



**CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL (DTSC)  
OFFICE OF HUMAN AND ECOLOGICAL RISK (HERO)**

**HUMAN HEALTH RISK ASSESSMENT (HHRA) NOTE**

**HERO HHRA NOTE NUMBER: 4**

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**ISSUE:** Screening Level Human Health Risk Assessments.

**SUMMARY**

In a memorandum dated October 28, 1994, HERO recommended guidelines for use of the U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) at military sites (DTSC 1994). In 2008, the U.S. EPA released Regional Screening Levels (RSLs) to replace the PRGs formerly available from several U.S. EPA Regional offices (U.S. EPA 2010). In HHRA Note 3, HERO addressed the recommended methodology for use of U.S. EPA RSLs in the HHRA process at DTSC hazardous waste sites and permitted facilities (DTSC 2011a). This HHRA Note outlines the current recommended methodology for conducting screening level human health risk assessments, and is an update which replaces our 1994 memorandum.

Historically, U.S. EPA PRGs have been used mostly at military facilities. However, the recommendations included in this Note are intended for use at any DTSC site where DTSC has approved the use of RSLs in a screening risk assessment. Please contact the HERO Office Technician<sup>1</sup>, to be placed in contact with the other HERO Section Chiefs regarding human health risk assessment at properties and facilities other than military facilities (e.g. civilian facilities, schools).

**WHAT'S NEW**

This HHRA Note supersedes HERO's previous November 19, 2009 HHRA Note 4. Among other updates, this revision incorporates updated recommendations for use of the USEPA RSLs and evaluation of exposures to lead in soil.

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## **BACKGROUND**

Beginning in the early 1990s, California developed a process for conducting screening level human health risk assessments at Federal Facilities (open and closed military facilities). Since baseline risk assessments require a more intensive use of resources, time and cost, screening level risk assessments can facilitate the determination of “no further action” (i.e. unrestricted land use including residential uses) or further evaluation. If the cumulative risk and hazard index estimates are acceptable under the most conservative screening assumptions, then site-specific conditions can be expected to result in acceptable risk and hazard index levels. Consequently, the results of a screening risk assessment indicate whether or not a quantitative baseline risk assessment or further site investigation is warranted.

In a memorandum dated October 28, 1994, HERO recommended guidelines for use of the Region 9 PRGs at military sites (DTSC 1994). The screening level human health risk assessment (HHRA) process at Federal Facility sites in California has historically used the U.S. Environmental Protection Agency (U.S. EPA) Region 9 Preliminary Remediation Goals (PRGs, U.S. EPA 2004) supplemented with Cal-modified PRGs that are based on California-derived toxicity criteria [Office of Environmental Health Hazard Assessment (OEHHA), Toxicity Criteria Database]. In 2008, the U.S. EPA released Regional Screening Levels (RSLs) to replace the PRGs formerly available from several U.S. EPA Regional offices (U.S. EPA 2010). This, as well as other updates in the area of risk assessment methodology, has necessitated an update in our 1994 recommendations.

HERO's HHRA Note 3 addresses DTSC's recommended methodology for use of the soil and tap water RSLs in the HHRA risk assessment process (DTSC 2011a) and should be used in conjunction with this Note. HERO plans a phased review of the RSLs as resources allow. Phase I (addressed in HHRA Note 3) provides recommendations on the use of the Spring 2010 RSLs for soil (residential use and industrial/commercial use) and tap water, while recommendations for use of RSLs for air will be completed at a later date. Soil and tap water RSLs were reviewed first because: 1) they are more commonly used in risk assessments reviewed by HERO than air risk-based concentrations; and 2) oral toxicity values are more prevalent than inhalation toxicity values.

