STATISTICAL METHODOLOGY REPORT

BMI COMMON AREAS (EASTSIDE)

HENDERSON, NEVADA

Prepared by

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For

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I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations and ordinances. I hereby certify that all laboratory analytical data was generated by a laboratory certified by the NDEP for each constituent and media presented herein.

Dr. Ranajit Sahu, C.E.M. (No. EM-1699, Exp. 10/07/2007)
BRC Project Manager

I hereby certify that I have subjected the attached document to quality control review by external reviewer and have also reviewed the document myself.

Dr. Ranajit Sahu, C.E.M. (No. EM-1699, Exp. 10/07/2007)
BRC Project Manager

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1. INTRODUCTION

This document describes the statistical methodologies that will be utilized in confirming the final soils closure at each of the Eastside Sub-Areas of the BMI Common Areas (Figure 1).[1,2] This revision of the report incorporates Nevada Division of Environmental Protection (NDEP) comments dated July 20, 2006 on the June 16, 2006 version of this report. NDEP comments and response to comments are provided in Appendix A. The definitions of the Sub-areas and the location of the Site are described in the Closure Plan (in review by NDEP) and are therefore not repeated here. The analyses discussed below will be performed within each Sub-area of the site subsequent to a sequence of initial and intermediate cleanup and sampling activities, as follows:

- **Initial Cleanup:** The cleanup of each Sub-area will be initiated by the removal of impacted soils based on the Conceptual Site Model (the "CSM")[3]; review and analysis of the existing soil and sediment physical and chemical data, including the extent of discolored soil and sediment; and detailed inspection of aerial photographs. These initial removals are intended to address all the known impacted parts of the Sub-area, primarily relying on visual evidence and site knowledge, as guided by historical data. Further details of the initial removal as well as the iterative nature of the removal/sampling along with certain "stopping" rules are discussed in the Corrective Action Plan (the "CAP").[4]

- **Confirmation Sampling:** Upon completion of the initial cleanup, a series of multi-depth confirmatory samples will be collected based on a combination of stratified

[1] This report contains as much detail as is practically possible to provide at this time by focusing on methodology issues. It is expected that the individual Sub-area reports will contain complete data analyses. The No-Build Sub-area report will also address ecological risk end-points, which are relevant for that Sub-area.

[2] The Eastside Sub-Areas of the BMI Common Areas includes areas to the east of Boulder Highway and north of Lake Mead Parkway.

[3] BRC acknowledges that the CSM has not been finalized at this time.

[4] The stopping rules and the general iterative methodology are shown in Figure J of the CAP. BRC acknowledges that the CAP is under review by NDEP at this time.

random and biased (judgmental) sampling. The main elements of this confirmation sampling are discussed in Section 2 of this document. Collected samples will be assigned to specific soil layers according to well-defined if/then rules.

Intermediate Sampling and Cleanups: The confirmation data are then subjected to series of statistical tests to determine "exceeding" samples, if any, as described in Section 3 of this document. In case of a confirmed exceeding sample, its vicinity will be targeted for additional delineation sampling and/or removal. This removal will be followed by additional confirmation sampling at these erstwhile exceeding locations. Sample results from the removed part of the Sub-area will be marked as excluded in the dataset, while non-exceeding delineation and confirmatory samples will be included in the dataset. This iterative process continues until the Sub-area is devoid of any exceeding samples or any of the stopping rules discussed in the CAP are reached.

- **Final Confirmation Dataset:** At this stage, the final confirmation dataset, consisting of the original non-exceeding confirmation data, and non-exceeding data generated during intermediate cleanups, will be subjected to series of statistical analyses to provide the necessary information concerning representative exposure concentrations, as discussed in Section 4 of this document.

- **Data Adequacy and Sample Size Evaluation:** Finally, as described in Section 5 of this document, the adequacy of the final confirmation dataset in each Sub-area will be evaluated in accordance with probabilistic procedures developed by Neptune and Company, Inc. for the TRECO site (Appendix C, Attachment C-2, MWH, 2006).

The statistical computations and tests described herein will be performed using GISdT® (Neptune and Company, Inc., 2006) or SPSS Version 11.5.0 (www.spss.com) software.

2. CONFIRMATION SAMPLING

Upon completion of the initial cleanup in a given sub-area, confirmation sampling will be conducted. This sampling will be conducted on the basis of combined random and bias (judgmental) sampling, as follows:

- **Stratified Random Locations:** For this purpose, the Sub-area will be covered by a 3-acre cell grid network. Within each 3-acre cell, a sampling location will be

randomly selected. The main objective of this stratified random sampling is to provide a uniform coverage of the Sub-area.

- **Biased Locations:** Additional sampling locations will be selected within or near small-scale contamination points of interests, including but not limited to previous debris locations, berm walls near excavated ponds, and conveyance ditches. For this purpose, the randomly-selected location within a corresponding 3-acre cell may also be adjusted in order to cover a nearby point of interest, if needed. Enough additional biased sample locations will be selected to provide coverage of all such small scale contamination points of interest. Further details concerning biased sampling in specific Sub-areas, including maps showing each proposed sampling location and sample depths will be provided in the corresponding Sampling and Analysis Plan (the "SAP") for that Sub-area.

