	9	
	01046	Diss Iron, ug/l	44	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	6	
	01056	Diss manganese, ug/l	29	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	11	
	01067	Total Nickel ug/L	8	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	32	
	01147	Total Selenium, ug/l	8	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	3	
	71900	Hg, Tot. Rec., ug/l	1	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	1	
	82303	Radon-222, total, pci/l	1	
P01034	01044	Susp Iron ug/l	0	
	01045	Total Iron, ug/l	251	11
	01046	Diss Iron, ug/l	80	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	227	12
	01056	Diss manganese, ug/l	71	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	6	
	01065	Diss Nickel, ug/l	22	
	01067	Total Nickel ug/L	91	1
	01095	Diss Antimony, ug/l	3	
	01097	Total Antimony, ug/l	22	
	01145	Diss Selenium, ug/l	22	
	01147	Total Selenium, ug/l	84	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	3	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	4	
	71900	Hg, Tot. Rec., ug/l	38	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	5	
	82303	Radon-222, total, pci/l	5	
P01044	01045	Total Iron, ug/l	2	1
	01046	Diss Iron, ug/l	2	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	1	1

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01055	Total manganese, ug/l	2	1
	01056	Diss manganese, ug/l	2	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	0	
	01067	Total Nickel ug/L	0	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	0	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	1	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01045	01046	Diss Iron, ug/l	528	223
	01047	Ferrous Iron, ug/l	105	78
	01054	Susp Manganese, ug/l	1	1
	01055	Total manganese, ug/l	865	488
	01056	Diss manganese, ug/l	534	216
	01057	Diss Thallium, ug/l	11	5
	01059	Total Thallium, ug/l	7	
	01065	Diss Nickel, ug/l	120	22
	01067	Total Nickel ug/L	145	13
	01095	Diss Antimony, ug/l	4	1
	01097	Total Antimony, ug/l	32	5
	01145	Diss Selenium, ug/l	33	
	01147	Total Selenium, ug/l	105	
	09510	Radium-226, diss, pci/l	10	1
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	3	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	25	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	71900	Hg, Tot. Rec., ug/l	66	2
	76001	Radium-226, diss, pci/l	17	
	76002	Radon-222, pci/l	138	1
	82303	Radon-222, total, pci/l	140	52
P01046	01047	Ferrous Iron, ug/l	126	86
	01054	Susp Manganese, ug/l	3	
	01055	Total manganese, ug/l	425	181
	01056	Diss manganese, ug/l	8344	2082
	01057	Diss Thallium, ug/l	11	5
	01059	Total Thallium, ug/l	8	
	01065	Diss Nickel, ug/l	1403	52
	01067	Total Nickel ug/L	85	7
	01095	Diss Antimony, ug/l	49	3
	01097	Total Antimony, ug/l	30	4
	01145	Diss Selenium, ug/l	706	8
	01147	Total Selenium, ug/l	29	
	09510	Radium-226, diss, pci/l	33	4
	09511	Radium-226, diss, pci/l	90	2
	22603	U-238, diss, pci/l	47	6
	22620	U-235, diss, pci/l	25	4
	71890	Hg, diss, ug/l	158	3
	71900	Hg, Tot. Rec., ug/l	27	
	76001	Radium-226, diss, pci/l	145	
	76002	Radon-222, pci/l	2607	3
	82303	Radon-222, total, pci/l	2603	533
P01047	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	85	60
	01056	Diss manganese, ug/l	135	70
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	29	
	01067	Total Nickel ug/L	0	14
	01095	Diss Antimony, ug/l	1	
	01097	Total Antimony, ug/l	0	1
	01145	Diss Selenium, ug/l	1	
	01147	Total Selenium, ug/l	0	
	09510	Radium-226, diss, pci/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	1	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01054	01055	Total manganese, ug/l	1	1
	01056	Diss manganese, ug/l	3	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	2	
	01067	Total Nickel ug/L	0	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	0	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	2	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	1	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01055	01056	Diss manganese, ug/l	466	261
	01057	Diss Thallium, ug/l	10	
	01059	Total Thallium, ug/l	8	2
	01065	Diss Nickel, ug/l	121	26
	01067	Total Nickel ug/L	133	13
	01095	Diss Antimony, ug/l	2	1