As discussed in HHRA Note 3, for the majority of the 706 listed chemicals with RSLs, HERO recommends use of the soil and tap water values listed in the Spring 2010 U.S. EPA RSL table. However some values listed in the U.S. EPA RSL table differ significantly (greater than four-fold) than values calculated using Cal/EPA toxicity criteria and risk assessment procedures. HERO has prepared a reference table for soil and tap water RSLs which indicate contaminants for which: 1) the 2004 EPA Region 9 PRG should be used; 2) the 2004 EPA Region 9 'Cal-modified' PRG should be used; or 3) the Cal/EPA California Human Health Screening Level (CHHSL) should be used. In addition, specific recommendations are made for five contaminants. Alternatively, in consultation with HERO, the on-line screening calculator can be used to calculate site-specific values using the more protective of Cal/EPA and U.S. EPA toxicity values and

applying assumptions consistent with HERO recommendations (e.g., route-to-route extrapolation between oral and inhalation exposure where no inhalation toxicity value is available but an oral toxicity value is available). Cal/EPA toxicity criteria can be located in the OEHHA Toxicity Criterion Database (OEHHA 2011; <http://oehha.ca.gov/risk/chemicaldb/index.asp>).

As an update to our 1994 recommendations, this HHRA Note provides recommendations for screening level HHRAs using the soil and tap water U.S. EPA RSLs. HHRA Note 3 should be consulted for chemicals in which HERO recommends an alternate value be used such as the 2004 EPA Region 9 PRG, 2004 EPA Region 9 'Cal-modified' PRG, or Cal/EPA CHHSL. Most of the discussion in this Note regarding limitations and assumptions for soil and tap water RSLs is also applicable to the 2004 PRGs, 2004 'Cal-modified' PRGs, and CHHSLs. At this time, HERO has not completed review of the RSLs for air. Until this review is completed, we do not recommend use of the RSLs for air and the DTSC toxicologist should be contacted regarding the recommended methodology for site screening if air sampling data (either ambient or indoor air) are available. Toxicity criteria for air, acceptable to HERO, are included in the DTSC version of the Johnson and Ettinger indoor air model ([http://www.dtsc.ca.gov/AssessingRisk/IE\\_Models.cfm](http://www.dtsc.ca.gov/AssessingRisk/IE_Models.cfm)). This HHRA Note does outline a process for incorporating the vapor intrusion to indoor air pathway into screening level human health risk assessments.

Prior to implementing the use of RSLs in screening level risk assessments, the U.S. EPA RSL User's Guide and Frequently Asked Questions should be consulted to ensure familiarity with how the numbers were derived and the limitations on their use (U.S. EPA 2010). This HHRA Note reiterates many of the points discussed in the U.S. EPA RSL User's Guide.

Limitations associated with the use of RSLs for screening level HHRAs must be carefully noted and understood prior to making risk management decisions. As discussed in more detail below, it is critical that a site-specific conceptual site model (CSM) be developed prior to conducting a screening level risk assessment to ensure the assumptions used to derive the RSLs are applicable and inclusive of all potentially complete exposure pathways and receptors at a site. For example, the derivation of the U.S. EPA RSLs did not include an evaluation of the intrusion of vapors from the subsurface to indoor air. The vapor intrusion to indoor air from volatile chemicals in soil or groundwater has become recognized as a potentially major exposure pathway.

Finally, this HHRA Note addresses HERO's recommendation that screening level risk evaluations for hazardous waste sites and permitted facilities include the calculation of both the site-related risk and hazard index, and the total risk and hazard index. The latter presents the risk and hazard associated with exposure to all detected chemicals prior to elimination of inorganic chemicals that are determined to be consistent with site-specific background or ambient concentrations. This information may be helpful for making risk management decisions about appropriate land uses and for public

transparency. The HERO toxicologist for the site should be contacted as this may not be necessary at all sites.

## **HUMAN HEALTH RISK ASSESSMENTS**

### **A. LAND USE AND HUMAN RECEPTORS**

In general, HERO recommends that an unrestricted land use scenario (i.e. a residential scenario) be assumed for site screening at all facilities, both active and closing/closed. HERO assumes that reuse of hazardous waste sites could result in a change of ownership and land use, including potential residential reuse of the property. For active facilities, HERO considers the residential scenario evaluation a health-conservative approach which will allow for a determination of “no further action”, further investigation, or land use management decisions. However, the residential scenario would not necessarily be protective of unrestricted land use for those chemicals that bioaccumulate in food products (e.g., dioxins which are addressed in HHRA Note 2 [DTSC 2009]).

If a residential scenario is not implemented in the screening evaluation, documentation should be provided that unrestricted land use will not occur in the future and DTSC approval should be obtained prior to conducting the risk assessment. For open Military Facilities, the Base Master Plan should indicate that unrestricted land use evaluation is required if future land use changes. For closed Bases or civilian facilities other than Department of Defense (DoD) facilities, a land use control (LUC) may be needed to restrict future residential use of the property if a risk assessment has not been conducted for a residential scenario.