At each selected location, multi-depth soil samples will be collected and analyzed for the list of site-related chemicals. The analytical sample results will then be divided into surface (0-2' depth), subsurface (2'-10' depth), and deep (>10' depth) layers, according to the following if/then rules:

- **Rule 1: IF** the sample is collected in a relatively flat part of the Sub-area (i.e., not targeted for substantial grading), **THEN** the depth of the collected soil sample will be used to designate its soil layer grouping.

- **Rule 2: IF** the sample is collected in a part of the Sub-area targeted for substantial grading, **AND** the sampled soil is located in an area expected to be covered by fill material (e.g. exposed excavated surfaces of ponds), **THEN** the soil layer grouping of the sampled soil will be determined based on the difference between its elevation and the final (post-graded) surface elevation in that part of the Sub-area.

- **Rule 3: IF** the sample is collected in a part of the Sub-area targeted for substantial grading, **AND** the sampled soil is expected to be used as surface or subsurface fill (e.g. soil within a berm), **THEN** the sampled soil will be assigned to the surface or subsurface layer, respectively.

All soil samples will be tagged in the database with numeric designations of their corresponding assigned soil layer grouping based on these three rules.

3. INTERMEDIATE SAMPLING AND CLEANUP

Upon layer-designation of confirmation soil samples, a series of tests will be conducted to determine whether sampled locations within a given layer include "exceeding" samples. An exceeding sample is defined as a sample that warrants further investigation, which may lead to additional localized soil removal. Exceeding samples will be determined consistent with the following if/then rules:

- **Chemicals without background concentrations:** For such a chemical, the distribution of its reported concentrations in each layer (e.g. histogram or probability plot) will be constructed. The 95% upper confidence limit of its mean (the "UCL") will also be computed. **IF** the constructed distribution indicates presence of anomalous concentrations (e.g. values at the end of an elongated high tail of a uni-modal distribution, or values forming an elevated sub-population of a multi-modal distribution), **AND** the inclusion of these anomalous values causes the computed UCL to exceed 1/10 of the risk-based screening level of the chemical,[5] **THEN** samples associated with anomalous values will be considered as potential exceeding samples.

- **Chemicals with background concentrations:** For such a chemical, the distribution of its reported concentrations in each layer (e.g. histogram or probability plot) will be constructed. These concentrations will then be statistically compared to the background dataset. For this purpose, appropriate two-sample tests, including parametric Levene's Test for equality of variances, t-Test for equality of mean (assuming equal variances), and t-Test for equality of mean (assuming unequal variances), as well as non-parametric Slippage Test, Quantile Test, and Wilcoxon Rank Sum Test with Gehan modification (e.g., DON, 2004). In addition, the 95% upper tolerance limit (the "UTL") of the reported concentrations of such chemicals in each layer will be computed. **IF** inclusion of elevated measured values in a given layer causes the rejection of the appropriate two-sample test, **THEN** samples associated with such elevated values will be considered as potential exceeding samples.

[5] The multiplier 1/10 is proposed as a reasonably conservative criterion for allowing for cumulative risks from multiple chemicals.

Potential exceeding samples may be subjected to re-sampling prior to the confirmation of the location as an exceeding sample. After any such re-sampling, the above process will be repeated to confirm the exceeding status of the targeted sample.

Upon confirmation of an exceeding sample, additional neighboring delineation sampling will be conducted based on a "step-out" approach. Step sizes and directions will be dependent on the location of the exceeding sample and perhaps the magnitude of the exceedance. Additional step-out or step-in sampling may be conducted to further refine the extent of the required removal. Each removal will be followed by confirmatory sampling. General aspects of intermediate delineation and confirmatory sampling procedures will be discussed in the SAP for the Sub-area.

After the above intermediate removals, results associated with removed exceeding samples will be marked as excluded from the dataset, while non-exceeding delineation and confirmation data will be included in the dataset. The revised dataset will then be subjected to the above exceeding sample determination process, which will be repeated until all exceeding samples are adequately addressed.

4. FINAL CONFIRMATION DATASET

At this stage, the final confirmation dataset for the Sub-area, consisting of the original non-exceeding confirmation data for the Sub-area, along with the non-exceeding data generated after intermediate sampling and cleanup, will be subjected to series of statistical analyses in order to determine the representative exposure concentrations for that Sub-area, as described below.

Correlation Analysis: Confirmation measurements of each chemical in a given soil layer will be used to compute their variograms.[6] Spatially correlated data will yield variograms that are clearly distinguishable from those produced by uncorrelated data. Upon a thorough inspection of computed omni-directional and directional variograms, the status of spatial correlation of a chemical in a given soil layer will be determined. Given the fact that the investigated measurements will be devoid of exceeding samples, presence of spatial correlations can be attributed to natural or anthropogenic patterns.