	01097	Total Antimony, ug/l	33	3
	01145	Diss Selenium, ug/l	25	
	01147	Total Selenium, ug/l	86	
	09510	Radium-226, diss, pci/l	10	2

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	09511	Radium-226, diss, pci/l	21	1
	22603	U-238, diss, pci/l	20	1
	22620	U-235, diss, pci/l	3	
	71890	Hg, diss, ug/l	23	1
	71900	Hg, Tot. Rec., ug/l	58	3
	76001	Radium-226, diss, pci/l	38	1
	76002	Radon-222, pci/l	108	1
	82303	Radon-222, total, pci/l	110	49
P01056	01057	Diss Thallium, ug/l	10	
	01059	Total Thallium, ug/l	4	2
	01065	Diss Nickel, ug/l	1451	64
	01067	Total Nickel ug/L	88	9
	01095	Diss Antimony, ug/l	47	3
	01097	Total Antimony, ug/l	24	3
	01145	Diss Selenium, ug/l	597	11
	01147	Total Selenium, ug/l	31	
	09510	Radium-226, diss, pci/l	32	3
	09511	Radium-226, diss, pci/l	94	3
	22603	U-238, diss, pci/l	55	18
	22620	U-235, diss, pci/l	32	8
	71890	Hg, diss, ug/l	181	4
	71900	Hg, Tot. Rec., ug/l	27	1
	76001	Radium-226, diss, pci/l	142	1
	76002	Radon-222, pci/l	2410	8
	82303	Radon-222, total, pci/l	2392	854
P01057	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	10	
	01067	Total Nickel ug/L	6	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	3	3
	01145	Diss Selenium, ug/l	11	
	01147	Total Selenium, ug/l	6	
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	1	
	76002	Radon-222, pci/l	1	
	82303	Radon-222, total, pci/l	1	1
P01059	01065	Diss Nickel, ug/l	2	
	01067	Total Nickel ug/L	8	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	6	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	3	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	2	
	71900	Hg, Tot. Rec., ug/l	5	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01065	01067	Total Nickel ug/L	57	8
	01095	Diss Antimony, ug/l	23	2
	01097	Total Antimony, ug/l	12	1
	01145	Diss Selenium, ug/l	380	2
	01147	Total Selenium, ug/l	15	
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	61	
	22603	U-238, diss, pci/l	44	9
	22620	U-235, diss, pci/l	40	8
	71890	Hg, diss, ug/l	66	3
	71900	Hg, Tot. Rec., ug/l	12	
	76001	Radium-226, diss, pci/l	60	
	76002	Radon-222, pci/l	1017	2
	82303	Radon-222, total, pci/l	994	9
P01067	01095	Diss Antimony, ug/l	4	
	01097	Total Antimony, ug/l	26	
	01145	Diss Selenium, ug/l	15	
	01147	Total Selenium, ug/l	55	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	8	
	71900	Hg, Tot. Rec., ug/l	30	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	3	
	82303	Radon-222, total, pci/l	3	
P01095	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	28	1
	01147	Total Selenium, ug/l	1	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	1	
	22603	U-238, diss, pci/l	10	1
	22620	U-235, diss, pci/l	2	
	71890	Hg, diss, ug/l	2	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	1	
	76002	Radon-222, pci/l	29	
	82303	Radon-222, total, pci/l	26	
P01097	01145	Diss Selenium, ug/l	2	
	01147	Total Selenium, ug/l	12	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	1	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	1	
	71900	Hg, Tot. Rec., ug/l	12	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01145	01147	Total Selenium, ug/l	20	
	09510	Radium-226, diss, pci/l	10	
	09511	Radium-226, diss, pci/l	6	
	22603	U-238, diss, pci/l	48	
	22620	U-235, diss, pci/l	41	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	71890	Hg, diss, ug/l	36	
	71900	Hg, Tot. Rec., ug/l	0	1
	76001	Radium-226, diss, pci/l	56	
	76002	Radon-222, pci/l	413	
	82303	Radon-222, total, pci/l	418	6
P01147	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	1	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	4	
	71900	Hg, Tot. Rec., ug/l	16	
	76001	Radium-226, diss, pci/l	1	
	76002	Radon-222, pci/l	2	
	82303	Radon-222, total, pci/l	2	
P09510	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	2	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	45	1
	76002	Radon-222, pci/l	36	
	82303	Radon-222, total, pci/l	36	9
P09511	22603	U-238, diss, pci/l	24	1
	22620	U-235, diss, pci/l	6	
	71890	Hg, diss, ug/l	23	2
	71900	Hg, Tot. Rec., ug/l	5	2
	76001	Radium-226, diss, pci/l	116	
	76002	Radon-222, pci/l	94	16
	82303	Radon-222, total, pci/l	94	8