Screening-level human health risk assessments may also include an evaluation of the industrial scenario using industrial RSLs. Evaluation of the industrial scenario provides additional information that may be used to evaluate receptors under current industrial use scenarios and to support risk management decisions. Although sites with acceptable risk under the residential land use scenario will likely have acceptable risk under other scenarios such as industrial land use, the inverse is not necessarily true. Sites with acceptable risk under the industrial land use could pose unacceptable risk under the residential land use scenario.

Construction scenarios cannot be evaluated in the screening level process because of the lack of applicable RSLs. Historically, it has been generally assumed that an evaluation of the residential land use scenario should be protective of construction worker receptors unless specific exposure pathways unique to construction workers exist (e.g. dermal contact with and inhalation of vapors from water in a trench). If such pathways are anticipated at a site, it would be necessary to proceed with a baseline site-specific human health risk evaluation to address potential risk to construction workers. In such cases, HERO recommends upfront discussion and agreement between DTSC and the responsible party regarding which of the following risk assessment approaches will be used: 1) screening level risk assessment for residential

and industrial receptors, and a baseline risk assessment for construction workers; or, 2) a baseline risk assessment for all receptors. Please note that because of greater soil exposure to construction workers, an industrial use scenario is not necessarily protective of construction workers. This is particularly true of lead where fetal exposure for a female worker will generate the lowest soil concentration.

## **B. ECOLOGICAL RISK ASSESSMENT**

This HHRA Note does not address ecological risk assessment. It is important to understand that ecological receptors were not considered in the calculation of the RSLs. That is, the RSLs apply to human receptors only and are not necessarily protective of ecological receptors. A separate ecological risk evaluation must be conducted if significant ecological habitat is present onsite or there is potential transport of contaminants to offsite habitat. A screening risk assessment for human receptors is never adequate to address the need for ecological risk assessment. Responsible parties should refer to DTSC's Ecological Guidance and EcoNOTEs for more information on appropriate procedures (Section 2.6 of DTSC 1999, DTSC 1996, DTSC EcoNOTEs). Prior to conducting an ecological risk assessment, the HERO toxicologist should be contacted.

## **C. EXPOSURE PATHWAYS CONSIDERED IN THE CALCULATION OF THE RESIDENTIAL AND INDUSTRIAL SOIL AND TAP WATER RSLs**

Before conducting a screening level human health risk assessment, a site-specific CSM is required to ensure all appropriate receptors and exposure pathways are addressed by the RSLs.

The residential and industrial soil RSLs consider several exposure routes: ingestion, inhalation of particles and volatile chemicals in ambient air, and dermal absorption.

The tap water RSLs are based on assumed residential exposure to water via ingestion from drinking and inhalation of volatile chemicals released during household use (e.g., showering, dish washing).

Although the soil and tap water RSLs account for many typical exposure pathways they do not account for the following potential exposure pathways (discussed with respect to PRGs in U.S. EPA 2004):

- i. The residential and industrial soil RSLs do not account for exposure to indoor air vapors from intrusion of soil gas; ingestion of plants (home-grown fruits and vegetables), meat, or dairy products; or inhalation of particles (fugitive dust) generated by activities which elevate particulate emissions such as truck traffic and use of heavy equipment.

ii. Pathways not considered in the calculation of the tap water RSLs include dermal absorption from bathing and subsurface vapor intrusion to indoor air from volatile organic compounds (VOCs) present in groundwater. In addition, the tap water RSLs include neither ingestion of water during swimming nor transfer of contaminants in the water column to aquatic organisms or terrestrial plants with subsequent ingestion by humans. The RSL Online Calculator and User's Guide do however include equations which can be used to calculate screening level fish concentrations assuming human consumption of fish. These equations do not address impacts to fish; but rather, human consumption of fish which may be contaminated.

