



Washington State Septage Characterization Analysis

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Solid Waste & Financial Assistance Program
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Washington State Department of Ecology
Solid Waste & Financial Assistance Program

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Abstract

In 1991, the United States Environmental Protection Agency performed an analysis on the quality of domestic septage that formed the basis for managing septage under 40 CFR Part 503. That study was comprised of nine samples of domestic septage from Madison, Wisconsin. The results were used to determine loading rate calculations, based on the assumption that those nine samples had approximately the same probability distribution for pollutant concentrations as other domestic septage in the rest of the country.

The analysis discussed here examines domestic septage quality using real-world monitoring data from three different facilities in Washington State that deal primarily with domestic septage. A 95% confidence interval to estimate the mean concentration (μ) of pollutants and several nutrients in septage is determined and compared with the mean concentration of the corresponding EPA study characters. Compared to Washington State septage, this study finds that the EPA mean concentration value was below the 95% confidence interval for nine analytes (cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc), was within the confidence interval for two analytes (phosphorus and total Kjeldahl Nitrogen) and was above the confidence interval for two analytes (arsenic and ammonia). All mean concentration ranges for Washington septage are below the Table 3 pollutant concentration limits of 40 CFR Part 503.

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Introduction

Washington State's Chapter 173-308 WAC – *Biosolids Management* - sets the state standards for permitting, management, and land application of biosolids. Chapter 173-308 also addresses domestic septage, which is considered to be a form of biosolids. Biosolids that are applied to the land must meet strict requirements for pollutant concentrations and pathogen and vector attraction reduction. The amount of biosolids applied may be limited by the concentration of specific metals in the biosolids (outlined in WAC 173-308-160), but is usually determined by an agronomic rate calculation designed to prevent the leaching of nitrogen into ground water. The state rule includes both technical standards and a permit program. It is based on Federal rules adapted by the U.S. EPA under the Federal Clean Water Act.

In 1991, the EPA produced a study for their proposed 40 CFR 503 on the quality of domestic septage to develop loading rates for the land application of domestic septage. One grab sample was taken from each of nine trucks delivering domestic septage to the Madison Metropolitan Sewerage District in Madison, Wisconsin. Labs under contract with EPA performed the analysis. The results were assumed to be characteristic of domestic septage in Madison, and it was further assumed that domestic septage across the country has approximately the same probability distribution for pollutant concentrations (memo from Charles E. White to the EPA, 1992).

The Washington State Department of Ecology wanted to know how domestic septage in this state compares to the results of the 1991 EPA study. The intent of this comparison is to provide a better understanding of the quality of domestic septage in Washington, as well as to determine whether the application and loading rate calculations in the federal rule are appropriate for the state program.

For this comparison, monitoring data from three different facilities was compiled and analyzed. The facilities primarily handle domestic septage, but two of the three occasionally accept biosolids from small treatment works. The department does not have resources to engage a comprehensive sampling of septage sources and management facilities. Information from these facilities was used because it was available and was assumed to represent a real-world picture. The monitoring data and pollutant analyses provided by these facilities was performed by private laboratories.

It was recognized at the outset that there were some limitations using data from these facilities. The following assumptions were made. First, the material tested was primarily domestic septage and the relatively small amount of other types of biosolids was inconsequential. Second, the samples were obtained by a proper sampling method and there were no analysis or reporting errors. If grossly incorrect, these assumptions may impose some limitations on conclusions that are drawn, however the purpose of this short study was to look at information that was already available. Resources for a larger study with sampling and analysis performed by the department were not available at this time.

Statistical Methods

In order to determine the average concentration of pollutants in domestic septage for the State, a 95% confidence interval estimate of the population mean (μ) was calculated for each analyte (see Appendix A: Table 1). This means that we are 95% confident that the actual mean population value of the analyte concentration was in the range of the sample mean, plus or minus the variance of the data set ($\bar{x} \pm t \cdot s / \sqrt{n}$). Data from all three facilities was combined to form the sample set for each pollutant. The value of t used in these calculations is associated with a given area in the tail of a t-distribution and given degrees of freedom (ν) equal to $n-1$. For values of n that did not have a t-distribution value in the table (e.g. 50, 64, 48, 39, etc.), the next closest ν given in the table (either 40 or 60) was used. Because the number of samples was large, the value of t (approaching 1.96) changes very little as ν approaches infinity. Therefore the degrees of freedom used, even though they may not equal one minus the number of samples, should provide the precision needed in this study.

There are a variety of opinions regarding the value to record for analyte concentrations reported below the method detection limit (MDL). If the results are below the detection limit, are they assumed to be zero or should the value be set equal to or at some fraction of the method detection limit? The 1991 EPA Study used two different substitution methods (value equals zero if there was a non-detect at the MDL and value equals MDL if it was a non-detect) and reported the values for both methods. For this review, a zero value was used for those concentrations that were below the MDL for consistency and comparison with EPA's results (see Appendix A: Table 2) using the same substitution method. An exception was made for arsenic. The EPA study found no values above the method detection limit; consequently, use of a zero value would have resulted in a meaningless comparison to state numbers. Thus, the comparison was made by using the EPA substitution method that used the MDL value for the non-detects.

To test how the average pollutant concentration determined in this study compared to the average in the 1991 EPA study, a comparison of means was performed with a level of significance at $\alpha = 0.05$ (same level as the 95% confidence interval). Comparison of these means was based on the following null hypothesis:

The mean concentration of a pollutant, determined from this study, is equal to the mean concentration of the EPA study with 95% confidence.

This null hypothesis is used to compare the equality of EPA's mean pollutant concentrations with the results of this study. The comparison used the following equation:

$$t = \frac{\bar{x}_1 - \bar{x}_0}{s/\sqrt{n}}$$

where :

\bar{x}_1 = mean in Table 1

\bar{x}_0 = mean in Table 2

s = standard deviation of \bar{x}_1

n = number of samples

Validation or rejection of the null hypothesis is the basis for drawing conclusions about comparisons of the values obtained by the two studies. For all tests the result (t) must be $-1.96 < t < 1.96$ at the .05 level of significance to support the null hypothesis, thereby validating the null hypothesis. If $t_{\alpha/2}$ falls outside of this range then the null hypothesis is rejected, meaning that the EPA results and the results found in this study are statistically different.

Discussion of Results

Overall there was noticeable variation between samples for most pollutants as evidenced by their large standard deviations (see Appendix A: Table 1). Evaluating results of the state study by looking at any nine points, such as in the 1991 EPA study, would likely produce a different result. Fortunately, there were a large number of samples analyzed for most of the pollutants (most had $n \geq 30$), which increases the accuracy of the mean.

When the data are reviewed, a few individual data points for pollutant concentrations appear (intuitively) too high or too low when looking at the data as a whole. It was decided to retain these data points in the analysis, because of the assumptions that samples are statistically characteristic of the whole and that lab analysis was performed properly. However, it is possible that some of these apparently "uncharacteristic" spikes may be due to sampling, analysis, or reporting errors. It is also possible that the spikes are real. Regardless of the accuracy of these two explanations, concentration spikes such as those seen for lead (Appendix B: Chart 8) or zinc (Appendix B: Chart 20) should be examined closely by the facility operator after receipt of the lab results to attempt to verify the data's accuracy. It is beneficial for the operator and the Department of Ecology if questionable results are examined in a timely fashion. For the purposes of discussion, the results are split into three groups: metals of concern, nitrogen, and other constituents.

Metals of Concern

WAC 173-308-160 and 40 CFR 503.13 establishes the pollutant concentration limits for nine pollutants of primary concern, these are: arsenic, cadmium, copper, lead, mercury, nickel, selenium, zinc, and molybdenum. With the exception of the Table 1 ceiling value, EPA is reevaluating the Part 503 pollutant limits for molybdenum. The original pollutant concentration limit from Table 3 (18mg/kg) provides an interim benchmark for comparison in this study.

There were several sample measurements for zinc (Appendix B: Chart 20), copper (Appendix B: Chart 6), and lead (Appendix B: Chart 8) that exceeded the Table 3 pollutant concentration

limits. These spikes did not occur regularly and appear as anomalies when the data is viewed on the whole. These may be the result of sampling, analytical, or reporting errors. Accepting for the moment that those values may be correct, the most important observation is that the estimates of the pollutant concentration averages (95% confidence estimation of μ) are *well below* the pollutant concentration limit for all of the metals of concern (see Appendix A: Table 1).

The data suggest that concentrations for cadmium 3.62 ± 0.65 mg/kg (Appendix B: Chart 4), nickel 20.80 ± 4.10 mg/kg (Appendix B: Chart 11), and selenium 4.26 ± 0.91 mg/kg (Appendix B: Chart 16) are consistently low and of a relatively constant concentration. Lead is also relatively constant (86.60 ± 50.4 mg/kg), with the exception of a few values that approached or exceeded the Part 503 pollutant concentration limit; these apparent spikes do not appear to be characteristic of the average lead concentration. Cadmium, copper, lead, molybdenum, nickel, selenium, and zinc all had $t_{0.025}$ values well above 1.96 (see Appendix A: Table 1); lead was closest with $t_{0.025} = 3.29$. Consequently, the null hypothesis is rejected and therefore a difference between those metal concentrations in the EPA study and Washington septage is distinguished in this study.

This review found that the 95% confidence estimate for arsenic (6.9 ± 1.4 mg/kg) was the only metal where the 1991 EPA study was above the mean concentration of Washington septage (Appendix B: Chart 2). A comparison of the means showed that, at an $\alpha = .05$ level of significance, the means are close but still not close enough ($t_{0.025} = -2.61$) to accept the null hypothesis that they are statistically the same. The difference may be due in part to the EPA value, based on using the MDL value for non-detectable analytes. There was one non-detectable sample for arsenic in the Washington septage, and the value of the method detection limit was used (10mg/kg) instead of zero. This MDL value was higher than the majority of concentration values used in this study. If the EPA study also had similar results then their actual concentration may have been much closer to that found in Washington.

The mean concentration of mercury in Washington septage was found to be 3.12 ± 1.04 mg/kg with 95% confidence (Appendix B: Chart 9). A comparison with the EPA study showed the mean concentration of mercury in this study to be significantly higher than EPA's mean concentration ($t_{0.025} = 5.94$), thereby rejecting the null hypothesis. Although the mean value for mercury was still below the Part 503 pollutant concentration limit, the magnitude of the difference in mercury estimations between Washington septage and Wisconsin septage in the EPA study (0.06 mg/kg) calls attention to mercury. This suggests that additional evaluation, by the state or the EPA, of mercury in septage might be helpful. The evaluation might include additional monitoring or reevaluation of analytical methods to insure consistency and accuracy at the local level.