[6] Variogram analysis is an assessment of spatial correlation. Englund and Sparks (1988) define the variogram as a plot of the variance (one-half the mean squared difference) of paired sample measurements as a function of the distances (and optionally of the direction) between samples.

Representative Exposure Concentrations: Depending on the chemical-specific findings of variogram analyses above, the following computations will be conducted.

- **Uncorrelated Data:** If the confirmation dataset of a given chemical in a given soil layer exhibits no discernable spatial correlation, then each measurement is assumed to be equally representative for that chemical at any point in the Sub-area. Under this condition, the available dataset, as well as the descriptive summary statistics, including mean and standard error will be used to compute the appropriate UCL for deterministic risk assessment purposes for that chemical. For cumulative risk evaluation,[7] as well as for probabilistic risk assessment,[8] the computed mean concentration and standard error will be considered as parameters of the distribution of representative exposure concentrations for that chemical within the given soil layer of the Sub-area.

- **Correlated Data:** If the confirmation data set for a given chemical within a given soil layer exhibits spatial correlation, geostatistical block estimation analysis (known as block kriging[9]) will be performed. For this purpose, the Sub-area will be covered by grids consisting of cells equal to the size of desired exposure units, i.e. 1/8-acre (for

[7] The intent of the cumulative risk calculation is to compute the combined risks posed by chemicals of interest. These calculations will be performed within a probabilistic framework for each category of chemicals of interest, e.g. carcinogens (chemicals and radionuclides), non-carcinogens, lead, and asbestos. For this purpose, concentrations of each chemical of interest within the targeted category in a specific layer will be represented by a distribution consistent with the mean concentration and standard error of the observed data of that chemical within the given layer. Having these concentration distributions, multiple sets of concentrations of chemicals of interest within a given a soil layer will be generated through Monte Carlo simulation. For each set, which contains one simulated concentration for each chemical of interest in the targeted category, risks associated with individual chemicals will be calculated, and then summed. This summed risk represents the cumulative risk of the given set of simulated concentrations. This process is repeated for all simulated sets, which yields a large number of simulated cumulative risks. The simulated cumulative risks will then be ranked in order to determine the 95 percentile cumulative risk. This 95 percentile risk will be considered as the representative cumulative risk of the targeted category of chemicals in the given soil layer for the Sub-area in question.

[8] In the probabilistic risk assessment, distribution parameters of the concentration term of a given chemical at a specific layer will be based on the computed mean concentration and standard error of measured data of that chemical within the given layer.

[9] Block kriging is a minimum-variance linear estimation process in which point measurements in and around a given block (referred herein as a cell) are used in order to compute the estimated value of the investigated variable (i.e., chemical concentration) over the targeted cell. Block kriging also computes the standard error of the estimated cell value, which can be used as a measure of its accuracy. This computational process is mainly driven by the spatial correlation of the investigated variable. For more information, see Matheron (1971), Journel and Huijbregts (1978), Isaaks and Srivastava (1989), and ASCE (1990a, b).

residential receptors) and ½-acre (for worker and recreational receptors) cell grids. At this stage, the expected, layer-specific, chemical concentration over each cell and the corresponding estimation standard deviation will be computed, which in turn will be used to calculate the UCL at each cell. The estimated average concentrations have a tendency toward normal distribution, as demonstrated by the Central Limit Theory (Kallenberg, 1997). To avoid excessive undue amount of computations associated with large number of estimated cells in a given Sub-area, final confirmations based on deterministic risk assessment will be performed using UCLs from representative cells, including cells with average, 95 percentile, and maximum UCL.[10] Similarly for cumulative risk evaluation, as well as for probabilistic risk assessment, the estimated average concentration and estimation standard deviations from representative cells will be considered as parameters of the distribution of representative exposure concentration for the chemical of interest within the given soil layer of the Sub-area.

5. DATA ADEQUACY AND SAMPLE SIZE EVALUATION

The final confirmation dataset will consist of stratified random samples, additional samples biased toward known small-scale contamination areas, as well as biased not-exceeding delineation and confirmation samples associated with intermediate cleanups in the Sub-area. The dataset is clearly aimed at providing coverage of the Sub-area in its entirety, as well as at all points of interest. The *a posteriori* nature of this dataset poses a number of difficulties when considered within the traditional framework of *a priori* statistical approaches, commonly used in data quality assessments ("DQAs") for confirmation of data quality objectives ("DQOs"). In response to these theoretical issues, NDEP proposed an alternative procedure, developed by Neptune and Company, Inc. at the TRECO site (Appendix C, Attachment C-2, MWH, 2006), for data adequacy assessment. Consistent with this proposed approach, the following procedures will be used to assess the adequacy of confirmation data within a given soil layer of the sub-area.