If pathways not considered in the derivation of the soil and tap water RSLs are anticipated at the site, a screening level risk evaluation may significantly underestimate risk. In addition, if there are exposure scenarios other than residential and industrial land use, a screening level risk evaluation using RSLs may not be appropriate (e.g. sites in which trench workers may be exposed to shallow groundwater). In such cases, the evaluation of risk to human receptors at the site should proceed with the baseline human health risk assessment process, at least for those receptors for which a screening level risk assessment is not appropriate. For reference, HERO has compiled a summary of recommended exposure factors which may be used as default values in baseline human health risk assessments at California hazardous waste sites and permitted facilities (DTSC 2011b). In other instances, the screening risk assessment may overestimate risk. In these cases, preparation of a baseline human health risk assessment is an option.

#### Additional Considerations Regarding the Use of Industrial RSLs

The tap water RSLs are calculated using residential land use assumptions. As such, these RSLs are not reflective of industrial exposures and may overestimate exposures via the water pathways.

Screening level evaluations using the industrial soil RSLs do not account for the following pathways: all uses of groundwater; exposure via vapor intrusion to indoor air; exposure to contaminated surface and ground water, and inhalation of particulates released from wind, truck traffic and use of heavy equipment. If these exposure pathways are significant at a site, screening risk assessment using RSLs is not appropriate.

#### **D. EVALUATION OF THE VAPOR INTRUSION TO INDOOR AIR PATHWAY**

As noted above, the U.S. EPA RSLs do not account for risk and hazard from the vapor intrusion to indoor air pathway. When VOC contamination is at significant concentrations in soil or groundwater, the vapor intrusion pathway often generates the highest cancer risk and hazard index. Therefore, when vapor intrusion is a potentially complete exposure pathway, it is essential that it be included in the screening risk assessment.

Please consult DTSC's vapor intrusion to indoor air guidance for a more detailed discussion of this topic (DTSC 2005). Soil gas data are typically recommended for use in evaluating this pathway over soil matrix or groundwater data because soil gas data provide a direct measurement of the VOCs that may migrate to indoor air. Technical difficulties in sample collection and preservation of VOCs in soil matrix make soil matrix data unreliable for estimating vapor intrusion. If soil gas data are not available for a given site, a soil gas investigation should be conducted. In addition, for sites with shallow groundwater, HERO recommends that vapor intrusion to indoor air be evaluated using both soil gas and groundwater data.

The most current DTSC screening-level Johnson and Ettinger (J&E) model should be used to estimate the risk and hazard quotient from vapor intrusion to indoor air. The DTSC J&E models can be found on the DTSC website at: [http://www.dtsc.ca.gov/AssessingRisk/JE\\_Models.cfm](http://www.dtsc.ca.gov/AssessingRisk/JE_Models.cfm). Although less often used, another option for evaluation of this pathway is indoor air monitoring. HERO should be contacted before undertaking either soil gas sampling or indoor air monitoring.

Risk and hazard from this exposure pathway must be summed with risk and hazard from other pathways to estimate the total site risk and hazard index (See separate discussion entitled "Additivity of Risk and Hazard").

## **E. EVALUATION OF IMPACTS TO SURFACE AND GROUND WATER**

The derivation of soil RSLs does not consider the potential for contaminants to migrate to groundwater or surface water. The RSL Tables do however list risk-based and maximum contaminant level (MCL)-based screening levels in soil (SSLs), which identify chemical concentrations in soil that may impact the groundwater. The DTSC geologist and the California Regional Water Quality Control Board (RWQCB) should be contacted regarding the protection of groundwater and surface water.

If it is determined that groundwater has been impacted, exposure to groundwater must be quantitatively evaluated in the screening level risk evaluation unless no VOCs are present in the groundwater and a written statement is available from the RWQCB indicating that groundwater from the site has no beneficial uses. If VOCs are present in groundwater, vapor intrusion to indoor air must be evaluated, regardless of beneficial use determinations.

Contaminated surface water must also be evaluated in screening risk assessments. Limitations in the derivation of tap water RSLs must be addressed in screening surface water. The tap water RSLs assume ingestion from drinking and inhalation of VOCs, but do not consider dermal absorption, ingestion during swimming, or ingestion of contaminated fish or plants.

In most cases, HERO recommends that unfiltered water be used in the risk evaluation given that unfiltered water may be of potable quality at some sites (U.S. EPA 1989). If only grab sample groundwater data are available at a site, they can be used for

assessing risk. However, because grab groundwater samples may be associated with high levels of particulate matter, the risk assessment should discuss the potential for additional uncertainty in the risk estimates due to the use of grab sample groundwater data.