Nitrogen

One of the most difficult qualities to get a firm grasp on was the inorganic nitrogen content of septage. The monitoring data was generally presented in wet weight figures, which then had to be converted to dry weight concentrations using the percent solids for each sample analysis. Because the percent solids of the samples were very low, small errors in the solids concentration value can translate to large errors when converting to dry weight basis. There are many factors affecting the concentration of inorganic nitrogen in biosolids. The lime stabilization method for treating the septage at one of the facilities and the aerated lagooned septage at another are two

treatment methods that increase the volatilization rate of ammonia¹. There is also a difference in that the EPA study sampled septage directly from the pumping trucks versus the sampling performed in this study; which may have differed because of the sampling method, handling of samples, or the analysis.

In general, the nitrogen data analyzed compared fairly well with the 1991 EPA septage data for total Kjeldahl nitrogen (TKN). The mean concentration of TKN in Washington septage (Appendix B: Chart 19) was found to be $23,100 \pm 3400$. The comparison to the EPA study found that the levels of TKN between this and the EPA study are statistically the same ($t_{0.025} = -0.29$) thereby accepting the null hypothesis.

Ammonia was found to have a mean concentration of $5,100 \pm 1,040$ mg/kg (Appendix B: Chart 1), which was far below the EPA mean of 12,700mg/kg. As discussed previously, this can be interpreted several ways due to the reactive properties of inorganic nitrogen during treatment of the septage. It is possible that the initial ammonia content of the septage from the three Washington State facilities had approximately the same content as the Wisconsin septage from the EPA study (the same as EPA's assumption). Alternatively, the actual concentration of ammonia may be highly variable in septage and may not have a normal probability distribution. Timing of sampling in the Washington study may also have allowed for greater volatilization of ammonia than in the EPA study.

A follow-up test where samples are obtained in the same manner as the EPA study and analyzed for ammonia concentration would eliminate this uncertainty. However, this invalidates the initial assumption that all the data analyzed in this study reflects "real-world" data. The significant conclusion from this comparison is that data obtained for septage in Washington are more conservative than those used by the EPA for determining nitrogen loading rates. Consequently the inorganic nitrogen immediately available following land application would be less than what is expected when using EPA's application rate calculation.

The nitrate and nitrite (as N) data, shown in Chart 12 (Appendix B), is a combination of nitrate + nitrite concentrations given in the analysis results and nitrate concentrations (apart from nitrite) that also came from the lab analysis results. The estimate of the concentration mean was found to be 65.40 ± 23.9 mg/kg. Because nitrate usually makes up a small part of septage and biosolids (and nitrite to an even lesser extent) the analysis often did not detect any nitrate above the method detection limit (MDL). As discussed previously, a zero value was recorded where there was no detection of nitrate or nitrite above the MDL. There was no EPA concentration value to compare to this data.

Other Constituents

In addition to Part 503 pollutants and nitrogen content, data on 5 other metals was reviewed (barium, chromium, iron, potassium, and silver) as well as phosphorus and the total solids content and pH of the samples. The 1991 EPA septage quality study also covered phosphorus and chromium content so a comparison of means is possible. The data for the concentrations of barium (Appendix B: Chart 3), iron (Appendix B: Chart 7), and silver (Appendix B: Chart 17)

¹ Henry, C., et. al., 1999. Managing Nitrogen from Biosolids.

was analyzed to estimate the mean concentration with a 95% confidence interval. However, there are no standards for these in either the federal or state rules, and a comparison of means could not be performed. Monitoring data for these is not necessarily required in the conditions of a facility's solid waste or biosolids permit; consequently that data is not always available from each facility or it is not consistently monitored over time. Nevertheless, the smallest sample size (n =14 for barium) is still larger than the nine samples used by the EPA.

Phosphorus (Appendix B: Chart 14) was highly variable with a mean of $4,900 \pm 1,660$ mg/kg. Compared to the EPA study mean, this study found phosphorus concentrations to be statistically the same ($t_{0.025} = 0.39$) thereby accepting the null hypothesis. Presumably this is the result of the wide variability of phosphorus in Washington septage. The importance of phosphorus concentrations in soils is of growing concern for soil scientists in some areas. Phosphorus is the limiting nutrient in aquatic ecosystems that can cause significant eutrophication of surface and well waters. Monitoring of this nutrient may become more and more important in the coming years with an increasing focus on ground and surface water quality.

The mean pH estimate was found to be 8.89 ± 0.77 pH units (Appendix B: Chart 13). Although there is not a comparative value from the EPA study, this alkaline pH is consistent with what would be expected from a material with a high concentration of ammoniacal compounds.

Comparative Summary

This analysis shows that there are some statistically significant differences present in the septage looked at in this study compared to the results obtained by the EPA in its 1991 study. These differences, however, are still within regulatory limits. The nitrogen value of septage in this study was found to be conservative compared to EPA's result. As a result of being a little conservative, the nitrogen loading rate calculations in both state and federal regulations over-estimate the amount of nitrogen applied to the land from domestic septage, further protecting the soil and water quality of the state.

References:

Chapter 173-308 WAC Biosolids Management

Henry, C., Sullivan, D., Rynk, R., Dorsey, K., Cogger, C. 1999. Managing Nitrogen from Biosolids. Draft publication.

McCormick, David, and Roach, Alan. 1987. Measurement, Statistics and Computation. John Wiley & Sons, Great Britain.

U.S. Environmental Protection Agency. 1993 40 CFR Part 503. Standards for the Use or Disposal of Sewage Sludge.

U.S. Environmental Protection Agency. Technical Support Document for Land Application of Sewage Sludge Volume II. US EPA 822/R-93-001B.

White, Charles E. 1992. "Summary Statistics for EPA's Study on the Quality of Domestic Septage". Technical Support Document for Land Application of Sewage Sludge Volume II. US EPA 822/R-93-001B. pp. 25-65.

Appendix A

Tables

Table 1: Constituent Concentrations in Septage

Pollutant	Units	Pollutant Concentration		n	StDev	Estimate of μ with 95% Confidence Interval		$t_{0.025}^*$
		Mean	Limit			lower limit	upper limit	
AMMONIA	mg/kg	5,100	NA	66	4,240	4,060	6,140	-14.56
ARSENIC	mg/kg	6.90	41	50	4.90	5.50	8.30	-2.61
BARIUM	mg/kg	427.00	NA	14	373.00	212.00	642.00	
CADMIUM	mg/kg	3.62	39	50	2.27	2.97	4.27	9.32
CHROMIUM	mg/kg	21.40	NA	50	15.80	16.90	25.90	5.39
COPPER	mg/kg	445.00	1500	50	301.00	359.00	531.00	7.80
IRON	mg/kg	5,880	NA	15	4,620	3,320	8,440	
LEAD	mg/kg	86.60	300	49	176.00	35.80	137.00	3.29
MERCURY	mg/kg	3.12	17	48	3.57	2.08	4.16	5.94
MOLYBDENUM	mg/kg	5.39	18 (RE)	40	4.20	4.05	6.74	7.62
NICKEL	mg/kg	20.80	420	49	14.20	16.70	24.90	8.05
NITRATE + NITRITE (as N)	mg/kg	65.40	NA	91	114.00	41.50	89.30	2.43
pH	STD UNITS	8.89	NA	39	2.39	8.12	9.66	
PHOSPHORUS	mg/kg	4,900	NA	41	5,250	3,240	6,560	0.39
POTASSIUM	mg/kg	3,880	NA	44	4,270	2,580	5,180	
SELENIUM	mg/kg	4.26	100	48	3.11	3.36	5.17	8.41
SILVER	mg/kg	5.36	NA	15	5.29	2.44	8.29	
SOLIDS	%	3.62	NA	64	5.48	2.25	4.99	
TOTAL KJELDAHL NITROGEN	mg/kg	23,100	NA	67	14,100	19,700	26,500	-0.29
ZINC	mg/kg	1,140.00	2800	50	808.00	909.00	1,370.00	4.99

These values represent the data set for three Washington State facilities treating domestic septage for the monitoring years of 1991-1998 (not all years were covered by two of the three). Dry weight mg/kg were calculated for measurements given in weight weight or other determinations. Percent solids from a specific sample set where possible. Wherever a percent solids was not given, the average percent solids of the entire data set was used for dry weight conversions. Pollutants not detected above the method detection limit (MDL) were reported here as zero. The pollutant concentration limits are the values listed in Table 3 of WAC 173-308-160 (RE means the pollutant concentration limit is being re-evaluated by the EPA).

*The Student's T-test to compare means was used to accept or reject the null hypothesis that the mean of a pollutant in this study was equal to the mean of the pollutant in the 1991 EPA study with a level of significance of $\alpha = 0.05$, σ was substituted with s.

