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MCAS EL TORO
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Cal/EPA

July 24, 1996

Department of Toxic Substances Control

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COMMENTS ON TECHNICAL MEMORANDUM BACKGROUND AND REFERENCE LEVELS REMEDIAL INVESTIGATION, MARINE CORPS AIR STATION (MCAS) EL TORO

Dear Mr. Joyce:

The California Environmental Protection Agency (Cal/EPA) has completed the review of the above subject document dated June 1996, prepared by Bechtel National, Inc. The technical memorandum presents the procedures and results for the calculation of background concentrations for metals and reference levels for herbicides and pesticides in the soils at MCAS El Toro.

This letter is to transmit the enclosed Department of Toxic Substances Control staff Toxicologist comments and the Regional Water Quality Control Board comments dated July 22, 1996 and June 20, 1996, respectively. Please consider the enclosed comments when you prepare the final document.

If you have any questions, please call me at (310) 590-4891.

Sincerely,

Tayseer Mahmoud
Remedial Project Manager
Base Closure Unit
Office of Military Facilities
Southern California Operations

Enclosures

cc: See Next Page

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MEMORANDUM

TO: Tayseer Mahmoud
Southern California Office of Military Facilities (OMF)
Region 4, Long Beach

FROM: John P. Christopher, Ph.D., D.A.B.T.
Staff Toxicologist
Human and Ecological Risk Division (HERD)

DATE: 22 July 1996

SUBJECT: MCAS El Toro: Background Levels of Metals in Soils
PCA: 14740 Site: 400055-45

Background

Southern California Region 4 has asked OSA for continuing support on issues regarding risk assessment at Marine Corps Air Station (MCAS) El Toro, a closing base in Orange County which is also designated a Federal Superfund site. Remedial activities at this base are being directed by Naval Facilities Engineering Command, Southwest Division (SWDIV).

Ambient Levels of inorganic constituents in soils at MCAS El Toro has been the subject of several previous investigations by the Navy. The current document summarizes those investigations and defines ranges of concentrations of inorganic constituents thought to be representative of soils in the vicinity of the base. These ranges are intended for use in defining inorganic constituents of potential concern (COPC) in risk assessment. They might also be relevant to any cleanup goals selected.

Document Reviewed

We reviewed "Technical Memorandum: Background and Reference Levels, Remedial Investigation, Marine Corps Air Station El Toro, California, CTO-0076/0189". This document, dated June 1996, was prepared by Bechtel National, Inc., contractors to SWDIV. We received a request to review this document on 10 June 1996.

Scope of Review

The document was reviewed for scientific content. Minor grammatical or typographical errors that do not affect the interpretation have not been noted. However, these should be corrected in any future version of the document. We assume that sampling of environmental media, analytical chemistry data, and quality assurance procedures have been examined by regional personnel. If inadequacies in this regard for the purposes of risk assessment were encountered, they are noted. Any future changes or additions to the document should be clearly identified.

Comments

1. **Developments Since This Document was Prepared:** The Navy convened a technical workshop on 22-23 May 1996 in San Francisco to discuss the subject of determining ambient levels of inorganic COPC. HERD, USEPA, and contractors were present. The Navy and regulatory agencies reached a consensus at this workshop regarding preparation of data sets and statistical methodology for comparing investigated sites to ambient data. The Department's understanding of this consensus is attached to this memorandum in the form of a draft policy on the subject. The Navy's understanding is contained in a volume entitled "Navy Analysis of Background Workshop" dated July 1996. We prepared these few comments under the presumption that the Navy will apply the consensus methods to MCAS El Toro, thereby requiring some changes to the current document.