Finally, as discussed below in the section entitled "Ecological Risk Assessment", the tap water RSLs only address human health. It cannot be assumed that these screening levels are protective of aquatic organisms and wildlife.

## **F. AIR MODELS USED IN THE CALCULATION OF THE SOIL RSLs**

The following points related to the air modeling used in the calculation of the RSLs must be considered during the screening level risk evaluation at sites:

The soil RSLs do not consider the potential for enhanced volatilization of compounds which can occur in the presence of landfill gases such as methane. In addition, the soil RSLs consider exposure to VOCs in outdoor (ambient) air, but not the subsurface vapor intrusion to indoor air pathway. Volatilization from shallow groundwater may be an additional source to ambient air.

Various assumptions were utilized in the RSL air modeling. For example, 0.5 acres was used as the default source area. HERO recommends an evaluation of whether the default RSL assumptions are reasonable for a specific site. If the default assumptions are significantly less health-protective than the actual conditions at the site, use of the RSLs is not appropriate and a site-specific evaluation is needed.

Some soil RSLs are denoted as "s", indicating that the RSL may exceed the soil saturation concentration (C<sub>sat</sub>) for that chemical. The RSL User's Guide defines C<sub>sat</sub> as the contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. At levels exceeding the C<sub>sat</sub> concentration, the soil contaminant may be present in free phase (i.e., nonaqueous phase liquids [NAPLs] for contaminants that are liquid at ambient soil temperatures and pure solid phases for compounds that are solid at ambient soil temperatures). This is important because the volatilization model used to calculate the RSLs is not applicable when free-phase contaminants are present. Cases in which the C<sub>sat</sub> is exceeded need to be addressed in the risk assessment. These should be discussed with the DTSC toxicologist prior to performing a risk assessment.

## **G. LISTING OF STRICTLY RISK-BASED SCREENING LEVELS IN RSL TABLES**

The soil RSLs values are risk-based. They do not consider physical limitations such as soil saturation and some RSLs exceed the "ceiling limit" concentration of  $1 \times 10^{+5}$  mg/kg. Soil RSLs that exceed C<sub>sat</sub> are denoted as "s." Soil RSLs exceeding  $1 \times 10^{+5}$  mg/kg are denoted as "m", meaning that the chemical represents more than 10% by weight of the soil sample. At such concentrations, the assumptions for soil contact used to derive the

RSLs may no longer be valid. Cases in which the chemicals are present at concentrations exceeding  $1 \times 10^{+5}$  mg/kg or Csat need to be identified and addressed in the risk assessment. These cases should be discussed with the DTSC toxicologist prior to performing a risk assessment.

## **ADDITIONAL CONSIDERATIONS RELATED TO SCREENING LEVEL HUMAN HEALTH RISK ASSESSMENTS AT FEDERAL FACILITIES**

### **A. SAMPLING AND ANALYSIS PLANS/ RISK ASSESSMENT WORK PLANS**

HERO recommends that the sampling and analysis work plans and risk assessment work plans be submitted to DTSC for review and approval prior to sampling activities and the preparation of a risk assessment. A consensus with the regulatory agencies prior to field activities will aid in ensuring that the collected data meet the requirements of a risk assessment. The risk assessment work plan provides the opportunity to resolve issues related to risk assessment methodology so that the risk assessment can be performed in a more efficient and timely manner.

#### i. Detection Limits.

The work plan should address the adequacy of the method detection limits. In general, the method detection limits must be sufficiently low to detect chemicals below the medium-specific and compound-specific RSLs or applicable risk-based screening criteria. If this is not technically feasible, chemicals for which the method detection limits exceed risk-based screening levels should be discussed in the Uncertainty Section of the screening level risk assessment report.

#### ii. Soil Sampling.

The work plan should address the proposed soil sampling depths and methodology for review by HERO and DTSC's Geologic Services Unit (GSU). For risk assessment purposes, HERO currently recommends that discrete (rather than composite) soil samples be collected given that composite samples can mask hot spots of contamination. Proposed new sampling methodologies might result in HERO altering this recommendation. If the sampling recommendations change, HERO will reflect this in an update to this HHRA Note. Contacting the HERO toxicologist when developing the sampling plan can provide an early indication of any possible changes.