- **Chemicals without background concentrations:** For such chemicals, the NDEP proposed procedure will be used, which is a simple probabilistic approach to data adequacy. This procedure is initiated by the construction of a distributional model (estimated distribution) for the mean concentration of each chemical of interest.

[10] For example, if the cell with the maximum UCL passes the risk assessment, then it will be assumed that the other cells will also pass.

Distributional models are selected among an appropriate class of distributions (e.g. normal or gamma), whose parameters will be estimated using bootstrapping, or maximum likelihood estimation procedures. The estimated distributions of mean concentrations are then used to evaluate the probability of the mean concentration exceeding the risk-based screening level for the chemical of interest. The above cited TRECO site document provides further details about merits of the proposed and alternative procedures.

- **Chemicals with background concentrations:** For such chemicals, consistent with the spirit of the above proposed probabilistic approach, and per discussion and agreement with NDEP and its consultants per the meeting held on May 31, 2006, a probabilistic two-sample test is proposed. For this purpose, multiple pairs of sub-area (layer-specific) measurements and background measurements will be selected randomly. For each pair, the difference between their reported concentrations will be calculated. The distribution of simulated differences will then be evaluated to demonstrate the likelihood of a zero-mean difference.

6. REFERENCES

American Society of Civil Engineers (ASCE) Task Committee on Geostatistical Techniques in Geohydrology (S. Rouhani, Chairman and Principal Author), Review of Geostatistics in Geohydrology, I. Basic concepts, *ASCE Journal of Hydraulic Engineering*, 116(5), 612-632, May 1990a.

American Society of Civil Engineers (ASCE) Task Committee on Geostatistical Techniques in Geohydrology (S. Rouhani, Chairman and Principal Author), Review of Geostatistics in Geohydrology, II. Applications, *ASCE Journal of Hydraulic Engineering*, 116(5), 633-658, May 1990b.

Englund, E., and A. Sparks, GEO-EAS (Geostatistical Environmental Assessment Software) User's Guide, EPA600/4-88/033, ENMSL, Environmental Protection Agency, Las Vegas, 1988.

Isaaks, E.H., and R.M. Srivastava, *Applied Geostatistics*. Oxford University Press, 561 p., 1989.

Kallenberg, O. *Foundations of Modern Probability*. New York: Springer-Verlag, 1997

Journel, A.G., and C.J. Huijbregts. *Mining Geostatistics* Academic Press, London, 600 p., 1978.

Matheron, G. *The Theory of Regionalized Variables and its Applications*. Les Cahiers du Centre de Morphologie Mathematique de Fontainebleau, No. 5, 211 p., 1971.

MWH. Risk Assessment Report, TRECO Property, Henderson, Nevada. April 2006.

Neptune and Company, Inc. Guided Interactive Statistical Decision Tools (GISdT). www.gisdt.org. 2006.

United States Department of the Navy (DON). *Guidance For Environmental Background Analysis*. Volume I: Soil. Naval Facilities Engineering Command. UG-2049-ENV. Washington, DC, 2004.

REDLINE VERSION

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At each selected location, multi-depth soil samples will be collected and analyzed for the list of site-related chemicals. The analytical sample results will then be divided into surface (0-2' depth), subsurface (2'-10' depth), and deep (>10' depth) layers, according to the following if/then rules:

- **Rule 1: IF** the sample is collected in a relatively flat part of the Sub-area (i.e., not targeted for substantial grading), **THEN** the depth of the collected soil sample will be used to designate its soil layer grouping.

- **Rule 2: IF** the sample is collected in a part of the Sub-area targeted for substantial grading, **AND** the sampled soil is located in an area expected to be covered by fill material (e.g. exposed excavated surfaces of ponds), **THEN** the soil layer grouping of the sampled soil will be determined based on the difference between its elevation and the final (post-graded) surface elevation in that part of the Sub-area.

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Upon layer-designation of confirmation soil samples, a series of tests will be conducted to determine whether sampled locations within a given layer include "exceeding" samples. An exceeding sample is defined as a sample that warrants further investigation, which may lead to additional localized soil removal. Exceeding samples will be determined consistent with the following if/then rules:

- **Chemicals without background concentrations:** For such a chemical, the distribution of its reported concentrations in each layer (e.g. histogram or probability plot) will be constructed. The 95% upper confidence limit of its mean (the "UCL") will also be computed. **IF** the constructed distribution indicates presence of anomalous concentrations (e.g. values at the end of an elongated high

tail of a uni-modal distribution, or values forming an elevated sub-population of a multi-modal distribution), **AND** the inclusion of these anomalous values causes the computed UCL to exceed 1/10 of the risk-based screening level of the chemical,[5] **THEN** samples associated with anomalous values will be considered as potential exceeding samples.

