Recommended Protocol for Evaluating the Location of Sensitive Land Uses Adjacent to Major Roadways

DRAFT

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1. Introduction

In April 2005 the California Air Resources Board (ARB) issued a guidance document on air quality and land use[1]. This document specifically offered guidance on siting sensitive land uses in proximity to sources of air toxics. Sensitive land uses include new residences, schools, day care centers, playgrounds, and medical facilities. One particular source of air toxics treated in the guidance is freeways and high traffic roadways. These roadways are sources of diesel particulate matter (PM), which ARB has listed as a toxic air contaminant. The specific guidance recommends that sensitive land uses be sited no closer than 500 ft from a freeway or other high traffic roadway. This recommendation was based on traffic related studies that showed a 70% drop in ambient PM concentrations at a distance of 500 ft from the roadway. Presumably, the lifetime cancer risk from exposure to the diesel PM is lowered proportionately.

This land use siting recommendation has major implications relative to land development projects. In particular, new residence development projects would be especially constrained if the nearest new residence in the project were required to be at least 500 ft from a nearby freeway. The ARB guidance is advisory in nature, and suggests that development project site specific analyses be performed to characterize the health risks of a given development project. However, local officials faced with land use siting decisions question the need to require a site specific health risk assessment (HRA) for every sensitive land use project (e.g., new housing) proposed that deviates from the ARB guidance. Such questions are indeed valid given that the ARB guidance is based on very conservative analyses that include worst case risk parameter assumptions. Moreover, even in instances in which a site specific HRA is appropriate, there is currently little guidance regarding how such a HRA be performed.

The purpose of this document is to provide land use decisionmakers with a methodology to make informed land use decisions on siting new residential projects and other sensitive land uses in proximity to a freeway or other high traffic volume roadway. This methodology is intended to give local officials the information needed to assess health risk issues within the spectrum of other land use issues that must be considered in the land use planning process. These other issues include housing and transportation needs, the benefits of urban infill, and community economic development priorities.

The methodology defines a stepwise process that indicates the need for and methodology to conduct a site specific HRA. In this stepwise process, project site specific characteristics are used to evaluate the relative health risk posed within the project and to determine whether a site specific HRA is warranted. In cases for which a site specific HRA is indicated, this methodology gives guidance regarding how the HRA should be performed.

In the following, Section 2 describes the stepwise project evaluation process that includes screening steps that can be used to decide whether a complete HRA is needed for a particular land use project. Section 3 describes the methodology recommended for completing a site specific HRA in instances in which the screening steps conclude that one should be done. Section 4 provides a list of resources to use in the screening and HRA process. The technical

[1] California Air Resources Board (ARB). Air Quality and Land Use Handbook: A Community Health Perspective. April 2005.

discussion that provides the background and justification for many aspects of the risk evaluation is given in the Appendix.

The scope of this protocol is limited to assessing how traffic on a single roadway affects the PM-related cancer health risk posed to an individual at a nearby sensitive land use such as a new residential housing development. The methodology developed in this effort also assumes that the roadway is a limited-access freeway, with no traffic signals and associated traffic queues. Ways to incorporate multiple roadways, freeway intersections, controlled traffic roadways (i.e. with traffic signals and intersections), and other, non-roadway, toxic air contaminant sources into the HRA process may be the subject of future efforts.

2. Health Risk Assessment Screening

The stepwise, or tiered, approach to be used to assess the potential population health risk of a proposed land use project is illustrated in Figure 1. The flowchart in Figure 1 shows the steps that a planning agency needs to take. They are summarized as follows:

1. Determine if the nearest person affected by the project (receptor) is at least 500 feet from the nearest high traffic volume roadway (defined as a freeway, urban roadway with greater than 100,000 vehicles/day, or rural roadway with 50,000 vehicles/day).[2] If yes, then the proposed project meets the ARB guidance distance and no further air quality evaluations are required under this protocol. If no, proceed to step 2.
2. Using the screening process described in this section, determine if the nearest receptor has a health risk level lower than the screening criterion for requiring a full HRA. If lower risk, then no further air quality evaluations are required under this protocol and the projected relative health risk should be recorded in the environmental documentation. If higher risk, the proposed project must complete step 3.
3. Complete a site specific HRA using procedures in accordance with those described in Section 3, and submit records in the environmental documentation.

Assuming the project must proceed to step 2, this guidance calls for using a pair of screening tables to determine if the project distance exposes receptors to greater risk than the protocol's risk criterion. The information needed to screen a project in step 2 is shown below.

Information needed to screen a project

1. Compass orientation (direction) of the roadway affecting the project
2. Compass orientation (direction) of the project with respect to the roadway
3. Peak hourly traffic volume on the roadway at the project location

Peak hourly traffic volumes are tabulated by Caltrans[3] for each of the numbered highways in the state at various locations along the highway. One should select from the location (milepost) nearest the project. The back peak hour volume should be selected for projects south or west of the nearest milepost location; the ahead peak hour volume for projects north or east of the nearest milepost location. For projects near roadways not tabulated by Caltrans, SMAQMD should be consulted.