For evaluation of future residential land use scenarios, soil samples from the 0 to 10 foot (ft) below ground surface (bgs) interval should be collected. While recommended soil sampling depths may vary based on site-specific conditions; in general, discrete soil samples should be collected from both surface (0 to 0.5 ft bgs) and subsurface soil. Collection of surface soil is particularly important for contaminants such as lead which have limited vertical mobility in the soil column. A lack of surface soil data for use in the risk evaluation could lead to a significant underestimate of risk. Please see Section E below for a discussion of exposure point calculations to be used for screening level risk assessments.

iii. Key Chemical Groups.

The work plan must address the proposed chemical analyses and analytical methods for the collected samples. Typically, HERO recommends that the following comprehensive suite of analytes be included during site investigations: metals, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). In addition, analyses for additional chemicals (e.g. polychlorinated dibenzo-p-dioxins (PCDDs); polychlorinated dibenzofurans (PCDFs), hexavalent chromium) may be warranted depending on the site history. The screening level risk evaluation should provide a clear and scientifically defensible rationale for selecting the chemical analytes. Unless it can be shown that there is no reason to suspect the presence of a particular chemical group, HERO recommends that the full suite of analyses be conducted.

iv. Total Petroleum Hydrocarbons. DTSC's Interim Guidance for Evaluating Human Health Risks from TPH dated June 16, 2009 is no longer active or available on the internet. Future approaches to petroleum hydrocarbon contamination will be addressed as part of the Preliminary Endangerment Assessment (PEA) Manual which is currently under revision. In light of this fact, we recommend that in the interim, TPH be evaluated in screening level risk assessments using data for specific toxic constituents of TPH including benzene, toluene, ethylbenzene, and xylene (BTEX), hexane, other volatile fuel components, polycyclic aromatic hydrocarbons (PAHs), and metals. Depending on site-specific conditions and the results of the screening level evaluation, additional evaluation of TPH using the methodology outlined by others such as the Massachusetts Department of Environmental Protection may be recommended until the revised PEA Manual becomes available. The DTSC toxicologist should be contacted for any questions on this issue.

## **B. SELECTION OF INORGANICS AS COPCs AND CALCULATION OF BACKGROUND RISK AND HAZARD INDEX**

Previous HERO guidance (DTSC 1997) provides recommended methodology for selecting inorganic constituents as chemicals of potential concern (COPCs). Historically, inorganic chemicals eliminated as COPCs were not carried forward into the quantitative risk assessment. More recent U.S. EPA (2002) guidance recommends the inclusion of naturally occurring inorganic chemicals in the risk assessment. Background issues for inorganic chemicals are to be addressed during risk characterization.

HERO recommends the screening level risk assessment include the calculation of both the site-related risk and hazard index, and the total risk and hazard index. The latter presents the risk and hazard associated with exposure to all detected chemicals prior to elimination of inorganic chemicals that are determined to be consistent with site-specific background or ambient concentrations. This information is useful for risk management decisions about appropriate land uses and for public transparency. It is critical that

different expressions of the risk assessment results (i.e., site-related and total risk) be based on the same statistic in order to be comparable.

The HERO toxicologist should be contacted if there are questions in this regard. In particular, at some sites, it may not be necessary to calculate total risk and hazard. In addition, an important distinction between the approach outlined herein and U.S. EPA's 2002 guidance is that HERO does not allow the elimination of compounds as COPCs based on comparison to risk-based screening levels. HERO's reference to the 2002 U.S. EPA guidance does not imply concurrence with the screening-out of individual chemicals as COPCs based on PRGs, RSLs or other risk-based criteria.

### **C. "SCREENING-OUT" COPCS**

In general, HERO recommends that all detected compounds be selected as COPCs and be included in the quantitative risk evaluation. In limited cases, HERO may agree to eliminate specific chemicals from full consideration in the risk assessment; however, such cases must be discussed with and agreed to upfront by the DTSC toxicologist. To facilitate an evaluation regarding whether it is appropriate to exclude a detected chemical from the risk assessment, a rationale should be provided for each chemical proposed for elimination which considers factors such as the frequency of detection, detection limit, chemical toxicity, concentration detected, site history, co-location of high concentrations (i.e., a 'hot spot'), essential nutrient status, and/or comparison to background for inorganics as discussed above. Potential chemical breakdown products must also be considered, and the rationale should not be based on a "brightline" approach (e.g. preliminary cancer risk  $<1E-07$ , preliminary HQ $<0.1$ ). As detailed above, inorganics which are determined to be present at concentrations consistent with background will still need to be included in the total risk and hazard evaluation.