Table 2: Concentrations of Pollutants in Septage from 1991 U.S. EPA Study

Pollutant	Units	Mean	n	StDev	Min Value	Median	Max Value	Coeff of Variation
AMMONIA	mg/kg	12,700	9	19,200	78	8,210	61,300	151.00
ARSENIC	mg/kg	8.71	9	11.80	0.14	3.04	30.60	135.00
BARIUM*								
CADMIUM	mg/kg	0.63	9	1.05	0.00	0.00	2.77	166.00
CHROMIUM	mg/kg	9.36	9	11.40	0.00	6.92	35.30	122.00
COPPER	mg/kg	113.00	9	123.00	0.81	105.00	328.00	108.00
IRON*								
LEAD	mg/kg	3.96	9	8.20	0.00	0.00	24.80	207.00
MERCURY	mg/kg	0.06	9	0.11	0.00	0.00	0.35	189.00
MOLYBDENUM	mg/kg	0.33	9	0.98	0.00	0.00	2.95	300.00
NICKEL	mg/kg	4.47	9	8.62	0.00	0.00	26.80	193.00
NITRATE + NITRITE (as N)	mg/kg	36.40	9	34.9	0.00	32.40	91.20	95.90
pH*								
PHOSPHORUS	mg/kg	4,580	9	3,150	176	3,500	10,700	68.70
POTASSIUM*								
SELENIUM	mg/kg	0.49	9	1.00	0.00	0.00	2.74	206.00
SILVER*								
SOLIDS*								
TOTAL KJELDAHL NITROGEN	mg/kg	23,600	9	3,150	176	3,500	10,700	68.70
ZINC	mg/kg	570.00	9	439.00	43.70	433.00	1,290.00	77.10

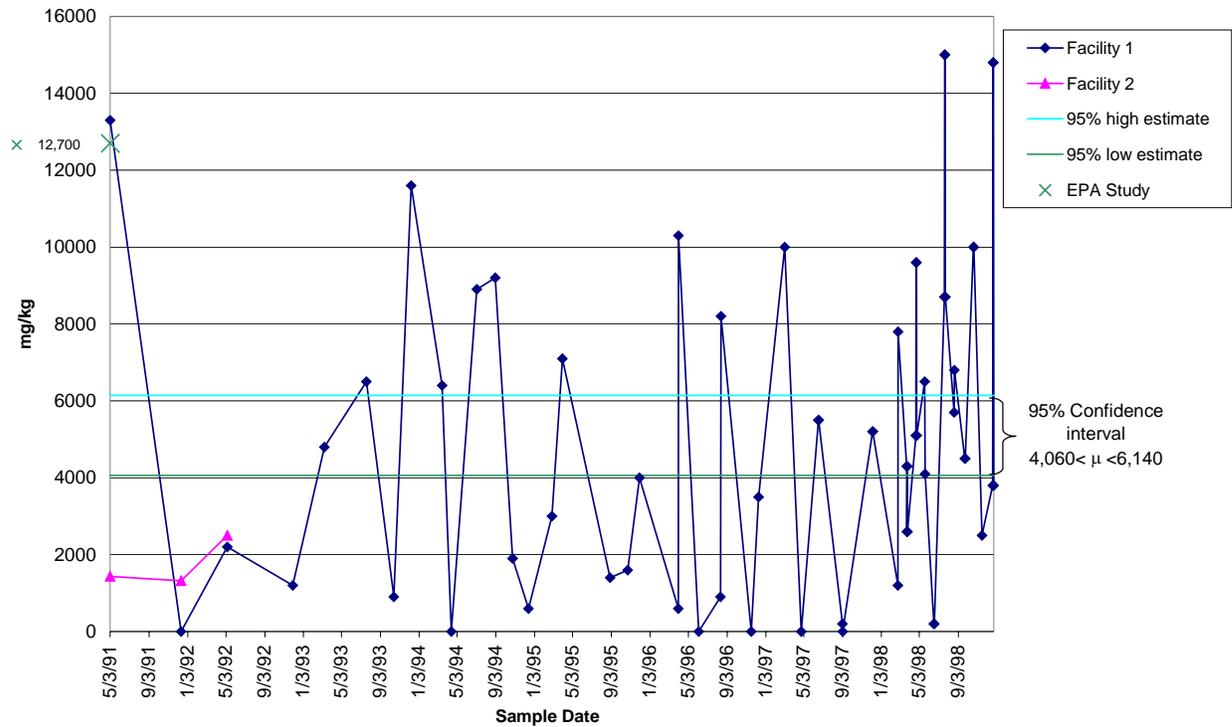
Values obtained from a 1991 U.S. EPA Memorandum titled "Summary Statistics for EPA's Study on the Quality of Domestic Septage" from Charles E. White to Alan Rubin. These results come from the Substitution Method SM-0 (where non-detect values below the MDL are equal to zero) to be consistent with calculations for septage from the three Washington State facilities. The only exception is arsenic because it was not detected by the EPA above the MDL a zero value would result, therefore the other calculation was used where the value of non-detects above the MDL was equal to the MDL. This allowed for a comparison between the EPA study and the data in Table 1. Dry Weight Concentrations are given.

* EPA Study did not address these in their statistical summary.

Appendix B

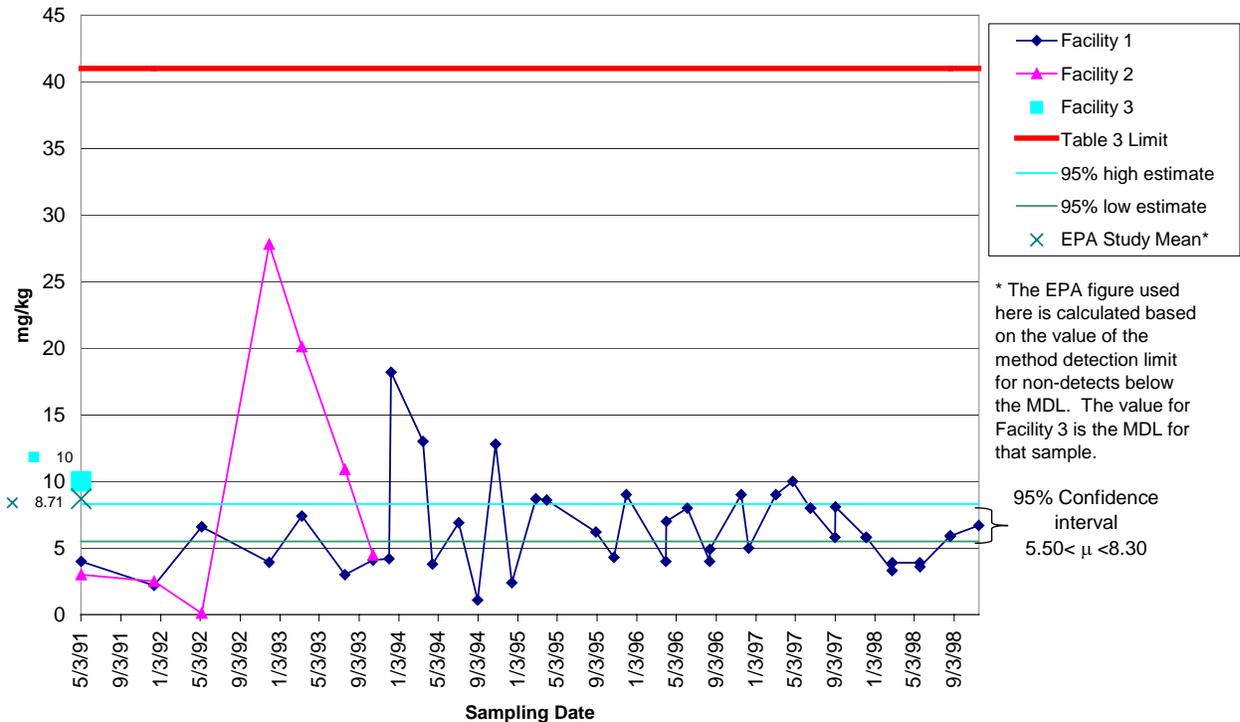
Charts

**Chart 1: Ammonia Monitoring for Domestic Septage in Washington State
1991-1998**



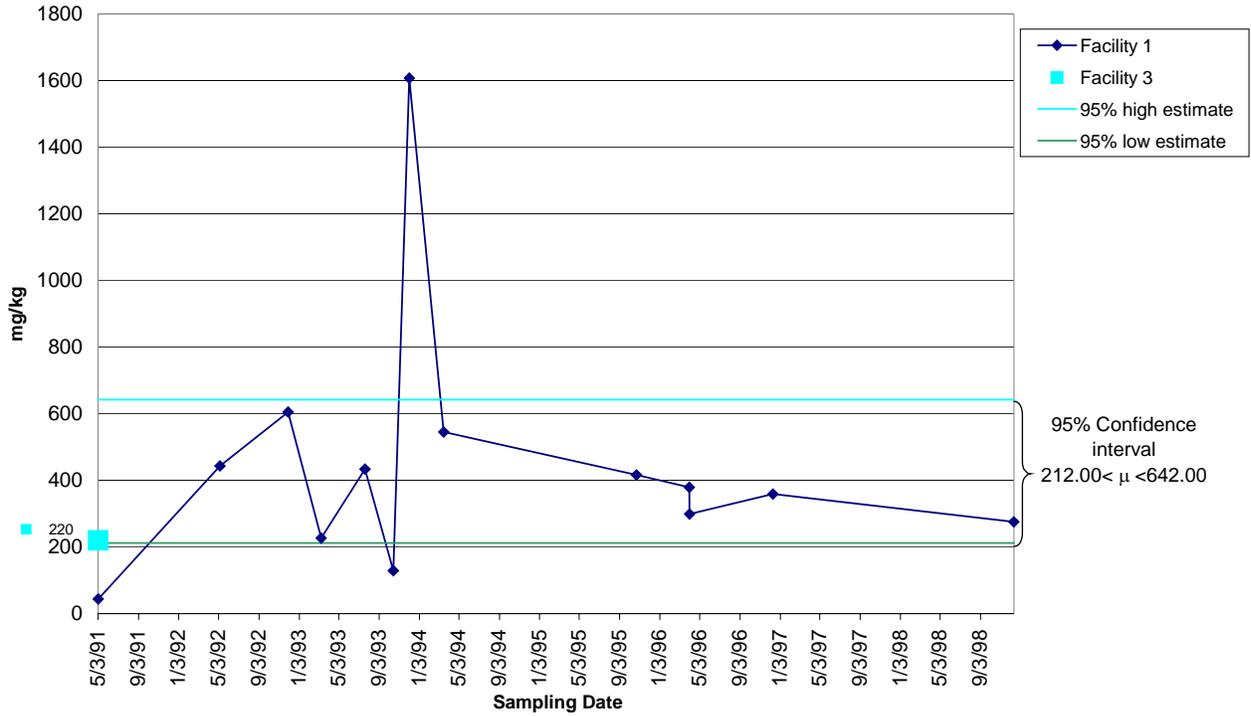
Dates apply to Facility 1 only. Facility 2 data do not correspond to these dates.