P22603	22620	U-235, diss, pci/l	63	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	29	
	76002	Radon-222, pci/l	80	6
	82303	Radon-222, total, pci/l	76	46
P22620	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	76001	Radium-226, diss, pci/l	11	
	76002	Radon-222, pci/l	53	2
	82303	Radon-222, total, pci/l	52	6
P71890	71900	Hg, Tot. Rec., ug/l	11	3
	76001	Radium-226, diss, pci/l	25	
	76002	Radon-222, pci/l	45	
	82303	Radon-222, total, pci/l	45	3
P71900	76001	Radium-226, diss, pci/l	5	
	76002	Radon-222, pci/l	6	
	82303	Radon-222, total, pci/l	6	2
P76001	76002	Radon-222, pci/l	137	
	82303	Radon-222, total, pci/l	137	1
P76002	82303	Radon-222, total, pci/l	4439	44

Appendix B: Number of Stations with Co-occurring Pair Counts for Surface water
(Shading shows pairs above sample size threshold)

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
P00613	00615	Nitrite-N Total, mg/l as N	771	
	00618	Nitrate mg/l	3958	
	00720	Total Cyanide, mg/l	77	
	00723	Diss. Cyanide, mg/l	10	
	00945	Diss. Sulfate, mg/l	3130	
	01000	Diss. Arsenic, ug/l	625	
	01002	Total, Arsenic, ug/l	452	
	01005	Dissol. Barium, ug/l	1199	
	01007	Total Barium, ug/l	147	
	01010	Diss Beryllium, ug/l	114	
	01012	Total Beryllium, ug/l	37	
	01025	Diss Cadmium, ug/l	255	
	01027	Total Cadmium, ug/l	131	
	01030	Diss chromium, ug/l	448	
	01032	Hexval chromium, ug/l	15	
	01034	Total chromium, ug/l	444	
	01045	Total Iron, ug/l	636	
	01046	Diss Iron, ug/l	2626	
	01047	Ferrous Iron, ug/l	2	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	575	
	01056	Diss manganese, ug/l	2649	
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	2	
	01065	Diss Nickel, ug/l	776	
	01067	Total Nickel, ug/l	480	
	01095	Diss Antimony, ug/l	54	
	01097	Total Antimony, ug/l	32	
	01145	Diss Selenium, ug/l	358	
	01147	Total Selenium, ug/l	127	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	112	
	22603	U-238, diss, pci/l	3	
	22620	U-235, diss, pci/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	71890	Hg, diss, ug/l	237	
	71900	Hg, Tot. Rec., ug/l	197	
	76001	Radium-226, diss, pci/l	112	
	76002	Radon-222, pci/l	19	
	82303	Radon-222, total, pci/l	19	
P00615	00618	Nitrate mg/l	751	
	00720	Total Cyanide, mg/l	51	
	00723	Diss. Cyanide, mg/l	9	
	00945	Diss. Sulfate, mg/l	1171	
	01000	Diss. Arsenic, ug/l	199	
	01002	Total, Arsenic, ug/l	313	
	01005	Dissol. Barium, ug/l	495	
	01007	Total Barium, ug/l	81	
	01010	Diss Beryllium, ug/l	46	
	01012	Total Beryllium, ug/l	52	1
	01025	Diss Cadmium, ug/l	116	
	01027	Total Cadmium, ug/l	104	
	01030	Diss chromium, ug/l	165	
	01032	Hexval chromium, ug/l	14	
	01034	Total chromium, ug/l	362	
	01045	Total Iron, ug/l	411	
	01046	Diss Iron, ug/l	693	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	384	
	01056	Diss manganese, ug/l	676	
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	9	
	01065	Diss Nickel, ug/l	386	
	01067	Total Nickel, ug/l	366	
	01095	Diss Antimony, ug/l	22	
	01097	Total Antimony, ug/l	25	
	01145	Diss Selenium, ug/l	141	
	01147	Total Selenium, ug/l	69	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	51	
	22603	U-238, diss, pci/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	105	
	71900	Hg, Tot. Rec., ug/l	263	
	76001	Radium-226, diss, pci/l	51	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P00618	00720	Total Cyanide, mg/l	83	
	00723	Diss. Cyanide, mg/l	10	
	00945	Diss. Sulfate, mg/l	3068	66
	01000	Diss. Arsenic, ug/l	610	7
	01002	Total, Arsenic, ug/l	464	5
	01005	Dissol. Barium, ug/l	1170	
	01007	Total Barium, ug/l	151	
	01010	Diss Beryllium, ug/l	117	
	01012	Total Beryllium, ug/l	37	
	01025	Diss Cadmium, ug/l	271	
	01027	Total Cadmium, ug/l	151	
	01030	Diss chromium, ug/l	431	
	01032	Hexval chromium, ug/l	15	
	01034	Total chromium, ug/l	438	
	01045	Total Iron, ug/l	651	4
	01046	Diss Iron, ug/l	2548	2
	01047	Ferrous Iron, ug/l	2	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	593	5
	01056	Diss manganese, ug/l	2580	11
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	5	
	01065	Diss Nickel, ug/l	762	
	01067	Total Nickel, ug/l	479	
	01095	Diss Antimony, ug/l	51	2
	01097	Total Antimony, ug/l	31	1
	01145	Diss Selenium, ug/l	360	7