2. **Identification of Ambient Data Set:** On pages 1 and 2, the Navy defines 43 judgmentally located samples of soil as the data set for determining ambient concentrations of metals. In our experience, judgmentally selected samples are not always adequate to describe the upper tails of the distributions of metals. This is especially true if frequency of detection is low or if a small number of high values are encountered. In these cases, we recommend expanding the data base of samples, as described in the attachment to this memorandum

   Cadmium at MCAS El Toro is an excellent case in point. "Background" location 00-BGN1910 yielded two values for cadmium in soil which were 4-5 times higher than the any of the other 41 values in the data set (Table 1). The detected values in the normal probability plot for cadmium (Appendix A) show a bimodal distribution resembling the pattern one might expect in the presence of contamination. If the Navy wants to use these two values in their description of ambient conditions, they should define the upper tail of the plot better by incorporating into their analysis data collected at other locations on the base during the remedial investigation, including data from contaminated sites. We have found this procedure extremely

useful at several other naval bases in California. The procedure is outlined in the attachment.

3. **Statistical Methods:** We find no fault in the Navy's description of methods on pages 2 through 5. However, we recommend some additions and deletions to conform to the above mentioned consensus.

The Navy has described estimating upper tolerance limits (UTL) on quantiles of ambient distributions of metals in soils. We do not favor the use of the UTL, because it can be defeated by a small sample size. This method should be deleted. Instead, we recommend that the Navy calculate simple estimates of upper quantiles of the distributions of metals. As the number of data available increase and descriptions improve for the upper tails of these distributions, the Navy may employ estimates of higher quantiles, such the 95th or even the 99th, for comparison to investigated sites. A metal may be eliminated as an inorganic COPC when the highest value detected at the investigated site is less than this benchmark value. Methods for estimating quantiles, both parametrically and non-parametrically, should be added.

As described in the attachment (and at the Navy's suggestion), the Wilcoxon rank sum test may be employed when the number of samples from the investigated site becomes large and false positive rates become unacceptable. By "false positive" we mean selecting a metal as a COPC when it is actually within the ambient distribution. A description of the Wilcoxon rank sum test should be added to the document, along with logical rules on when and how it will be applied. This will entail creating a flowchart different from the one shown in Figure 2.

Conclusions and Recommendations

The Navy should re-analyze their data on metals in soils at MCAS El Toro employing methods agreed upon among the Navy and regulatory agencies. These methods include pooling data from additional locations around the base, using simple estimates of quantiles, and using the Wilcoxon rank sum test.

Barbara Renzi

Reviewer: Barbara Renzi, M.S.
Associate Toxicologist, HERD

Attachment: "Draft Interim Final Policy, Determining Ambient Concentrations of Metals for Risk Assessments at Hazardous Waste Sites and Permitted Facilities, June 1996"

cc: Dr. M. Wade, HERD
Mr. J. Paull, USEPA Region IX

INTERIM FINAL POLICY

DETERMINING AMBIENT CONCENTRATIONS OF METALS FOR RISK ASSESSMENTS AT HAZARDOUS WASTE SITES AND PERMITTED FACILITIES

JUNE 1996

I. Introduction

1.1 Purpose

The purpose of this policy is to provide a framework in which risk assessors may identify which metals detected in soils at investigated sites are present at concentrations which represent contamination due to site-related activities. This is done by comparing concentrations of metals at the site to a body of data representative of local conditions unaffected by site-related activities. Metals present at concentrations elevated with respect to these local conditions become chemicals of potential concern (COPC) and are carried forward into the health risk assessment. After remedial action, this same description of ambient concentrations of metals in soil can be useful in interpretation of confirmation sampling.

This policy is not intended to define or prescribe techniques of sampling, minimum numbers of samples, or analytical procedures. The methods described here are intended to make best use of data already available.

Following this introduction, this policy has three more parts. Section 2 presents the logical framework in which the policy is intended to be used. Section 3 gives an overview of the two statistical methods recommended for identifying COPC. Section 4 details the steps to follow for defining the data set for ambient conditions. Appendix A describes the Wilcoxon rank sum test and Appendix B presents tables needed for interpreting this test.

1.2 Definitions

1. "Pristine Conditions" are concentrations of metals in soils naturally occurring in locations unaffected by human activity.

2. "Ambient Conditions" are concentrations of metals in soils in the vicinity of a site but which are unaffected by site-related activities. Ambient conditions are sometimes referred to as "local background".