**Chart 2: Arsenic Monitoring for Domestic Septage in Washington State
1991-1998**



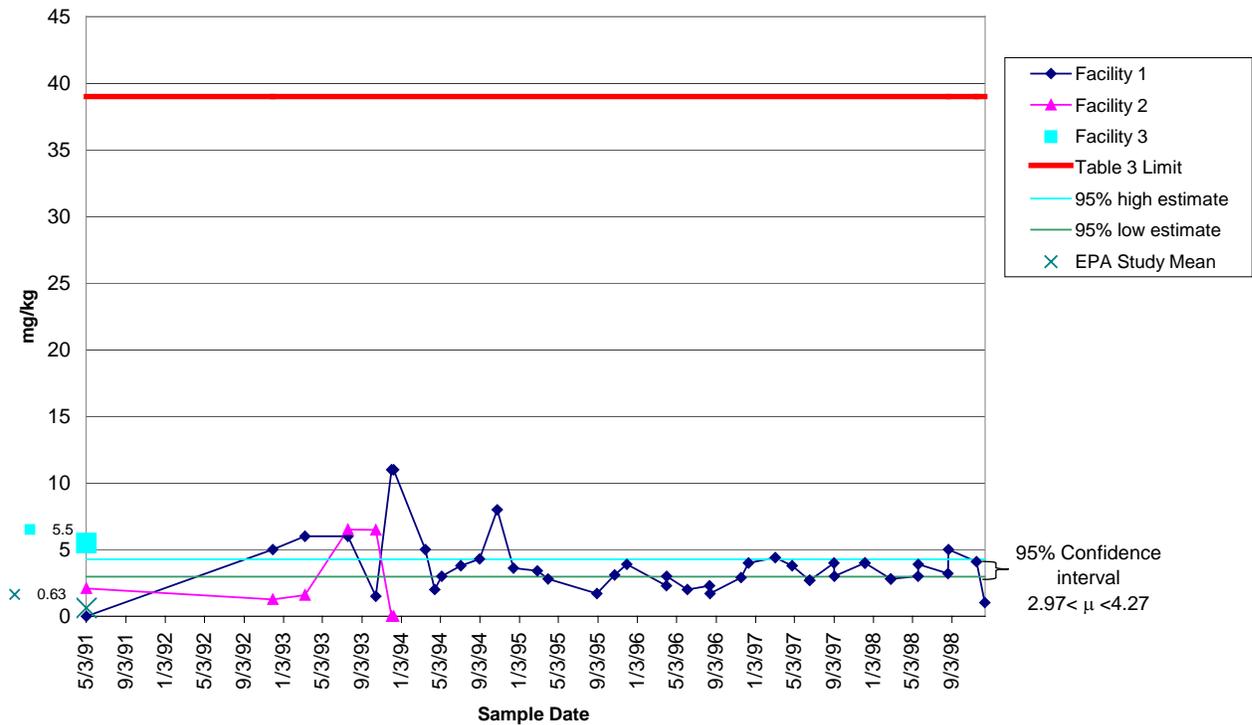
Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

**Chart 3: Barium Monitoring for Domestic Septage in Washington State
1991-1998**



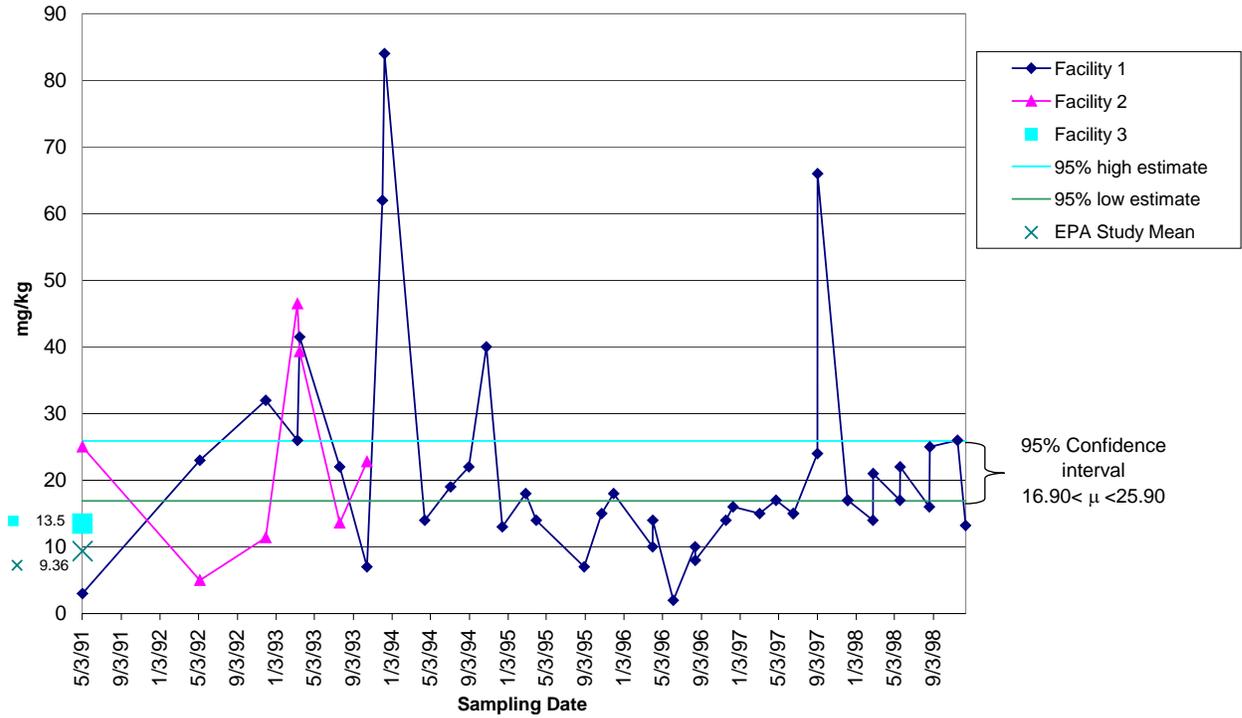
Dates apply to Facility 1 only. Facility 2 data do not correspond to these dates.

**Chart 4: Cadmium Monitoring for Domestic Septage in Washington State
1991-1998**



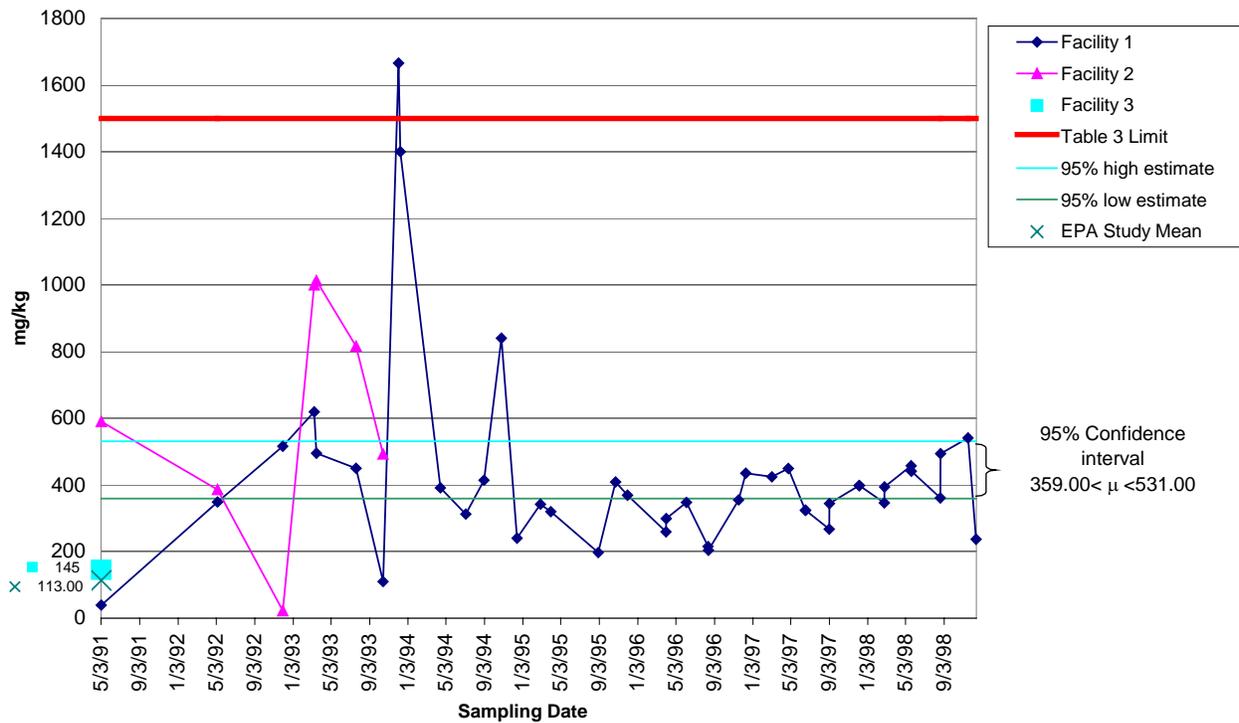
Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

**Chart 5: Chromium Monitoring for Domestic Septage in Washington State
1991-1998**



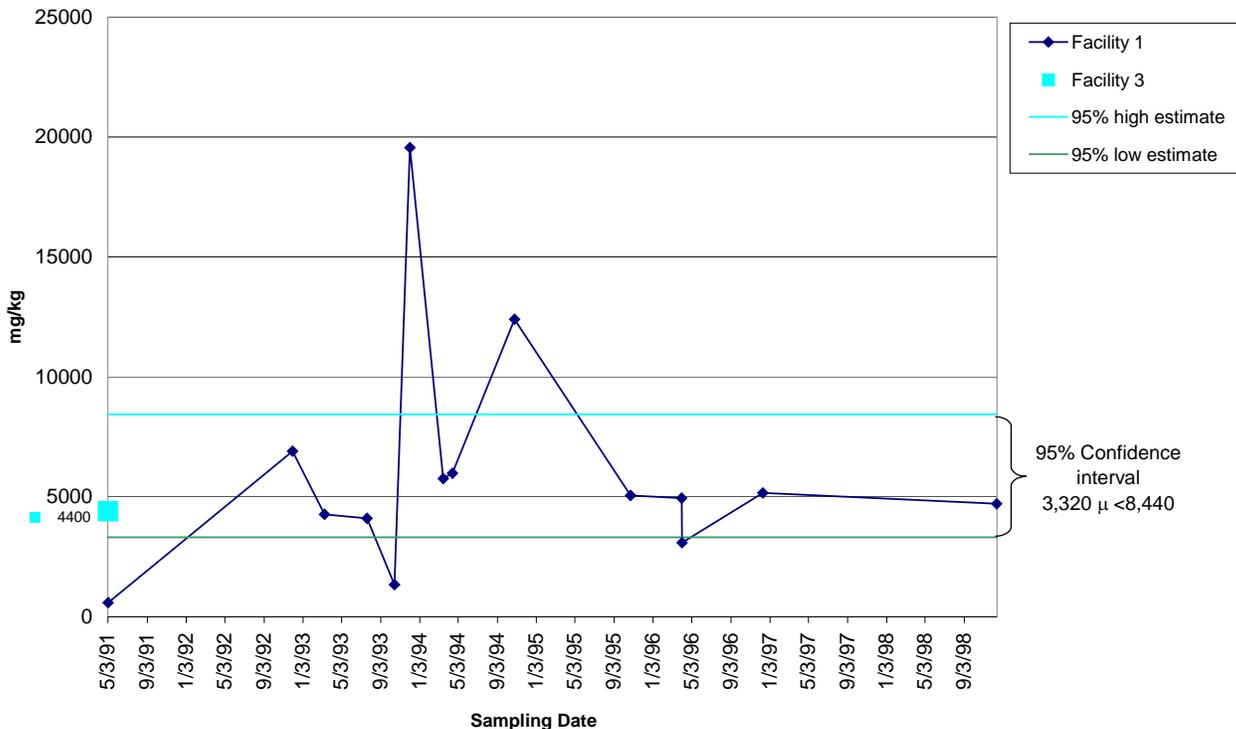
Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