- **Chemicals with background concentrations:** For such a chemical, the distribution of its reported concentrations in each layer (e.g. histogram or probability plot) will be constructed. These concentrations will then be statistically compared to the background dataset. For this purpose, appropriate two-sample tests, including parametric Levene's Test for equality of variances, t-Test for equality of mean (assuming equal variances), and t-Test for equality of mean (assuming unequal variances), as well as non-parametric Slippage Test, Quantile Test, and Wilcoxon Rank Sum Test with Gehan modification (e.g., DON, 2004). In addition, the 95% upper tolerance limit (the "UTL") of the reported concentrations of such chemicals in each layer will be computed. **IF** ~~the constructed distribution indicates presence of anomalous concentrations (e.g. values at the end of an elongated high tail of a uni-modal distribution, or values forming an elevated sub-population of a multi-modal distribution), **AND**~~ inclusion of ~~the anomalous~~ elevated measured values in a given layer causes the rejection of the appropriate two-sample test ~~due to elevated reported concentrations at the sub-area dataset~~, ~~**OR** inclusion of the anomalous values causes the computed UTL to exceed 1/10 of the risk-based screening level of the chemical,~~ **THEN** samples associated with ~~anomalous~~ such elevated values will be considered as potential exceeding samples.

[5] The multiplier 1/10 is proposed as a reasonably conservative criterion for allowing for cumulative risks from multiple chemicals.

Potential exceeding samples may be subjected to re-sampling prior to the confirmation of the location as an exceeding sample. After any such re-sampling, the above process will be repeated to confirm the exceeding status of the targeted sample.

Upon confirmation of an exceeding sample, additional neighboring delineation sampling will be conducted based on a "step-out" approach. Step sizes and directions will be dependent on the location of the exceeding sample and perhaps the magnitude of the exceedance. Additional step-out or step-in sampling may be conducted to further refine the extent of the required removal. Each removal will be followed by confirmatory sampling. General aspects of intermediate delineation and confirmatory sampling procedures will be discussed in the SAP for the Sub-area.

After the above intermediate removals, results associated with removed exceeding samples will be marked as excluded from the dataset, while non-exceeding delineation and confirmation data will be included in the dataset. The revised dataset will then be subjected to the above exceeding sample determination process, which will be repeated until all exceeding samples are adequately addressed.

4. FINAL CONFIRMATION DATASET

At this stage, the final confirmation dataset for the Sub-area, consisting of the original non-exceeding confirmation data for the Sub-area, along with the non-exceeding data generated after intermediate sampling and cleanup, will be subjected to series of statistical analyses in order to determine the representative exposure concentrations for that Sub-area, as described below.

Correlation Analysis: Confirmation measurements of each chemical in a given soil layer will be used to compute their variograms.[6] Spatially correlated data will yield variograms

[6] Variogram analysis is an assessment of spatial correlation. Englund and Sparks (1988) define the variogram as a plot of the variance (one-half the mean squared difference) of paired sample measurements as a function of the distances (and optionally of the direction) between samples.

that are clearly distinguishable from those produced by uncorrelated data. Upon a thorough inspection of computed omni-directional and directional variograms, the status of spatial correlation of a chemical in a given soil layer will be determined. Given the fact that the investigated measurements will be devoid of exceeding samples, presence of spatial correlations can be attributed to natural or anthropogenic patterns.

Representative Exposure Concentrations: Depending on the chemical-specific findings of variogram analyses above, the following computations will be conducted.

- **Uncorrelated Data:** If the confirmation dataset of a given chemical in a given soil layer exhibits no discernable spatial correlation, then each measurement is assumed to be equally representative for that chemical at any point in the Sub-area. Under this condition, the available dataset, as well as the descriptive summary statistics, including mean and standard error will be used to compute the appropriate UCL for deterministic risk assessment purposes for that chemical. For cumulative risk evaluation,[7] as well as for probabilistic risk assessment,[8] the computed mean concentration and standard error will be considered as parameters

[7] The intent of the cumulative risk calculation is to compute the combined risks posed by chemicals of interest. These calculations ~~Cumulative risks~~ will be ~~evaluated~~ performed within a probabilistic framework for each ~~class~~category of chemicals of interest, e.g. carcinogens (chemicals and~~,~~ radionuclides), ~~hazard quotients~~non-carcinogens, lead, and asbestos. For this purpose, concentrations of each chemical of interest within the targeted ~~class~~category in a specific layer will be represented by a distribution consistent with the mean concentration and standard error of the observed data of that chemical within the given layer. Having these concentration distributions, multiple sets of concentrations of chemicals of interest within a given a soil layer will be generated through Monte Carlo simulation~~randomly selected from their corresponding distributions~~. For each set, which contains one simulated concentration for each chemical of interest in the targeted ~~class~~category, ~~the~~ risks associated with individual chemicals will be calculated, and then ~~added~~summed. This ~~added~~ summed risk represents the cumulative risk of the given set of simulated concentrations~~will then be calculated~~. This process is repeated for all simulated sets, which yields a large number of simulated cumulative risks. The ~~distribution of the~~ simulated cumulative risks will then be ~~evaluated to~~ ranked in order to determine the 95 percentile cumulative risk. This 95 percentile risk~~, which~~ will be considered as the representative cumulative risk of the targeted ~~class~~category of chemicals in the given soil layer for the Sub-area in question.