### **D. ADDITIVITY OF RISK AND HAZARDS**

For each site-related chemical, the chemical concentrations in each relevant medium should be divided by their corresponding soil and tap water risk-based screening levels. Please see HHRA Note 3 for a listing of chemicals which HERO recommends an alternate value other than the RSL. For compounds with non-threshold effects (carcinogens), that ratio must be multiplied by  $10^{-6}$  to provide an estimate of risk. Risk must be summed across all carcinogenic chemicals and exposure pathways (including vapor intrusion to indoor air evaluated separately from comparison to RSLs). Similarly, hazard quotients must be summed across all chemicals and exposure pathways (including vapor intrusion to indoor air evaluated separately from comparison to RSLs) for threshold (non-carcinogenic) effects to provide a hazard index. Please note that the soil and tap water "supporting" tables available on the U.S. EPA RSL website provides RSLs based on both non-threshold and threshold effects for most carcinogens. Carcinogens should be evaluated both for carcinogenicity and for threshold toxicity. If the summed hazard index for the site is greater than one, then the hazard index may be recalculated for chemicals which have the same toxic manifestation or which affect the same target organ.

## **E. EXPOSURE POINT CONCENTRATIONS**

In general, HERO recommends that the maximum detected concentrations of COPCs be used as the exposure point concentrations in screening level risk evaluations. Use of the 95 percent upper confidence limit (95% UCL) on the arithmetic mean concentrations must be approved by the DTSC toxicologist. In most cases, use of the maximum detected concentrations is appropriate because of the screening-level nature of such evaluations and because the screening-level sampling is usually limited.

## **F. SURROGATE COMPOUNDS**

Compounds for which RSLs are not available should be evaluated in the risk assessment through the selection of a surrogate chemical. Surrogates should have similar structure, activity, and mechanisms of toxicity. The HERO toxicologist should be contacted regarding the selection of the most appropriate surrogates.

## **G. CALCULATION OF TETRACHLORODIBENZO-P-DIOXIN AND BENZO(A)PYRENE EQUIVALENTS**

Dioxins and furans are evaluated based on quantitative comparison of the 2,3,7,8-tetrachlorodibenzofuran (TCDD)-equivalent concentration with the TCDD RSL. If congener specific polychlorinated biphenyl (PCB) data are included, these should also be included in calculating the TCDD-equivalent concentrations. HERO recommends the 2005 World Health Organization (WHO) toxic equivalency factors (TEFs) (Van den Berg, 2006). These values can be found in the RSL User's Guide and are also summarized in HERO's HHRA Note 2 (DTSC 2009).

In some cases, benzo(a)pyrene (BaP)-equivalent concentrations are calculated and used in screening-level risk evaluations to assess risk from carcinogenic PAHs. Please note that naphthalene is not included in the calculation of the BaP-equivalent concentration. Rather, this compound is evaluated separately using the naphthalene RSLs. If the BaP-equivalent concentration is calculated, the OEHHA potency equivalency factors (PEFs) should be used (OEHHA 2002). See Table 1.

## **H. EVALUATION OF LEAD**

In 2007, CalEPA OEHHA developed a new toxicity evaluation of lead which is detailed in "Child-specific benchmark change in blood lead concentration for school site risk assessment" (OEHHA 2007). Subsequently, in 2009, they released revised lead CHHSLs which are substantially lower than previously established CHHSLs and the 2004 PRGs (OEHHA 2009). As discussed in the 2007 and 2009 documents, OEHHA has replaced the 10 µg/dL threshold blood concentration with a source-specific "benchmark change" of 1 µg/dL and now recommends use of new residential and commercial/industrial CHHSLs consistent with the newly established benchmark.