**Chart 6: Copper Monitoring for Domestic Septage in Washington State
1991-1998**



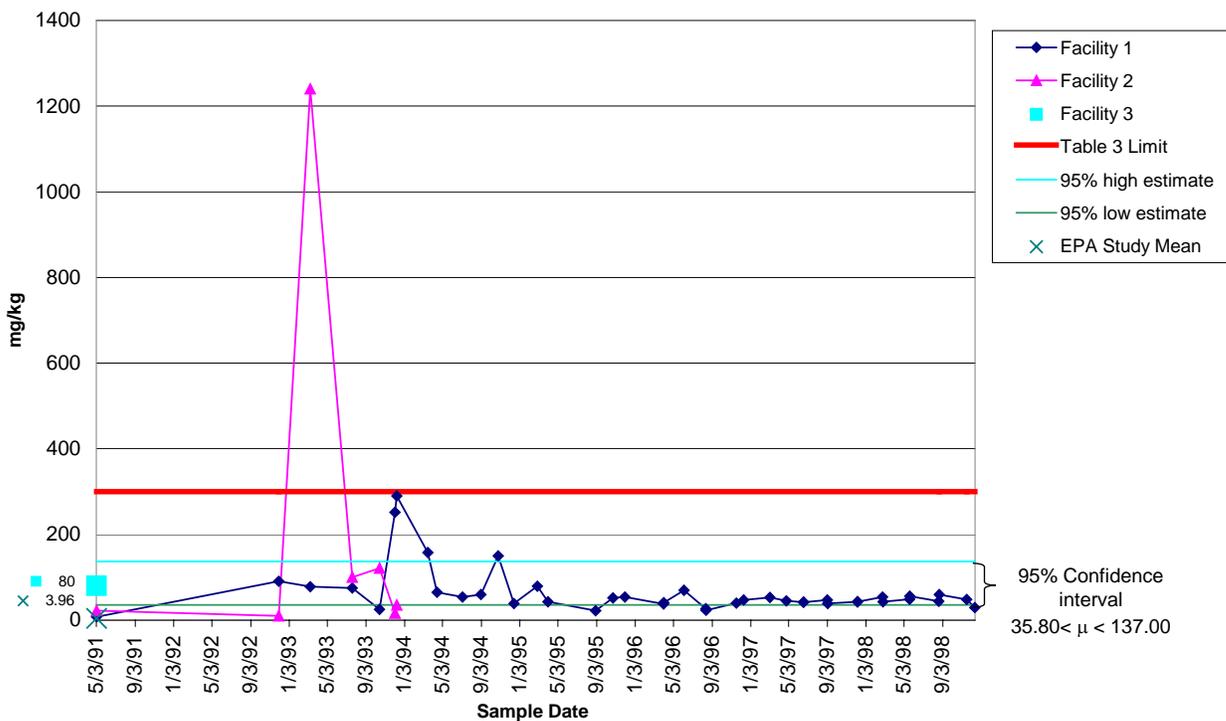
Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

**Chart 7: Iron Monitoring for Domestic Septage in Washington State
1991-1998**



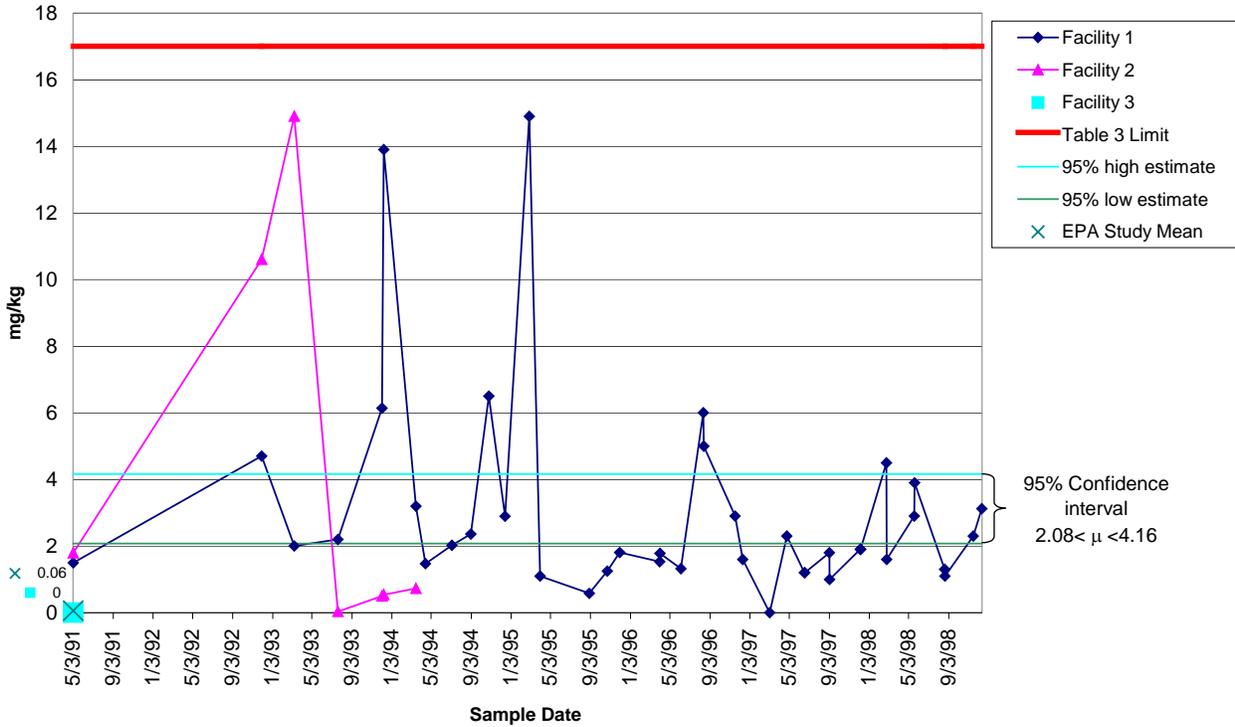
Dates apply to Facility 1 only. Facility 3 data do not correspond to these dates.

**Chart 8: Lead Monitoring for Domestic Septage in Washington State
1991-1998**



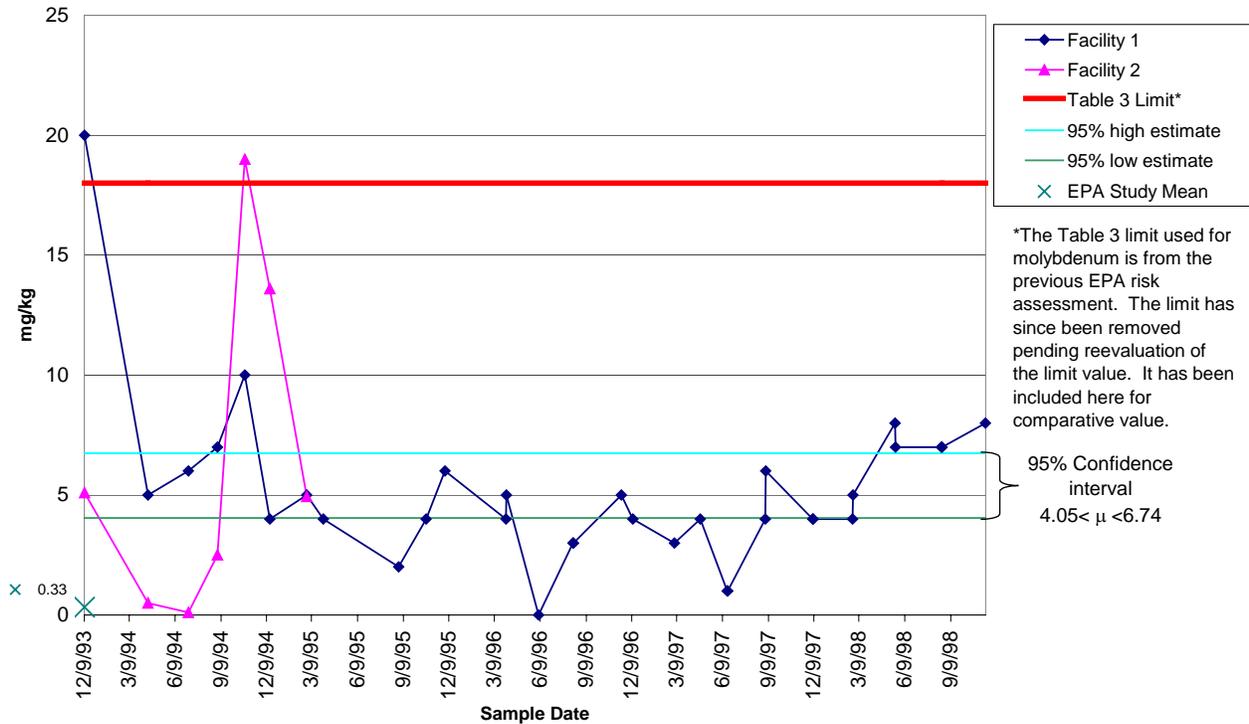
Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