	01147	Total Selenium, ug/l	126	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	104	
	22603	U-238, diss, pci/l	2	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	231	
	71900	Hg, Tot. Rec., ug/l	195	
	76001	Radium-226, diss, pci/l	104	
	76002	Radon-222, pci/l	19	
	82303	Radon-222, total, pci/l	19	3
P00720	00723	Diss. Cyanide, mg/l	2	1
	00945	Diss. Sulfate, mg/l	147	2
	01000	Diss. Arsenic, ug/l	19	1
	01002	Total. Arsenic, ug/l	129	1
	01005	Dissol. Barium, ug/l	98	
	01007	Total Barium, ug/l	95	
	01010	Diss Beryllium, ug/l	31	
	01012	Total Beryllium, ug/l	39	
	01025	Diss Cadmium, ug/l	24	
	01027	Total Cadmium, ug/l	68	
	01030	Diss chromium, ug/l	26	
	01032	Hexval chromium, ug/l	2	
	01034	Total chromium, ug/l	112	
	01045	Total Iron, ug/l	109	2
	01046	Diss Iron, ug/l	98	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	108	2
	01056	Diss manganese, ug/l	94	2
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	6	
	01065	Diss Nickel, ug/l	37	
	01067	Total Nickel, ug/l	117	
	01095	Diss Antimony, ug/l	3	
	01097	Total Antimony, ug/l	7	
	01145	Diss Selenium, ug/l	8	
	01147	Total Selenium, ug/l	53	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	2	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	71890	Hg, diss, ug/l	8	
	71900	Hg, Tot. Rec., ug/l	55	
	76001	Radium-226, diss, pci/l	2	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P00723	00945	Diss. Sulfate, mg/l	8	2
	01000	Diss. Arsenic, ug/l	4	2
	01002	Total, Arsenic, ug/l	4	2
	01005	Dissol. Barium, ug/l	12	
	01007	Total Barium, ug/l	2	
	01010	Diss Beryllium, ug/l	4	
	01012	Total Beryllium, ug/l	0	
	01025	Diss Cadmium, ug/l	4	
	01027	Total Cadmium, ug/l	2	
	01030	Diss chromium, ug/l	1	
	01032	Hexval chromium, ug/l	0	
	01034	Total chromium, ug/l	2	
	01045	Total Iron, ug/l	7	2
	01046	Diss Iron, ug/l	12	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	7	2
	01056	Diss manganese, ug/l	8	2
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	9	
	01067	Total Nickel, ug/l	4	
	01095	Diss Antimony, ug/l	3	
	01097	Total Antimony, ug/l	1	
	01145	Diss Selenium, ug/l	4	
	01147	Total Selenium, ug/l	4	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	10	
	71900	Hg, Tot. Rec., ug/l	2	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P00945	01000	Diss. Arsenic, ug/l	1185	624
	01002	Total, Arsenic, ug/l	836	342
	01005	Dissol. Barium, ug/l	2017	
	01007	Total Barium, ug/l	414	
	01010	Diss Beryllium, ug/l	231	24
	01012	Total Beryllium, ug/l	155	5
	01025	Diss Cadmium, ug/l	502	38
	01027	Total Cadmium, ug/l	355	20
	01030	Diss chromium, ug/l	703	6
	01032	Hexval chromium, ug/l	15	
	01034	Total chromium, ug/l	871	1
	01045	Total Iron, ug/l	1688	845
	01046	Diss Iron, ug/l	4730	401
	01047	Ferrous Iron, ug/l	125	94
	01054	Susp Manganese, ug/l	2	
	01055	Total manganese, ug/l	1578	875
	01056	Diss manganese, ug/l	4756	1179
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	25	
	01065	Diss Nickel, ug/l	1068	35
	01067	Total Nickel, ug/l	901	15
	01095	Diss Antimony, ug/l	106	7
	01097	Total Antimony, ug/l	88	3
	01145	Diss Selenium, ug/l	722	24
	01147	Total Selenium, ug/l	266	
	09510	Radium-226, diss, pci/l	2	
	09511	Radium-226, diss, pci/l	127	
	22603	U-238, diss, pci/l	16	1
	22620	U-235, diss, pci/l	6	
	71890	Hg, diss, ug/l	365	1
	71900	Hg, Tot. Rec., ug/l	420	1
	76001	Radium-226, diss, pci/l	131	
	76002	Radon-222, pci/l	52	2
	82303	Radon-222, total, pci/l	51	34

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
P01000	01002	Total, Arsenic, ug/l	315	195
	01005	Dissl. Barium, ug/l	825	
	01007	Total Barium, ug/l	59	
	01010	Diss Beryllium, ug/l	92	9
	01012	Total Beryllium, ug/l	15	1
	01025	Diss Cadmium, ug/l	268	15
	01027	Total Cadmium, ug/l	66	4
	01030	Diss chromium, ug/l	468	5
	01032	Hexval chromium, ug/l	10	
	01034	Total chromium, ug/l	155	
	01045	Total Iron, ug/l	252	106
	01046	Diss Iron, ug/l	997	17
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	2	
	01055	Total manganese, ug/l	217	101
	01056	Diss manganese, ug/l	1038	248
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	459	10
	01067	Total Nickel, ug/l	147	2
	01095	Diss Antimony, ug/l	101	20
	01097	Total Antimony, ug/l	33	2