3. "Type I Error" is rejecting the null hypothesis when it is true. Type I error is often referred to as a "false positive". An example of Type I error would be identifying a metal as a COPC when its concentrations are actually within the range of ambient conditions.

4. "Type II Error" is accepting the null hypothesis when it is false. Type II error is often referred to as a "false negative". An example of Type II error would be identifying concentrations of a metal as within the range of ambient conditions, and thus not a COPC, when contamination is actually present.

2. Decision Logic

Metals eliminated as COPC are never again considered in the process of risk assessment or risk management. Thus, it is highly desirable to avoid or minimize Type II error in selection of COPC. On the other hand , if a Type I error is made, two subsequent levels of decision-making provide opportunities for correction. At the level of risk assessment, health risks due to a false positive COPC might be estimated and found to be insignificant, thus not triggering unnecessary remediation. At the level of risk management, estimated health risks due to a false positive COPC can exceed risks due to ambient conditions only slightly, a situation also unlikely to trigger unnecessary remediation. Thus, acceptable Type II error should always be less than or equal to Type I error.

3. Overview of Methods

For determining COPC, we require the use of the comparison method. To this may be added the Wilcoxon rank sum test. Both are described in general terms here. Additional details on the Wilcoxon rank sum test are give in Appendix A. Tables of critical values for the statistic W, necessary for performing the test, are given in Appendix B. When using either of the methods described here, it is necessary to follow the steps and guidance outlined below.

3.1 Comparison Method

The simplest method for identifying metals as COPC involves comparison of the highest concentrations value detected at the site (C_{MAX}) with a concentration representing the upper range of ambient conditions. If C_{MAX} does not exceed this value, then the metal is excluded as a COPC. If it does, the metal is carried forward into the risk assessment as a COPC. The value representing the upper range of ambient conditions may be estimated parametrically (*i.e.* making use of the underlying shape of the distribution) in most cases; or non-parametrically (no assumption about the underlying distribution).

This comparison technique has the advantage of simplicity, but it suffers from increasing Type I error (false positive) as the number of samples taken from the site increases. For example, if the 95th percentile is selected to represent the upper range of ambient concentrations, then 5% of any group of samples from a truly ambient population will exceed the 95th quantile. Since a Type I error will be made if one sample exceeds the 95th percentile, and since the probability of encountering at least one sample greater than the 95th percentile increases with the number of samples collected from the site, it follows that the probability of Type I error must increase with the number of samples from the site.

Type II error (false negative) is not formally quantifiable for the comparison method. However, it is possible to minimize the number and importance of Type II errors. Their number can be reduced by selecting a value nearer to the center of the distribution of ambient conditions as the sample size for ambient conditions grows smaller. For example, with small sample sizes a 95% upper confidence limit on the arithmetic mean or the mean itself could serve as the comparator for ambient conditions. Type II errors made at the level of selection of COPC can potentially be corrected either in the risk assessment or via risk management.

3.2 Wilcoxon Rank Sum Test

The Wilcoxon rank sum test, as described in Gilbert (1987), is described in detail in Appendix A. This test may be used as an adjunct to the comparison test for selecting COPC when 10 or more samples are available to describe both the site and the ambient conditions.. The Wilcoxon rank sum test examines whether measurements from one population tend to be consistently larger (or smaller) than those from another population. Performing the Wilcoxon rank sum test involves combining the two sets of concentrations from ambient conditions and from the site, ranking these values from lowest to highest, and summing the ranks for the values from the site. This sum, designated W_{RS}, is then used together with data on the number of tied ranks to calculate another statistic, designated Z_{RS}. If Z_{RS} is greater than a critical value for a given level of significance, then the mean concentration at the site is greater than that of the mean for ambient conditions and the metal is identified as a COPC. If Z_{RS} is less than the critical value, then the metal is excluded as a COPC.

The Wilcoxon rank sum test is a non-parametric test (distribution-free) which has the advantage of formally quantifiable rates of Type I and Type II errors. Such formalization is useful in the context of USEPA methods for Data Quality Objectives (USEPA, 1994) and Data Quality Assessment (USEPA, 1996). Also, the Wilcoxon rank sum has the disadvantage of requiring more calculations than the comparison method.