**Chart 9: Mercury Monitoring for Domestic Septage in Washington State
1991-1998**



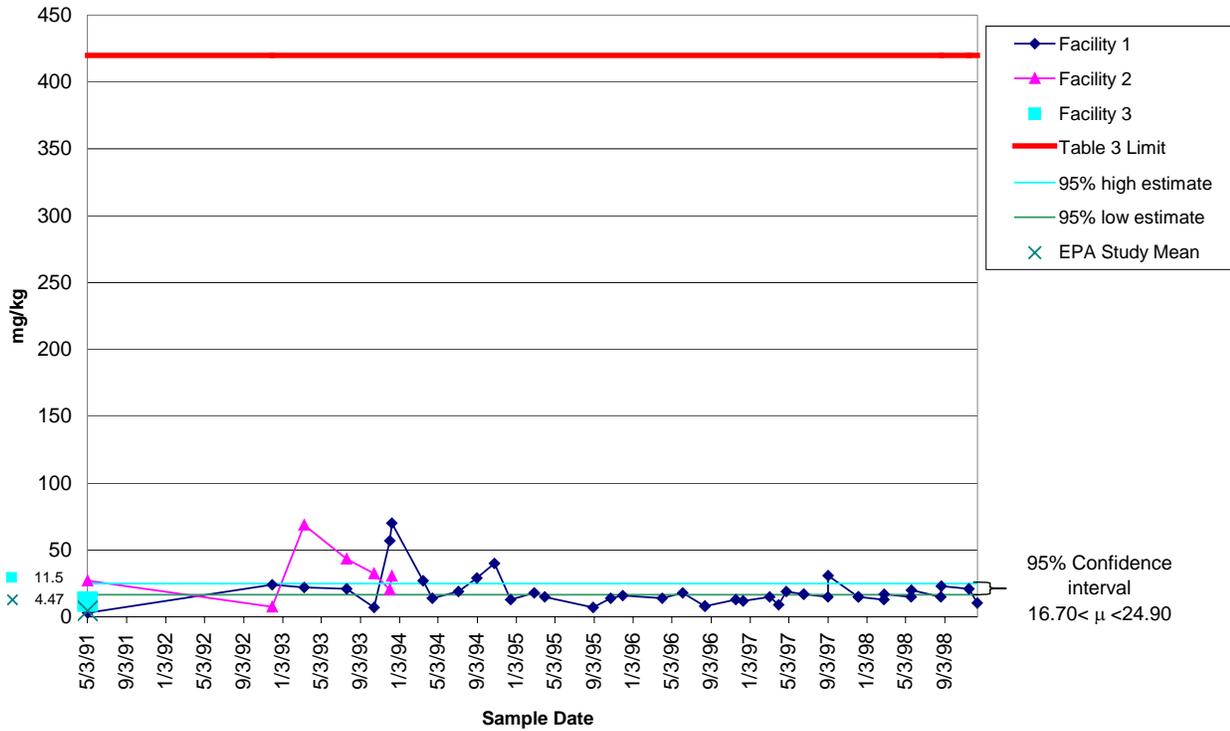
Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

**Chart 10: Molybdenum Monitoring for Domestic Septage in Washington State
1993-1998**



Dates apply to Facility 1 only. Facility 2 data do not correspond to these dates.

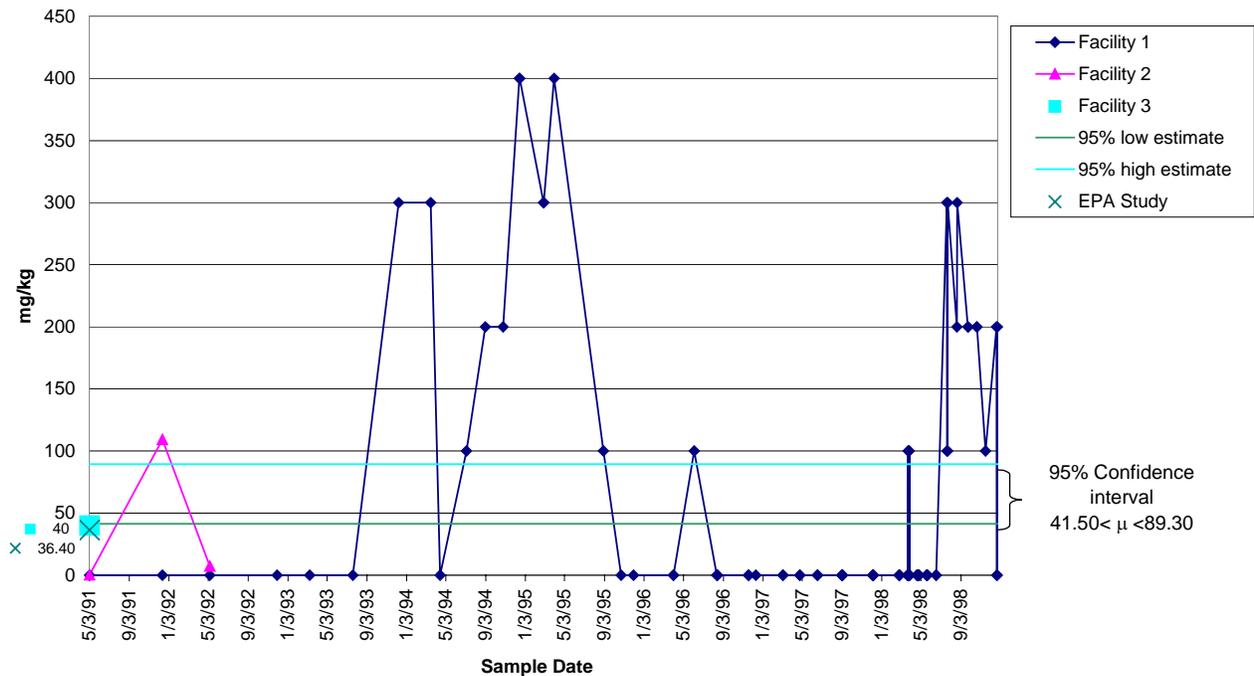
Chart 11: Nickel Monitoring for Domestic Septage in Washington State 1991-1998



Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

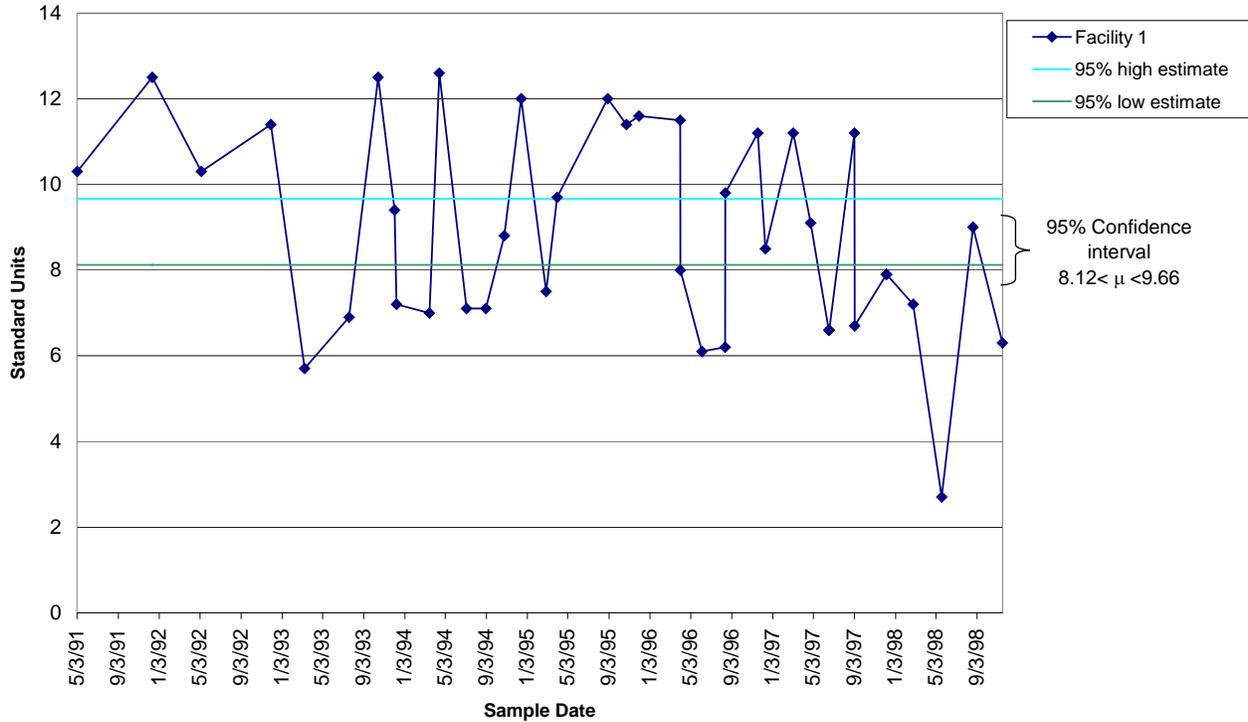
Chart 12: Nitrate + Nitrite (as N) Monitoring for Domestic Septage in Washington State 1991-1998

Note: Concentrations not detected at the MDL are consistently reported here as a zero amount. Nitrite concentrations from Facility 1 are also included and in some cases were originally reported as both nitrite and nitrate concentrations combined.