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of the distribution of representative exposure concentrations for that chemical within the given soil layer of the Sub-area.

- **Correlated Data:** If the confirmation data set for a given chemical within a given soil layer exhibits spatial correlation, geostatistical block estimation analysis (known as block kriging[9]) will be performed. For this purpose, the Sub-area will be covered by grids consisting of cells equal to the size of desired exposure units, i.e. 1/8-acre (for residential receptors) and ½-acre (for worker and recreational receptors) cell grids. At this stage, the expected, layer-specific, chemical concentration over each cell and the corresponding estimation standard deviation will be computed, which in turn will be used to calculate the UCL at each cell. The estimated average concentrations have a tendency toward normal distribution, as demonstrated by the Central Limit Theory (Kallenberg, 1997). To avoid excessive undue amount of computations associated with large number of estimated cells in a given Sub-area, final confirmations based on deterministic risk assessment will be performed using UCLs from representative cells, including cells with average, 95 percentile, and maximum UCL ~~will be considered in the subsequent deterministic risk assessment computations~~.[10] Similarly ~~to the uncorrelated data,~~ for cumulative risk evaluation, as well as for probabilistic risk assessment, the estimated average concentration and estimation standard deviations from representative cells will be considered as parameters of the distribution of representative exposure concentration for the chemical of interest within the given soil layer of the Sub-area.

[9] Block kriging is a minimum-variance linear estimation process in which point measurements in and around a given block (referred herein as a cell) are used in order to compute the estimated value of the investigated variable (i.e., chemical concentration) over the targeted cell. Block kriging also computes the standard error of the estimated cell value, which can be used as a measure of its accuracy. This computational process is mainly driven by the spatial correlation of the investigated variable. For more information, see Matheron (1971), Journel and Huijbregts (1978), Isaaks and Srivastava (1989), and ASCE (1990a, b).

[10] For example, if the cell with the maximum UCL passes the risk assessment, then it will be assumed that the other cells will also pass.

5. DATA ADEQUACY AND SAMPLE SIZE EVALUATION

The final confirmation dataset will consist of stratified random samples, additional samples biased toward known small-scale contamination areas, as well as biased not-exceeding delineation and confirmation samples associated with intermediate cleanups in the Sub-area. The dataset is clearly aimed at providing coverage of the Sub-area in its entirety, as well as at all points of interest. The *a posteriori* nature of this dataset poses a number of difficulties when considered within the traditional framework of *a priori* statistical approaches, commonly used in data quality assessments ("DQAs") for confirmation of data quality objectives ("DQOs"). In response to these theoretical issues, NDEP proposed an alternative procedure, developed by Neptune and ~~Associates~~ Compn~~a~~any, Inc. at the TRECO site (Appendix C, Attachment C-2, MWH, 2006), for data adequacy assessment. Consistent with this proposed approach, the following procedures will be used to assess the adequacy of confirmation data within a given soil layer of the sub-area.

- **Chemicals without background concentrations:** For such chemicals, the NDEP proposed procedure will be used, which is a simple probabilistic approach to data adequacy. This procedure is initiated by the construction of a distributional model (estimated distribution) for the mean concentration of each chemical of interest. Distributional models are selected among an appropriate class of distributions (e.g. normal or gamma), whose parameters will be estimated using bootstrapping, or maximum likelihood estimation procedures. The estimated distributions of mean concentrations are then used to evaluate the probability of the mean concentration exceeding the risk-based screening level for the chemical of interest. The above cited TRECO site document provides further details about merits of the proposed and alternative procedures.

- **Chemicals with background concentrations:** For such chemicals, consistent with the spirit of the above proposed probabilistic approach, and per discussion and agreement with NDEP and its consultants per the meeting held on May 31, 2006, a probabilistic two-sample test is proposed. For this purpose, multiple pairs

of sub-area (layer-specific) measurements and background measurements will be selected randomly. For each pair, the difference between their reported concentrations will be calculated. The distribution of simulated differences will then be evaluated to demonstrate the likelihood of a zero-mean difference.

6. REFERENCES

American Society of Civil Engineers (ASCE) Task Committee on Geostatistical Techniques in Geohydrology (S. Rouhani, Chairman and Principal Author), Review of Geostatistics in Geohydrology, I. Basic concepts, *ASCE Journal of Hydraulic Engineering*, 116(5), 612-632, May 1990a.

American Society of Civil Engineers (ASCE) Task Committee on Geostatistical Techniques in Geohydrology (S. Rouhani, Chairman and Principal Author), Review of Geostatistics in Geohydrology, II. Applications, *ASCE Journal of Hydraulic Engineering*, 116(5), 633-658, May 1990b.