3.3 Considerations of Sample Size

Multiple measurements of a metal in either ambient or site soils will describe a distribution of concentrations for that metal. When few data are available, this distribution may be described only poorly; perhaps only the central tendency may be estimated with confidence. When large data sets are available, the extremes of distributions are more likely to be adequately characterized. Depending on the size of the ambient data set and its quality, the 95th or even the 99th percentile might be an appropriate criterion for the upper range of ambient concentrations. When sample sets for ambient conditions are large, it is often possible to use an estimate of an upper percentile of ambient concentrations as the value to be compared with C_{MAX} from the site.

4.0 Details of Selecting Ambient Data Set and Selection of COPC

The basic method for identifying metals which are COPC is to compare the highest detected concentration at the site to a value representative of the upper range of the ambient distribution. When few data are available to describe ambient conditions, both the shape of the ambient distribution and its upper extremes are uncertain and the value representative of ambient conditions should be a measure of central tendency. When ambient conditions are well described, an estimate of an upper percentile of the ambient distribution may be used. In all cases, the Wilcoxon rank sum test may be used as an adjunct to the comparison method. The steps below outline a flexible process with which project teams can define ambient conditions of metals and select metals as COPC.

4.1 Step 1: Expand the data set.

The best description of ambient conditions will be obtained from the largest data set possible. Under favorable conditions, the data set describing ambient conditions may be expanded to include samples from other studies or even possibly contaminated areas. The ambient data set can be successfully expanded under the following conditions:

4.1.1 Using Previous Studies: Data from investigations performed at the same site or nearby may be combined with the ambient data set if soil types and analytical methods are generally similar. Minor differences will be identified and can be eliminated if necessary in the analysis to follow.

4.1.2: Using data from Possibly Contaminated Areas: Samples of soil must have been analyzed for many metals. Thus, areas contaminated with one metal might display ambient concentrations for others.

4.2 Step 2: Test the distribution.

The expanded data set should tested to see if it is normally distributed. This may be done using the Shapiro-Wilks test (Gilbert, 1987) or a similar test. If the test for normality fails, data should be log-transformed and tested again for log-normality. Metals present at high concentrations, such as aluminum, iron, calcium, and magnesium, tend to be normally distributed, while trace metals tend to be lognormally distributed. Distributions will generally fail tests for both normality and lognormality if they contain either multiple populations or a high proportion of non-detects.

4.3 Step 3: Display summary statistics for the expanded data set.

Construct a table showing for each metal the frequency of detection, range of detected values, range of sample quantitation limits, arithmetic means and standard

deviations, and coefficients of variation. Typically, data drawn from just one population will display a range of detected values of no more than 2 orders of magnitude and a coefficient of variation no greater than 1. When either of these conditions is not met, one must suspect that values representative of contamination have been included in the population.

4.4 Step 4: Plot concentration vs. cumulative probability.

Sort concentration data for a metal from the lowest to the highest value. Use one-half the sample quantitation limit for non-detects. Construct a plot of cumulative probability vs. concentration. It is helpful to indicate on the plot which data are non-detects. If data are lognormally distributed, construct plots in base 10 to facilitate cross reference to the descriptive statistics. When non-detects are present, it can be useful to plot the detected values only to help identify which values belong to which population.

4.5 Step 5: Identify the population nearest the origin.

If data are drawn from just one population, the cumulative probability plot will be a straight line. If multiple, overlapping populations are present, the plot will produce a gentle curve instead of a straight line. Gaps or Inflection points in the plot suggest multiple populations, including possible outliers which must be eliminated. The combination of the descriptive statistics and the cumulative frequency plot forms an extremely powerful and useful tool for identifying ambient conditions.

For the purpose of identifying COPC for risk assessment, ambient conditions are defined as the range of concentrations associated with the population nearest the origin, including all non-detects whose one-half SQLs which fall within this range. This definition may be performed by inspection. The population nearest the origin is selected to minimize Type II error.

Selection of the population nearest the origin is a graphical method of eliminating outliers. Following this step, it can be useful to return to test the distribution for normality or log-normality.