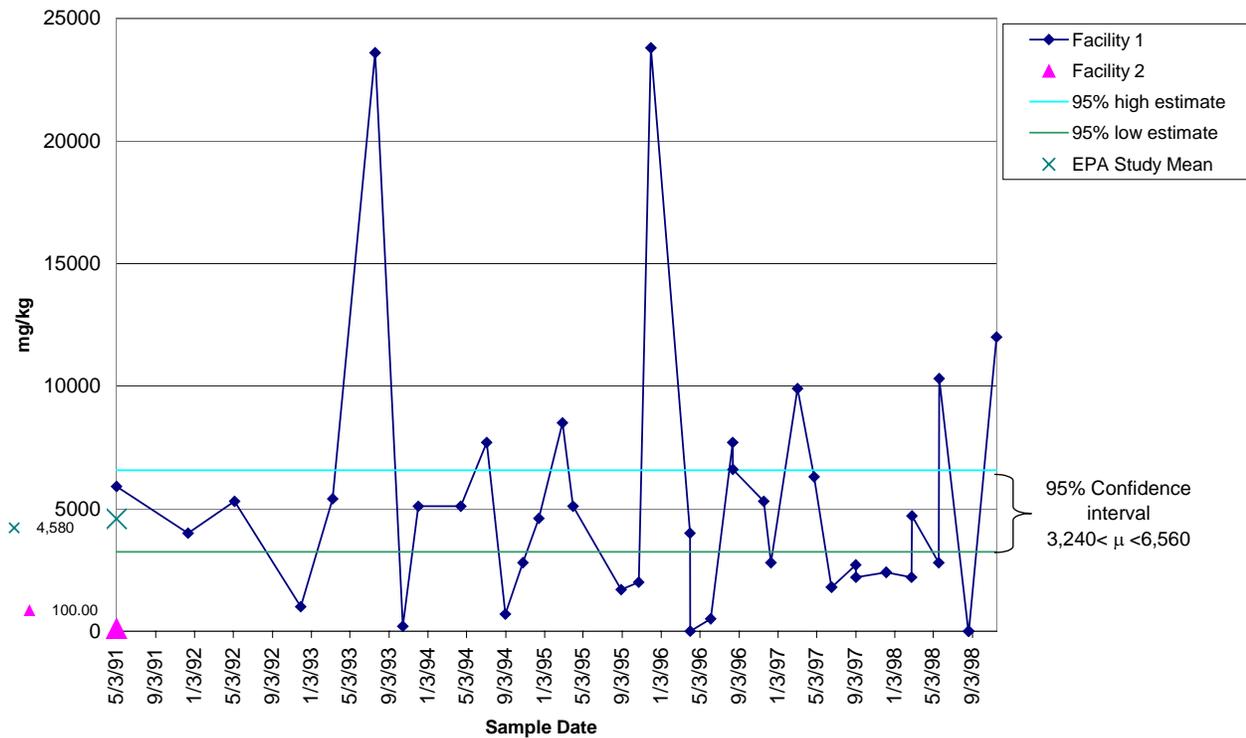


Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

**Chart 13: pH Monitoring from Domestic Septage in Washington State
1991-1998**

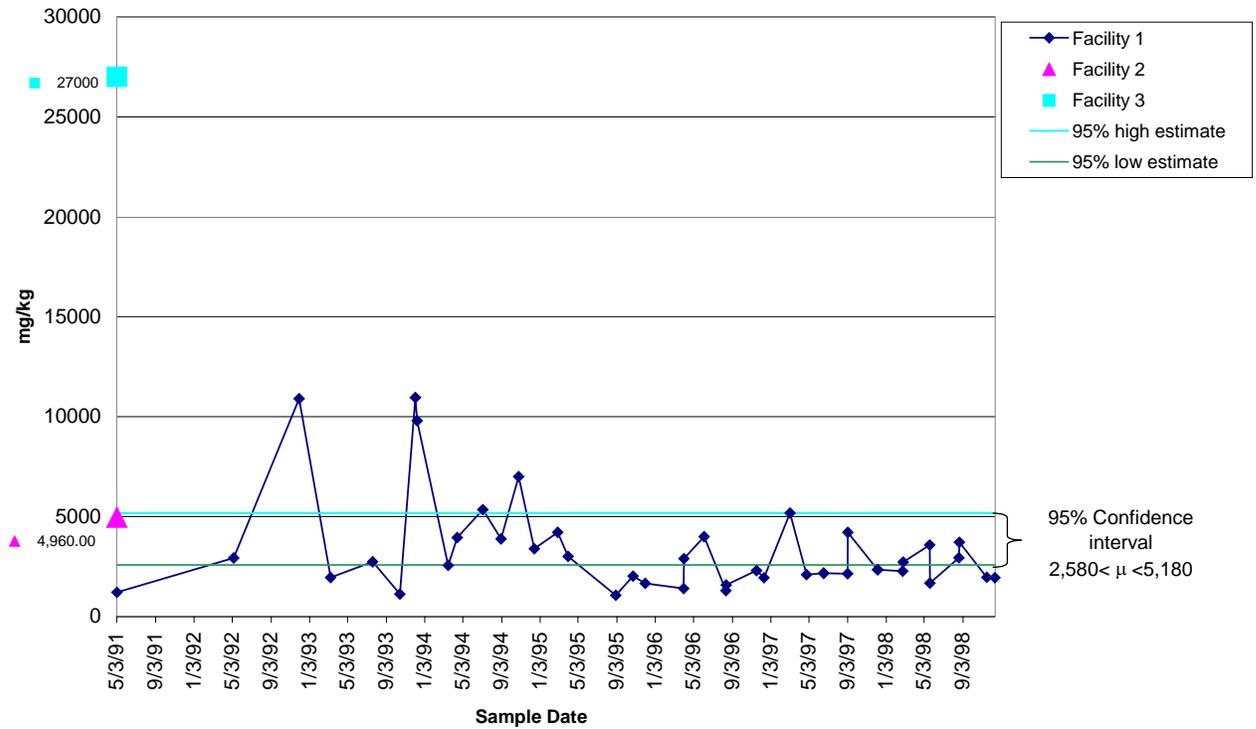


**Chart 14: Phosphorus Monitoring for Domestic Septage in Washington State
1991-1998**



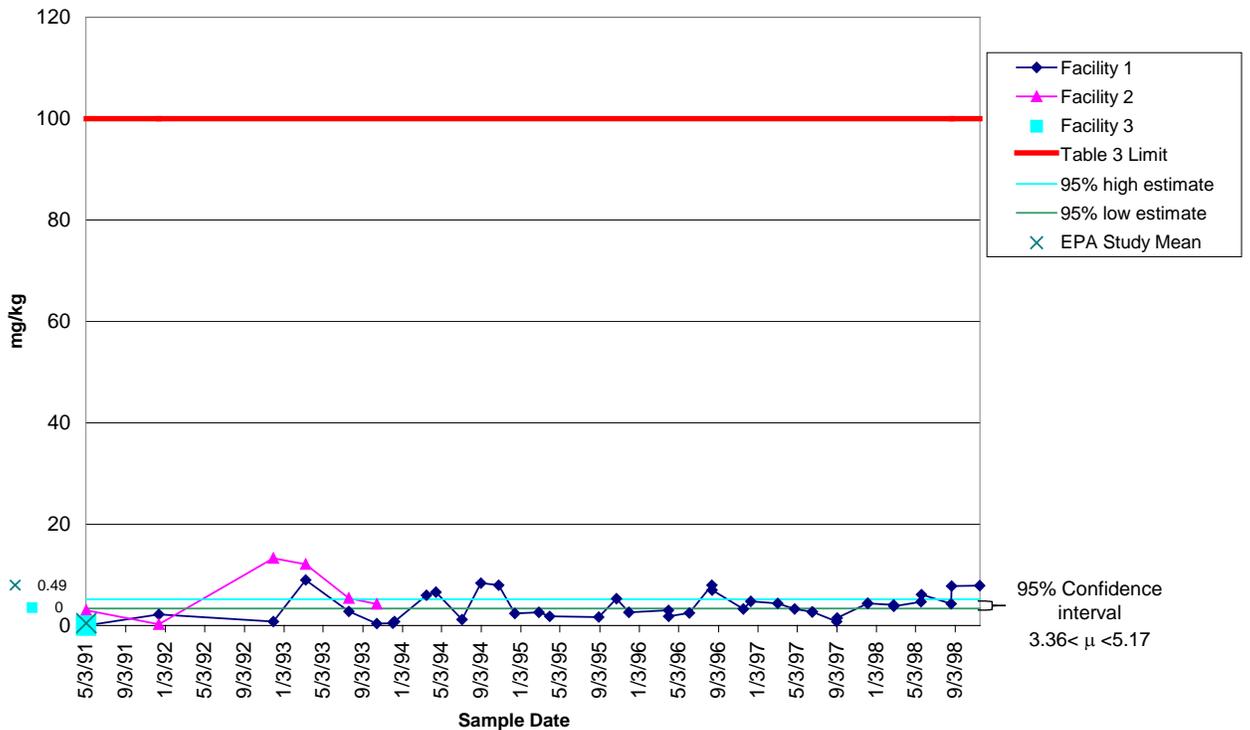
Dates apply to Facility 1 only. Facility 2 data do not correspond to these dates.

**Chart 15: Potassium Monitoring for Domestic Septage in Washington State
1991-1998**



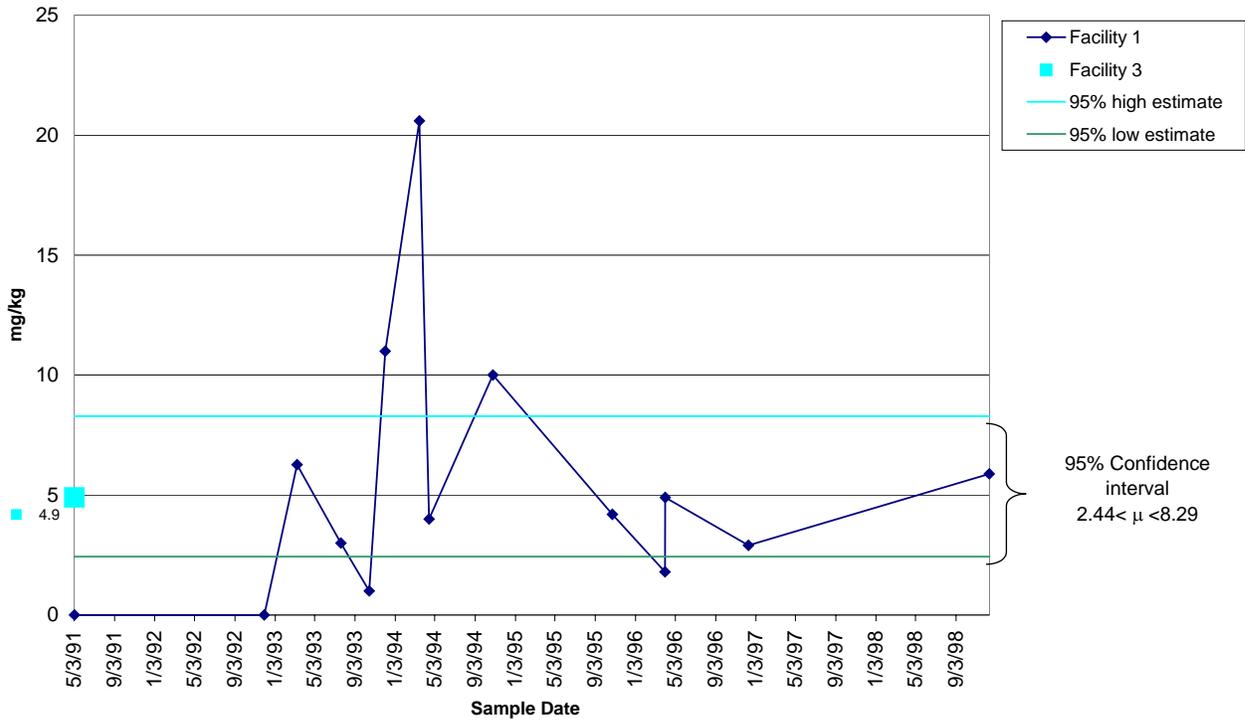
Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