	01145	Diss Selenium, ug/l	453	
	01147	Total Selenium, ug/l	98	
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	32	
	22603	U-238, diss, pci/l	5	
	22620	U-235, diss, pci/l	2	
	71890	Hg, diss, ug/l	303	2
	71900	Hg, Tot. Rec., ug/l	95	2
	76001	Radium-226, diss, pci/l	37	
	76002	Radon-222, pci/l	30	1
	82303	Radon-222, total, pci/l	29	26
P01002	01005	Dissl. Barium, ug/l	391	
	01007	Total Barium, ug/l	230	1
	01010	Diss Beryllium, ug/l	62	
	01012	Total Beryllium, ug/l	107	5

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01025	Diss Cadmium, ug/l	150	8
	01027	Total Cadmium, ug/l	243	16
	01030	Diss chromium, ug/l	164	
	01032	Hexval chromium, ug/l	12	
	01034	Total chromium, ug/l	592	4
	01045	Total Iron, ug/l	658	304
	01046	Diss Iron, ug/l	496	10
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	579	256
	01056	Diss manganese, ug/l	504	118
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	29	
	01065	Diss Nickel, ug/l	213	
	01067	Total Nickel, ug/l	628	6
	01095	Diss Antimony, ug/l	57	9
	01097	Total Antimony, ug/l	100	6
	01145	Diss Selenium, ug/l	104	1
	01147	Total Selenium, ug/l	204	1
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	26	
	22603	U-238, diss, pci/l	8	2
	22620	U-235, diss, pci/l	3	
	71890	Hg, diss, ug/l	86	
	71900	Hg, Tot. Rec., ug/l	308	2
	76001	Radium-226, diss, pci/l	26	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01005	01007	Total Barium, ug/l	391	
	01010	Diss Beryllium, ug/l	243	
	01012	Total Beryllium, ug/l	148	
	01025	Diss Cadmium, ug/l	411	
	01027	Total Cadmium, ug/l	196	
	01030	Diss chromium, ug/l	648	
	01032	Hexval chromium, ug/l	6	
	01034	Total chromium, ug/l	463	
	01045	Total Iron, ug/l	698	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01046	Diss Iron, ug/l	1914	
	01047	Ferrous Iron, ug/l	11	
	01054	Susp Manganese, ug/l	2	
	01055	Total manganese, ug/l	641	
	01056	Diss manganese, ug/l	2030	
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	25	
	01065	Diss Nickel, ug/l	1058	
	01067	Total Nickel, ug/l	474	
	01095	Diss Antimony, ug/l	102	
	01097	Total Antimony, ug/l	65	
	01145	Diss Selenium, ug/l	384	
	01147	Total Selenium, ug/l	137	
	09510	Radium-226, diss, pci/l	2	
	09511	Radium-226, diss, pci/l	121	
	22603	U-238, diss, pci/l	11	
	22620	U-235, diss, pci/l	3	
	71890	Hg, diss, ug/l	209	
	71900	Hg, Tot. Rec., ug/l	162	
	76001	Radium-226, diss, pci/l	125	
	76002	Radon-222, pci/l	42	
	82303	Radon-222, total, pci/l	41	
P01007	01010	Diss Beryllium, ug/l	93	
	01012	Total Beryllium, ug/l	152	
	01025	Diss Cadmium, ug/l	76	
	01027	Total Cadmium, ug/l	150	
	01030	Diss chromium, ug/l	76	
	01032	Hexval chromium, ug/l	2	
	01034	Total chromium, ug/l	345	4
	01045	Total Iron, ug/l	462	4
	01046	Diss Iron, ug/l	390	1
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	454	4
	01056	Diss manganese, ug/l	395	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	25	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01065	Diss Nickel, ug/l	133	
	01067	Total Nickel, ug/l	341	2
	01095	Diss Antimony, ug/l	7	
	01097	Total Antimony, ug/l	39	
	01145	Diss Selenium, ug/l	39	
	01147	Total Selenium, ug/l	106	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	4	
	22603	U-238, diss, pci/l	2	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	29	
	71900	Hg, Tot. Rec., ug/l	116	
	76001	Radium-226, diss, pci/l	4	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01010	01012	Total Beryllium, ug/l	74	1
	01025	Diss Cadmium, ug/l	133	18
	01027	Total Cadmium, ug/l	47	1
	01030	Diss chromium, ug/l	82	6
	01032	Hexval chromium, ug/l	4	
	01034	Total chromium, ug/l	97	
	01045	Total Iron, ug/l	117	4
	01046	Diss Iron, ug/l	243	23
	01047	Ferrous Iron, ug/l	3	
	01054	Susp Manganese, ug/l	2	
	01055	Total manganese, ug/l	121	4
	01056	Diss manganese, ug/l	237	24
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	2	
	01065	Diss Nickel, ug/l	142	22
	01067	Total Nickel, ug/l	102	1
	01095	Diss Antimony, ug/l	13	
	01097	Total Antimony, ug/l	5	
	01145	Diss Selenium, ug/l	34	
	01147	Total Selenium, ug/l	28	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	5	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	22603	U-238, diss, pci/l	1	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	56	