Englund, E., and A. Sparks, GEO-EAS (Geostatistical Environmental Assessment Software) User's Guide, EPA600/4-88/033, ENMSL, Environmental Protection Agency, Las Vegas, 1988.

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

Isaaks, E.H., and R.M. Srivastava, *Applied Geostatistics*. Oxford University Press, 561 p., 1989.

Kallenberg, O. *Foundations of Modern Probability*. New York: Springer-Verlag, 1997

Journel, A.G., and C.J. Huijbregts. *Mining Geostatistics* Academic Press, London, 600 p., 1978.

Matheron, G. *The Theory of Regionalized Variables and its Applications*. Les Cahiers du Centre de Morphologie Mathematique de Fontainebleau, No. 5, 211 p., 1971.

MWH. Risk Assessment Report, TRECO Property, Henderson, Nevada. April 2006.

Neptune and Company, Inc. Guided Interactive Statistical Decision Tools (GISdT). www.gisdt.org. 2006.

~~Singh, A. K., Singh, A., and Engelhardt, M. "Some Practical Aspects of Sample Size and Power Computations for Estimating the Mean of Positively Skewed Distributions in Environmental Applications," EPA/600/S-99/006. November 1997.~~

United States Department of the Navy (DON). *Guidance For Environmental Background Analysis*. Volume I: Soil. Naval Facilities Engineering Command. UG-2049-ENV. Washington, DC, 2004.

~~United States Environmental Protection Agency (EPA), "Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Soil Media," EPA230/02-89-042, 1989a.~~

~~United States Environmental Protection Agency (EPA), "Geostatistics For Waste Management: User's Manual For the GEOPACK (Version 1.0)," developed by S.R. Yates and M.V. Yates, EPA/600/8-90/004, 1990.~~

~~United States Environmental Protection Agency (EPA), "Guidance for Data Usability in Risk Assessment," EPA/540/G-90/008, 1990.~~

FIGURES

N

Las Vegas Wash Extent

CITY OF HENDERSON LANDFILL

CITY OF HENDERSON BIRD VIEWING PRESERVE

CITY OF HENDERSON WATER RECLAMATION FACILITY

CITY OF HENDERSON NORTHERN RIB PONDS

WESTON HILLS PROPERTY

TUSCANY HILLS PROPERTY

CITY OF HENDERSON SOUTHERN RIB PONDS

SUNSET ROAD

SOUTH BOULDER HIGHWAY

LAKE MEAD PARKWAY

Subarea

- First Eight Rows
- Galleria North
- Mohawk
- No Build
- Sunset North Commercial
- Southern RIBs
- Spray Wheel
- TIMET Ponds
- Upper Ponds
- Western Hook
- NFA Areas*
- CoH WRF*
- Ditches
- Flood Conveyance Channels
- Laterals

2,000 1,000 0 2,000

Feet

*Not part of the Closure Plan for soils.

BMI Common Areas (Eastside)
Clark County, Nevada

FIGURE 1

EASTSIDE
SUB-AREAS

Basic Remediation COMPANY

Prepared by:	Date	JOB No. 1881425
MWH MKJ	08/08/06	FILE: GIS/BRC/FIGURE_1.MXD

APPENDIX A

RESPONSE TO NDEP COMMENTS DATED JULY 20, 2006 ON THE JUNE 16, 2006 STATISTICAL METHODOLOGY REPORT

APPENDIX A

RESPONSE TO NDEP COMMENTS DATED JULY 20, 2006 ON THE JUNE 16, 2006 STATISTICAL METHODOLOGY REPORT

1. General comment, the subject document provides a good overview of the approach that will be taken to site characterization and providing concentration source terms for human health risk assessment purposes. However, details are not provided. The NDEP appreciates that at this time this is not necessarily unexpected, therefore we anticipate that greater detail will be provided in the final sub-area specific reports (e.g., exploratory data analysis methods, dealing with non-detects, potential issues with background comparisons related to differences in geology and depth for background distributions for some chemicals). The NDEP appreciates that greater statistical detail is difficult to provide without first seeing the data, but once the data are analyzed more detail should be provided in the final sub-area specific report. Any additional details that can be provided at this time should be. The NDEP also notes that ecological risk endpoints are not addressed explicitly, but presumably in the areas in which ecological risk is applicable similar statistical methods will be used. Please clarify this in the revised report.

Response: *BRC appreciates the above comment. As noted, additional information will be provided in subarea specific reports. The No-Build subarea report will address ecological risk endpoints as well.*

2. Page 1, first sentence states, "This document contains the statistical methodologies that will be utilized in confirming the final soils closure at each of the Eastside Sub-Areas of the BMI Common Areas." This document describes the general approach but does not contain specific details. Hence, "contains" should be changed to "describes". Additionally, the "Eastside" needs to be explicitly defined.

Response: *Suggested revision is incorporated. Additionally, a footnote describing Eastside subareas is added.*

3. Page 1, first bullet, first sentence "The cleanup of each Sub-area will be initiated by the removal of impacted soils based on the Conceptual Site Model (the "CSM");…" It should be noted here that the CSM is not finalized.