**Chart 16: Selenium Monitoring for Domestic Septage in Washington State
1991-1998**



Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

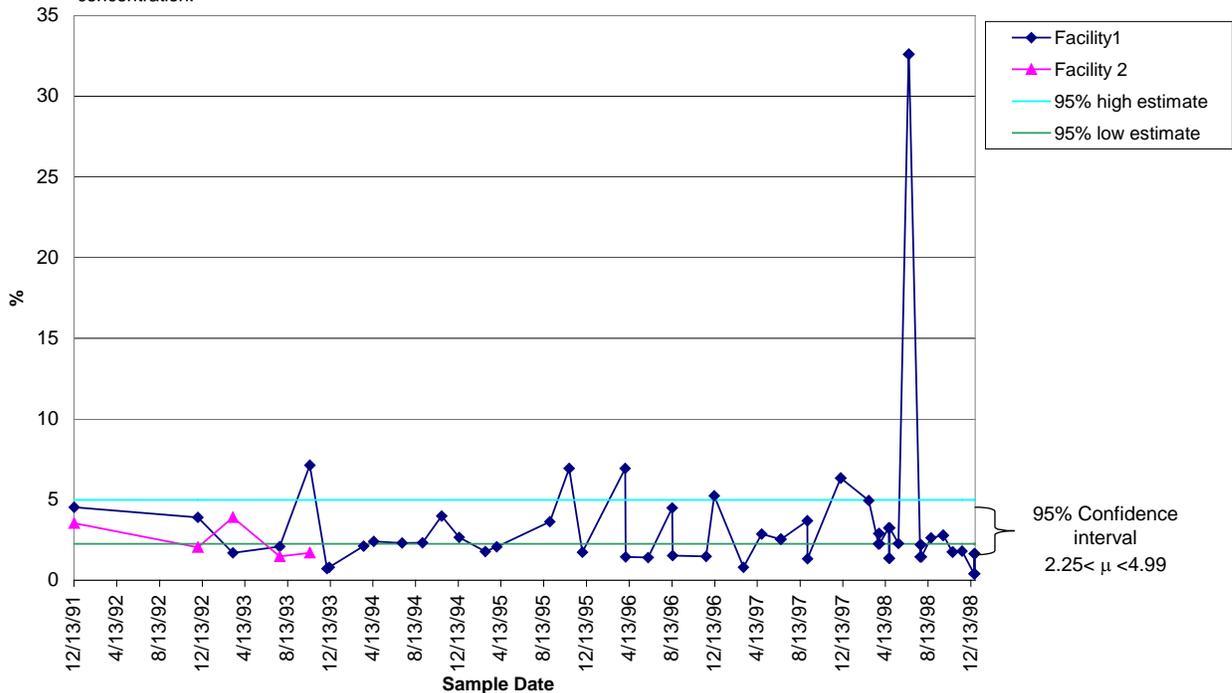
**Chart 17: Silver Monitoring for Domestic Septage in Washington State
1991-1998**



Dates apply to Facility 1 only. Facility 3 data do not correspond to these dates.

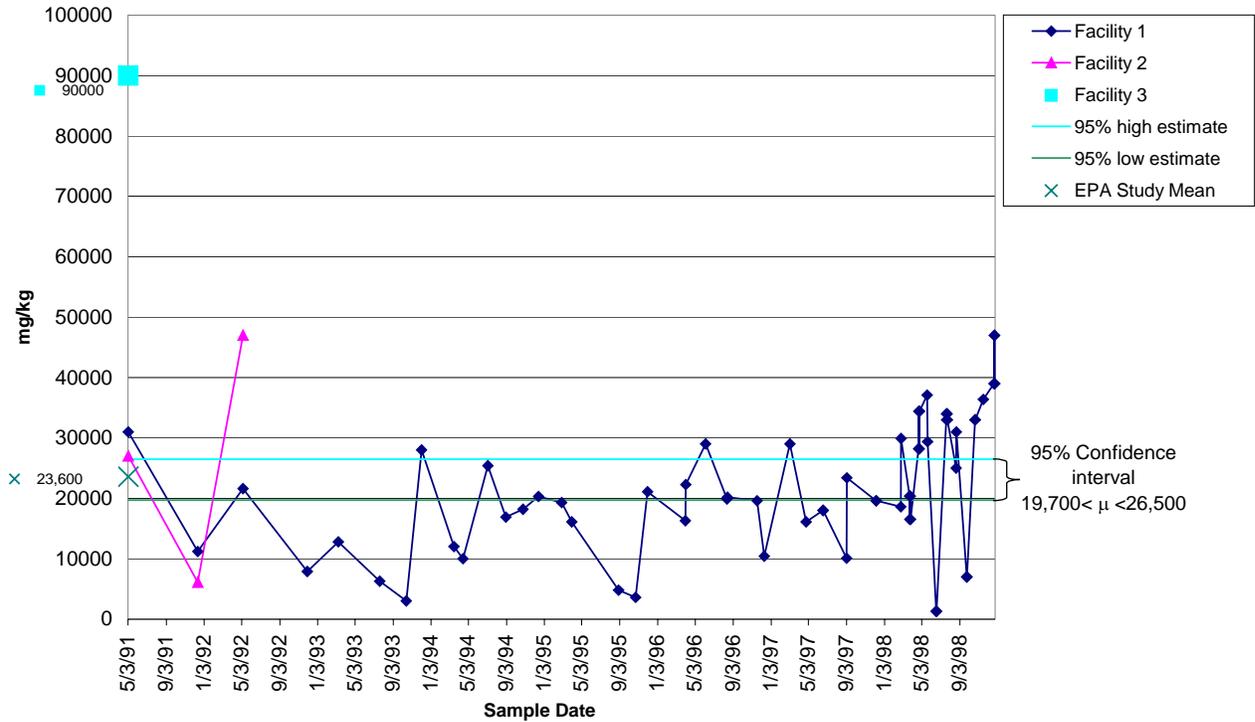
**Chart 18: Total Solids Monitoring for Domestic Septage in Washington State
1991-1998**

Note: The percent solids for the analysis on 6/19/1998 was reported by the lab as 32.6% solids. However, this is likely a mistake in reporting from the lab as that value is too high for normal sampling. It was not included with the data for calculating the average solids concentration.



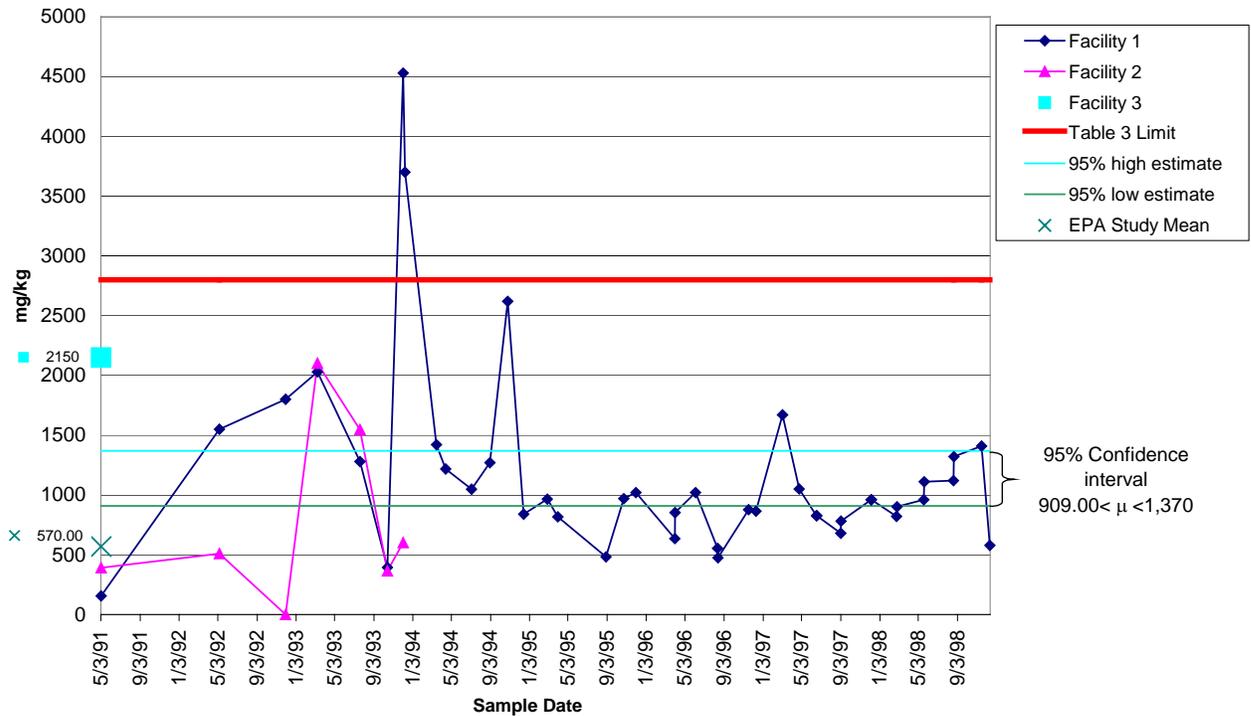
Dates apply to Facility 1 only. Facility 2 data do not correspond to these dates.

Chart 19: Total Kjeldahl Nitrogen Monitoring for Domestic Septage in Washington State 1991-1998



Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.

Chart 20: Zinc Monitoring for Domestic Septage in Washington State 1991-1998



Dates apply to Facility 1 only. Data for Facilities 2 and 3 do not correspond to these dates.