The newly revised OEHHA CHHSLs for lead under residential and industrial/commercial land use scenarios are 80 and 320 mg/kg, respectively. This is a departure from the previously utilized Cal-modified USEPA Region 9 PRG value of 150 mg/kg for residential land use. With regard to assessment of lead risk and evaluating cleanup options, if sufficient data are available, HERO recommends calculating the 95% UCL lead concentration for each exposure area. If individual samples exceed the CHHSL, it would not mean that the exposure area itself is in exceedance of the CHHSL as long as the 95% UCL itself is below 80 mg/kg for residential and 320 mg/kg for industrial/commercial, assuming hot spots are not present.

For initial site screening (i.e. screening level risk evaluations which are covered in this HHRA note) where data are insufficient to calculate a 95% UCL, comparison of the maximum detected concentration to the CHHSLs is appropriate. If individual sample results exceed the CHHSLs, depending on site-specific conditions and sampling results, additional investigation, evaluation, and potentially remediation may be warranted to address concerns about lead exposure.

Because the CHHSLs are based on a source-specific exposure to lead in soil only, other media which may be impacted by lead were not considered. The CHHSLs also do not consider lead exposure from the home grown produce pathway. If lead is present at levels above background in media other than soil (e.g. water, air) or if the home grown produce pathway is anticipated at the site, please contact the HERO toxicologist.

## **CONCLUSIONS**

Screening level risk evaluations are useful for determining whether a finding of “no further action” may be warranted with respect to human health. Such evaluations can also provide preliminary estimates of risk and hazard at a site prior to conducting a baseline risk assessment. There are important limitations which need to be considered when using screening level risk estimates for risk management decisions. Many of the limitations and important aspects of screening level risk evaluations are summarized herein.

Of importance is the fact that screening level risk assessments conducted using U.S. EPA Regional Screening Levels do not consider potential harm to ecological receptors. A separate ecological risk evaluation must be conducted if ecological habitat is present onsite or there is potential for transport of contaminants to offsite habitat.

Vapor intrusion into indoor air is frequently an important exposure pathway. Since the RSLs do not include this pathway, this HHRA Note provides recommendations to address this deficiency.

If you have any questions on this HHRA Note, please contact Dr. Michael Wade, HERO Senior Toxicologist, at (916) 255-6653.

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**Table 1:** Summary of Cal/EPA Polycyclic Aromatic Hydrocarbon (PAH) Cancer Potency Equivalency Factors (PEFs)

PAH or derivative	Cal/EPA Cancer Potency Equivalency Factor (PEF) <sup>a, b, c</sup>
Benzo(a)pyrene	1.0 (index compound)
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(j)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Dibenz(a,j)acridine	0.1
Dibenz(a,h)acridine	0.1
Dibenz(a,h)anthracene	0.34 <sup>d</sup>
7H-dibenzo(c,g)carbazole	1.0
Dibenzo(a,e)pyrene	1.0
Dibenzo(a,h)pyrene	10
Dibenzo(a,i)pyrene	10
Dibenzo(a,l)pyrene	10
Indeno(1,2,3-cd)pyrene	0.1
5-methylchrysene	1.0
1-nitropyrene	0.1
4-nitropyrene	0.1
1,6-dinitropyrene	10
1,8-dinitropyrene	1.0
6-nitrochrysene	10
2-nitrofluorene	0.01
Chrysene	0.01

<sup>a</sup> Office of Environmental Health Hazard Assessment, Cal/EPA, 1993. Benzo(a)pyrene as a Toxic Air Contaminant. Part B. Health effects of benzo(a)pyrene. Air Toxicology and Epidemiology Section, Berkeley, CA.

<sup>b</sup> Office of Environmental Health Hazard Assessment, Cal/EPA. 2002. Air Toxics Hot Spots Program Risk Assessment Guidelines – Part II Technical Support Document for Describing Available Cancer Potency Factors.

<sup>c</sup> The Cal/EPA OEHHA Toxicity Criterion Database lists oral and inhalation slope factors for these carcinogenic PAHs which are based on the use of BaP as the index compound and the PEFs listed in this summary table.

<sup>d</sup> Potency Equivalency Factor calculated using a ratio of the Cal/EPA oral cancer slope factors of  $12 \text{ (mg/kg/d)}^{-1}$  for benzo(a)pyrene and  $4.1 \text{ (mg/kg-d)}^{-1}$  for dibenz(a,h)anthracene.