	71900	Hg, Tot. Rec., ug/l	38	
	76001	Radium-226, diss, pci/l	3	
	76002	Radon-222, pci/l	3	
	82303	Radon-222, total, pci/l	3	
P01012	01025	Diss Cadmium, ug/l	28	1
	01027	Total Cadmium, ug/l	84	1
	01030	Diss chromium, ug/l	23	
	01032	Hexval chromium, ug/l	4	
	01034	Total chromium, ug/l	165	1
	01045	Total Iron, ug/l	175	4
	01046	Diss Iron, ug/l	154	2
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	175	4
	01056	Diss manganese, ug/l	146	1
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	20	
	01065	Diss Nickel, ug/l	55	1
	01067	Total Nickel, ug/l	157	3
	01095	Diss Antimony, ug/l	2	1
	01097	Total Antimony, ug/l	30	1
	01145	Diss Selenium, ug/l	8	
	01147	Total Selenium, ug/l	45	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	2	
	22603	U-238, diss, pci/l	1	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	11	
	71900	Hg, Tot. Rec., ug/l	89	
	76001	Radium-226, diss, pci/l	2	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01025	01027	Total Cadmium, ug/l	145	15
	01030	Diss chromium, ug/l	180	6

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01032	Hexval chromium, ug/l	4	
	01034	Total chromium, ug/l	124	
	01045	Total Iron, ug/l	241	15
	01046	Diss Iron, ug/l	483	26
	01047	Ferrous Iron, ug/l	4	
	01054	Susp Manganese, ug/l	1	
	01055	Total manganese, ug/l	237	21
	01056	Diss manganese, ug/l	492	37
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	8	
	01065	Diss Nickel, ug/l	215	22
	01067	Total Nickel, ug/l	123	6
	01095	Diss Antimony, ug/l	24	
	01097	Total Antimony, ug/l	27	
	01145	Diss Selenium, ug/l	109	
	01147	Total Selenium, ug/l	56	
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	9	
	22603	U-238, diss, pci/l	2	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	113	1
	71900	Hg, Tot. Rec., ug/l	66	
	76001	Radium-226, diss, pci/l	8	
	76002	Radon-222, pci/l	4	
	82303	Radon-222, total, pci/l	4	
P01027	01030	Diss chromium, ug/l	55	
	01032	Hexval chromium, ug/l	4	
	01034	Total chromium, ug/l	267	
	01045	Total Iron, ug/l	253	17
	01046	Diss Iron, ug/l	247	6
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	262	21
	01056	Diss manganese, ug/l	243	17
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	24	
	01065	Diss Nickel, ug/l	90	3

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01067	Total Nickel, ug/l	266	3
	01095	Diss Antimony, ug/l	17	
	01097	Total Antimony, ug/l	46	
	01145	Diss Selenium, ug/l	20	
	01147	Total Selenium, ug/l	74	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	4	
	22603	U-238, diss, pci/l	1	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	26	
	71900	Hg, Tot. Rec., ug/l	141	
	76001	Radium-226, diss, pci/l	4	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01030	01032	Hexval chromium, ug/l	13	
	01034	Total chromium, ug/l	188	
	01045	Total Iron, ug/l	222	
	01046	Diss Iron, ug/l	619	
	01047	Ferrous Iron, ug/l	3	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	195	
	01056	Diss manganese, ug/l	675	6
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	1	
	01065	Diss Nickel, ug/l	472	6
	01067	Total Nickel, ug/l	151	
	01095	Diss Antimony, ug/l	45	
	01097	Total Antimony, ug/l	32	
	01145	Diss Selenium, ug/l	209	
	01147	Total Selenium, ug/l	69	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	32	
	22603	U-238, diss, pci/l	2	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	112	
	71900	Hg, Tot. Rec., ug/l	67	
	76001	Radium-226, diss, pci/l	32	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	76002	Radon-222, pci/l	1	
	82303	Radon-222, total, pci/l	1	
P01032	01034	Total chromium, ug/l	18	
	01045	Total Iron, ug/l	15	
	01046	Diss Iron, ug/l	15	
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	15	
	01056	Diss manganese, ug/l	12	
	01057	Diss Thallium, ug/l	1	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	12	
	01067	Total Nickel, ug/l	15	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	6	
	01147	Total Selenium, ug/l	3	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	4	
	71900	Hg, Tot. Rec., ug/l	7	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01034	01045	Total Iron, ug/l	723	6