4.6 Step 6: Select a value to represent the upper range of ambient conditions.

Using only the data from the population nearest the origin of the cumulative probability plot, a value may be selected which represents the upper range of the distribution. This should be a value which can be supported by the available data. If sample populations are small ($n<20$), it might not be possible to estimate with confidence anything other than the central tendency, such as the arithmetic mean or an upper confidence limit about that mean. The 80% lower confidence limit on the 95th percentile may be used in most situations. This value becomes greater than an upper confidence

limit on the mean with increasing sample size; it may be estimated parametrically or non-parametrically. When sample sizes are larger and when the cumulative probability plot indicates that the distribution is well defined, it is acceptable to select a simple estimate of the 95th or a higher percentile.

There are methods we do not recommend. We do not favor the use of the upper tolerance limit nor any upper confidence limit on an upper percentile, because small sample sizes inflate these estimates. Upper percentiles should not be selected when data sets are small. We do not favor broadcast use of the mean plus a fixed number of standard deviations as a definition of background conditions.

4.7 Step 7: Include or exclude metals as COPC.

If the highest concentration of a metal detected at a site is less than the comparator selected to represent the upper range of ambient conditions, then eliminate the metal as a COPC. If concentrations higher than the comparator are found, then include the metal in the risk assessment as a COPC. For those metals retained, it is often useful to examine the spatial distribution of the elevated concentrations to determine if a "hot spot" is present. If so, it could be useful to re-analyze data excluding the hot spot.

4.8 Step 8 (optional): Perform Wilcoxon rank sum test.

If many samples are collected from the site, it is possible that the Type I error rate will be unacceptable using the comparison method. In these cases, the results of the Wilcoxon rank sum test may be used as an adjunct to the comparison test for deciding whether concentrations of a metal at a site are greater than those in the ambient distribution. The procedure for the Wilcoxon rank sum test is given in Appendix A.

5. References

Gilbert, R. O. (1987), *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold, New York.

U. S. Environmental Protection Agency (1994), "Guidance for Data Quality Objectives Process", USEPA QA/G-4, September 1994.

U. S. Environmental Protection Agency (1996). :Guidance for Data Quality Assessment" (pre-publication copy), USEPA, QA/G-9, February 1996.

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APPENDIX A

PERFORMING THE WILCOXON RANK SUM TEST

Introduction

The Wilcoxon rank sum test is presented here as described in Gilbert (1987). USEPA (1992) has published additional guidance on the Wilcoxon rank sum test and its application to hazardous waste sites. The test examines whether measurements from one population tend to be consistently larger (or smaller) than those from another population. The test may be performed using a hand calculator. For large data sets, computer spreadsheet software is recommended but not necessarily required. The test may be performed according to the steps below. An example is provided at the end of this appendix.

Assumptions and Comparison to the *t*-Test

Both the Wilcoxon rank sum test and the independent sample *t*-test are tests of means, but the rank sum test has two main advantages:

1. The two data sets need not be drawn from the same distribution.

2. The rank sum test can handle a moderate number of non-detect values (ND) by treating them as ties.

This is shown in the example below. However, both the Wilcoxon rank sum test and the *t*-test assume that the distributions of the two populations are identical in shape (variance), although the distributions need not be symmetric. The *t*-test test can be modified to account for unequal variances, but no such modifications exists for the rank sum test.

Sample Size

We recommend that the Wilcoxon rank sum test be used as shown here only when ten or more samples are available for both the site and the ambient data set. The test can be used in a slightly different form when sample sizes are smaller. The Office of Scientific Affairs should be consulted for proper use of the Wilcoxon rank sum test for such smaller sample populations.

Procedure

1. Suppose we have data set 1 with n_1 elements representing the site and data set 2 with n_2 measurements representing ambient conditions. It is necessary that $n_1 \geq 10$ and $n_2 \geq 10$, but n_1 need not equal n_2. The following null hypothesis is to be tested:

   H_0: The populations from which 1 and 2 have been drawn have the same mean.

versus the following one-tailed alternative hypothesis:

H_A: Population 1 has a higher mean than population 2.