Response: *In response to the above comment, a footnote is added.*

4. Page 1, first bullet, second sentence states, "These initial removals are intended to address all the known impacted parts of the Sub-area, primarily relying on visual evidence and site knowledge." It should be stated here that the historical data are used to guide initial cleanup as well, as applicable.

Response: *In response to the above comment, the cited sentence is supplemented by the phrase "as guided by historical data."*

5. Page 1, first bullet, third sentence states, "Further details of the initial removal as well as the iterative nature of the removal/sampling along with certain "stopping" rules are discussed in the Corrective Action Plan (the "CAP")." The stopping rules should be summarized herein since this plan depends on them; however, the CAP is not yet approved and should be noted as such. It is suggested that the resubmittal of this plan be tied to the approval of the CAP.

Response: *The plan now explicitly notes that the stopping rules are discussed in the CAP, which is under review by the NDEP. Since the stopping rules are discussed via a Figure in the CAP, BRC did not summarize this figure using text in this resubmittal. Hopefully by explicitly referencing the CAP, any reader can readily access the stopping rule discussion.*

6. Page 2, first bullet, fourth sentence states "Sample results from the removed part of the Sub-area will be marked as excluded in the dataset, while non-exceeding delineation and confirmatory samples will [be] included in the dataset." There is a missing word identified by square brackets.

Response: *Missing [be] was added.*

7. Page 2, section 2, the first word in the second sentence should be "This".

Response: *Change was incorporated.*

8. Page 3, the three rules presented herein are not exhaustive. For example, the following situation is not addressed. Rule 4: IF the sample is collected in a part of the Sub-area targeted for substantial grading, AND the sampled soil is expected to be used as subsurface fill, THEN the sampled soil will be assigned to the subsurface layer." Please review this section in detail and provide additional rules as necessary.

Response: *In response to the above comment, Rule 3 was modified accordingly.*

9. Page 3, the sentence following Rule 3 in the bullet states. "All soil samples will be tagged in the database with numeric designations of their corresponding assigned soil layer grouping based on these three layers." It appears the last word should be changed to "rules". If this is the case then the preceding word should be changed from "three" to "four" if the previous comment is accepted.

Response: *The cited sentence was revised accordingly.*

10. Page 4, footnote 2 should be moved to avoid confusion regarding the fraction.

Response: *The cited footnote was moved accordingly.*

11. Page 5, third sentence states, "For this purpose, appropriate tests,…" This should be changed to "For this purpose, appropriate two-sample tests,…"

Response: *Suggested change was incorporated.*

12. Page 5, fourth sentence states, "IF the constructed distribution indicates presence of anomalous…" The rest of this section needs to me modified in a way that reflects potential differences between two distributions. As stated, this is only appropriate in a one-sample testing context. Additionally, the text after the OR portion of the statement is only appropriate for chemicals that do not have background.

Response: *The cited section was revised accordingly.*

13. Page 6 and 7, bulleted discussion of the effect of spatial correlation, some more detail could be provided for the uncorrelated case concerning intentions for cumulative risk and probabilistic risk assessment (PRA). Presumably the intention for cumulative risk is to somehow add the mean risks for each chemical, or possibly simulate the cumulative risk by adding the distributions and finding a UCL for the accumulated risk. However, some more explanation is needed so that the NDEP understands that the intention is to add risks across chemicals (not adding concentrations, obviously, but not clear in the text), and that this will be done by simulation to generate a UCL. PRA is a little different, in that UCLs are not the ultimate goal. Instead a mean or median is used for decision making according to the PRA guidance. In this case the distributions of risk are added together and are presented. In addition, different classes of chemicals will be added together because of the different endpoints, (e.g., carcinogens, radionuclides, hazard quotients, lead, asbestos), and some discussion is needed in the documentation on how these calculations will be performed for each separate risk-class of chemicals. A further concern is that in the spatially correlated case this proposed approach could require an undue amount of work to arrive at cumulative risks and PRA endpoint distributions for each block used in the block kriging algorithm (this could be thousands of blocks). Some further consideration needs to be provided on how this will be performed and presented, and if some type of aggregation of blocks will be considered to facilitate calculation and presentation.

Response: *In response to the above comment, further clarifications were provided in the cited section accordingly. Clarifications included more details about cumulative risk calculations, use of computed mean and standard errors in probabilistic risk assessment, as well as avoiding undue amount of computations for correlated data.*

14. Page 7, final bullet, second sentence. Reference to "selected randomly" should be changed to "accomplished through Monte Carlo simulation"

Response: *The cited text was changed accordingly.*

15. Remove all references to "Neptune and Associates" and change them to "Neptune and Company Inc."

Response: *Global changes were made accordingly.*

16. There are several references listed at the end of the document that are not cited in the body of the text. Please remove these or utilize them in the text.

Response: *The reference list was refined accordingly.*