	01046	Diss Iron, ug/l	568	1
	01047	Ferrous Iron, ug/l	0	
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	678	6
	01056	Diss manganese, ug/l	567	1
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	20	
	01065	Diss Nickel, ug/l	257	
	01067	Total Nickel, ug/l	769	5
	01095	Diss Antimony, ug/l	39	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01097	Total Antimony, ug/l	79	
	01145	Diss Selenium, ug/l	88	
	01147	Total Selenium, ug/l	169	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	25	
	22603	U-238, diss, pci/l	7	
	22620	U-235, diss, pci/l	3	
	71890	Hg, diss, ug/l	65	
	71900	Hg, Tot. Rec., ug/l	336	
	76001	Radium-226, diss, pci/l	25	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01045	01046	Diss Iron, ug/l	1434	399
	01047	Ferrous Iron, ug/l	115	88
	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	1763	1216
	01056	Diss manganese, ug/l	1443	705
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	25	
	01065	Diss Nickel, ug/l	354	6
	01067	Total Nickel, ug/l	789	12
	01095	Diss Antimony, ug/l	44	2
	01097	Total Antimony, ug/l	95	6
	01145	Diss Selenium, ug/l	117	1
	01147	Total Selenium, ug/l	185	1
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	18	
	22603	U-238, diss, pci/l	11	1
	22620	U-235, diss, pci/l	5	
	71890	Hg, diss, ug/l	92	1
	71900	Hg, Tot. Rec., ug/l	303	
	76001	Radium-226, diss, pci/l	19	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01046	01047	Ferrous Iron, ug/l	124	94
	01054	Susp Manganese, ug/l	2	
	01055	Total manganese, ug/l	1362	378

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01056	Diss manganese, ug/l	4702	659
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	23	
	01065	Diss Nickel, ug/l	1050	32
	01067	Total Nickel, ug/l	572	5
	01095	Diss Antimony, ug/l	87	1
	01097	Total Antimony, ug/l	74	
	01145	Diss Selenium, ug/l	484	1
	01147	Total Selenium, ug/l	166	
	09510	Radium-226, diss, pci/l	1	
	09511	Radium-226, diss, pci/l	125	
	22603	U-238, diss, pci/l	15	
	22620	U-235, diss, pci/l	5	
	71890	Hg, diss, ug/l	342	1
	71900	Hg, Tot. Rec., ug/l	259	
	76001	Radium-226, diss, pci/l	126	
	76002	Radon-222, pci/l	22	
	82303	Radon-222, total, pci/l	21	
P01047	01054	Susp Manganese, ug/l	0	
	01055	Total manganese, ug/l	118	89
	01056	Diss manganese, ug/l	124	94
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	9	1
	01067	Total Nickel, ug/l	0	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	0	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	82303	Radon-222, total, pci/l	0	
P01054	01055	Total manganese, ug/l	0	
	01056	Diss manganese, ug/l	2	
	01057	Diss Thallium, ug/l	0	
	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	0	
	01067	Total Nickel, ug/l	0	
	01095	Diss Antimony, ug/l	0	
	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	0	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	2	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	1	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01055	01056	Diss manganese, ug/l	1387	799
	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	25	
	01065	Diss Nickel, ug/l	327	10
	01067	Total Nickel, ug/l	719	16
	01095	Diss Antimony, ug/l	34	1
	01097	Total Antimony, ug/l	80	6
	01145	Diss Selenium, ug/l	107	1
	01147	Total Selenium, ug/l	162	1
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	15	
	22603	U-238, diss, pci/l	13	2
	22620	U-235, diss, pci/l	5	
	71890	Hg, diss, ug/l	84	1
	71900	Hg, Tot. Rec., ug/l	307	
	76001	Radium-226, diss, pci/l	16	
	76002	Radon-222, pci/l	1	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	82303	Radon-222, total, pci/l	1	
P01056	01057	Diss Thallium, ug/l	2	
	01059	Total Thallium, ug/l	24	
	01065	Diss Nickel, ug/l	1119	35
	01067	Total Nickel, ug/l	587	11
	01095	Diss Antimony, ug/l	94	
	01097	Total Antimony, ug/l	78	
	01145	Diss Selenium, ug/l	514	4
	01147	Total Selenium, ug/l	170	
	09510	Radium-226, diss, pci/l	2	
	09511	Radium-226, diss, pci/l	122	
	22603	U-238, diss, pci/l	13	
	22620	U-235, diss, pci/l	5	
	71890	Hg, diss, ug/l	338	
	71900	Hg, Tot. Rec., ug/l	253	1
	76001	Radium-226, diss, pci/l	123	
	76002	Radon-222, pci/l	24	
	82303	Radon-222, total, pci/l	23	2