2. Select a level of significance α at which the null hypothesis may be accepted or rejected. This level is usually set at 0.05, although other levels might be selected.

3. Combine 1 and 2 into one data set with $m = n_1 + n_2$ elements. Rank these data from 1 to m. If several data have the same value, assign them all the average of the ranks that would otherwise be assigned to those data.

4. Sum the ranks assigned to the n_1 measurements from population 1. Denote this sum by W_{RS}.

5. If no ties are present, compute the statistic Z_{RS} as follows:

$$Z_{RS} = \frac{W_{RS} - \dfrac{n_1(m+1)}{2}}{\left[\dfrac{n_1 n_2 (m+1)}{12}\right]^{1/2}}$$

6. If ties are present, such as NDs, compute Z_{RS} as follows:

$$Z_{RS} = \frac{W_{RS} - \dfrac{n_1(m+1)}{2}}{\left\{\dfrac{n_1 n_2}{12}\left[(m+1) - \dfrac{\sum_{j=1}^{g} t_j(t_j^2 - 1)}{m(m-1)}\right]\right\}^{1/2}}$$

where g is the number of tied groups and t_j is the number of tied data in the jth group. This formulation reduces to the one shown in Step 5 in the absence of ties.

7. For a one-tailed test of H_0 versus H_A, reject H_0 and accept H_A if $Z_{RS} \geq Z_{1-\alpha}$. Values of Z may be selected from the following table:

α	1-α	Z_{RS}
0.10	0.90	1.282
0.05	0.95	1.645
0.025	0.975	1.960
0.01	0.99	2.327
0.001	0.999	3.080

Example Calculation

The table below shows two sets of 20 values for concentrations of copper in surface soil, one from a site and the other from representative ambient conditions. The ranks shown are for the combined data set.

Copper in Soil (mg/kg)			
Site	**Rank**	**Ambient**	**Rank**
5.9	3	5.5	1
7.4	5	5.6	2
15	9.5	6.3	4
18	13.5	8.8	6
19	16	11	7
19	16	13	8
24	21	15	9.5
31	25	16	11.5
31	25	16	11.5
34	27	18	13.5
36	28	19	16
40	29	20	18.5
42	30	20	18.5
45	31	22	20
46	32	25	22
53	34	30	23
62	36	31	25
66	37	50	33
69	38	57	34
81	40	73	39

The number of samples in each set is greater than 10. Select α = 0.05. Reject H_0 if Z_{RS} > 1.645. The sum of the ranks for the site, W_{RS}, is 496. Some ties were seen, so Z_{RS} is calculated using the second formulatoin above. Ties were observed at 15 mg/kg (2 values), 18 mg/kg (2 values), 19 mg/kg (3 values), and 31 mg/kg (3 values). Thus, Z_{RS} may be calculated

$$Z_{RS} = \frac{496 - \dfrac{(20)(20+20+1)}{2}}{\left\{\dfrac{(20)(20)}{12}\left[(20+1) - \dfrac{(2)(2)(2^2-1)+(2)(3)(3^2-1)}{(20)(20-1)}\right]\right\}^{1/2}}$$

$$Z_{RS} = 3.26$$

Z_{RS} is greater than 1.645, so H_0 is rejected and H_A is accepted. It is concluded that copper is present at concentrations higher than ambient conditions, so it is retained as a chemical of potential concern for the risk assessment.

State of California

Memorandum

To: Mr. Tayseer Mahmoud
Department of Toxic Substances Control
245 West Broadway, Suite 350
Long Beach, CA 90802-4444

Date: June 20, 1996

From: CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD - SANTA ANA REGION
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Subject: TECHNICAL MEMORANDUM BACKGROUND AND REFERENCE LEVELS REMEDIAL INVESTIGATIONS MARINE CORPS AIR STATION EL TORO CTO-0076/089

We have reviewed the subject document dated June 3,1996 and received by us on June 11,1996. As a result of our review, we have no significant comments.

If you have any questions, please call me at 909-782-4998.

Lawrence Vitale

Lawrence Vitale
DoD Section