P01057	01059	Total Thallium, ug/l	0	
	01065	Diss Nickel, ug/l	2	
	01067	Total Nickel, ug/l	2	
	01095	Diss Antimony, ug/l	1	
	01097	Total Antimony, ug/l	0	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	0	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	0	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01059	01065	Diss Nickel, ug/l	2	
	01067	Total Nickel, ug/l	25	
	01095	Diss Antimony, ug/l	0	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	01097	Total Antimony, ug/l	23	
	01145	Diss Selenium, ug/l	0	
	01147	Total Selenium, ug/l	9	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	0	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	16	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01065	01067	Total Nickel, ug/l	306	6
	01095	Diss Antimony, ug/l	51	
	01097	Total Antimony, ug/l	27	
	01145	Diss Selenium, ug/l	274	
	01147	Total Selenium, ug/l	87	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	92	
	22603	U-238, diss, pci/l	0	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	109	
	71900	Hg, Tot. Rec., ug/l	104	
	76001	Radium-226, diss, pci/l	93	
	76002	Radon-222, pci/l	3	
	82303	Radon-222, total, pci/l	3	
P01067	01095	Diss Antimony, ug/l	45	
	01097	Total Antimony, ug/l	85	2
	01145	Diss Selenium, ug/l	75	
	01147	Total Selenium, ug/l	143	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	14	
	22603	U-238, diss, pci/l	9	
	22620	U-235, diss, pci/l	3	
	71890	Hg, diss, ug/l	60	
	71900	Hg, Tot. Rec., ug/l	320	
	76001	Radium-226, diss, pci/l	14	

Appendix B

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01095	01097	Total Antimony, ug/l	21	2
	01145	Diss Selenium, ug/l	35	
	01147	Total Selenium, ug/l	14	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	1	
	22603	U-238, diss, pci/l	4	
	22620	U-235, diss, pci/l	2	
	71890	Hg, diss, ug/l	11	
	71900	Hg, Tot. Rec., ug/l	16	
	76001	Radium-226, diss, pci/l	1	
	76002	Radon-222, pci/l	14	
	82303	Radon-222, total, pci/l	14	
P01097	01145	Diss Selenium, ug/l	20	1
	01147	Total Selenium, ug/l	50	
	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	4	
	22603	U-238, diss, pci/l	4	
	22620	U-235, diss, pci/l	2	
	71890	Hg, diss, ug/l	10	
	71900	Hg, Tot. Rec., ug/l	53	
	76001	Radium-226, diss, pci/l	4	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P01145	01147	Total Selenium, ug/l	159	10
	09510	Radium-226, diss, pci/l	2	
	09511	Radium-226, diss, pci/l	20	
	22603	U-238, diss, pci/l	3	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	165	
	71900	Hg, Tot. Rec., ug/l	46	
	76001	Radium-226, diss, pci/l	26	
	76002	Radon-222, pci/l	29	1
	82303	Radon-222, total, pci/l	29	1
P01147	09510	Radium-226, diss, pci/l	0	
	09511	Radium-226, diss, pci/l	11	

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
	22603	U-238, diss, pci/l	1	
	22620	U-235, diss, pci/l	1	
	71890	Hg, diss, ug/l	41	
	71900	Hg, Tot. Rec., ug/l	81	
	76001	Radium-226, diss, pci/l	11	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P09510	09511	Radium-226, diss, pci/l	1	
	22603	U-238, diss, pci/l	1	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	1	
	76001	Radium-226, diss, pci/l	2	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P09511	22603	U-238, diss, pci/l	3	
	22620	U-235, diss, pci/l	0	
	71890	Hg, diss, ug/l	6	
	71900	Hg, Tot. Rec., ug/l	12	
	76001	Radium-226, diss, pci/l	125	
	76002	Radon-222, pci/l	1	
	82303	Radon-222, total, pci/l	1	
P22603	22620	U-235, diss, pci/l	6	
	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	3	
	76001	Radium-226, diss, pci/l	3	
	76002	Radon-222, pci/l	3	
	82303	Radon-222, total, pci/l	3	
P22620	71890	Hg, diss, ug/l	0	
	71900	Hg, Tot. Rec., ug/l	1	
	76001	Radium-226, diss, pci/l	0	
	76002	Radon-222, pci/l	1	
	82303	Radon-222, total, pci/l	1	
P71890	71900	Hg, Tot. Rec., ug/l	59	
	76001	Radium-226, diss, pci/l	5	
	76002	Radon-222, pci/l	4	
	82303	Radon-222, total, pci/l	4	1

	Code	Parameter Name	Co-occurring Pairs	Pairs Above Threshold
P71900	76001	Radium-226, diss, pci/l	12	
	76002	Radon-222, pci/l	0	
	82303	Radon-222, total, pci/l	0	
P76001	76002	Radon-222, pci/l	1	
	82303	Radon-222, total, pci/l	1	
P76002	82303	Radon-222, total, pci/l	64	4