[2] ARB, Air Quality and Land Use Handbook.
[3] http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/, viewed July 2006

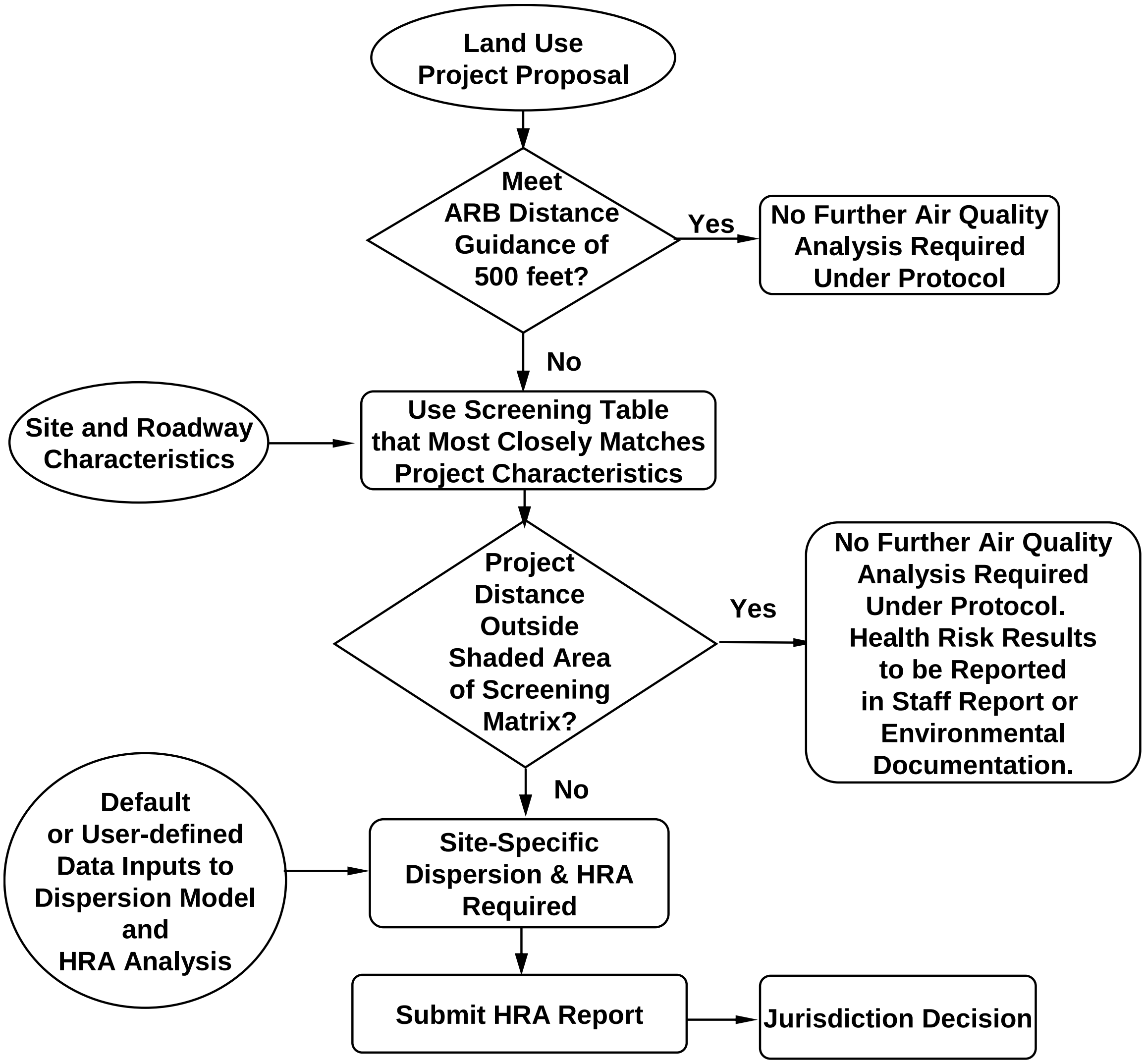

Figure 1. Stepwise approach to evaluating sensitive land use projects adjacent to major roadways

In the screening process, the agency or its consultant uses project information to locate the appropriate cell in the screening matrix that will determine whether or not to move on to step 3. One determines the appropriate cell by referencing the roadway and project direction, and traffic volume in the tables. There are two tables to choose from: one is for East-West roadways and one is for North-South roadways. Within each table, there are matrices for projects that are upwind and downwind of the roadway. The upwind or downwind designation corresponds to the annual average general wind direction taken from the SMAQMD meteorological data (see Section 3).

One should locate the cell that most closely represents the project screening risk by first choosing the correct table. If the roadway is predominantly East-West, choose Table 1. If the roadway is predominantly North-South, choose Table 2. If the predominant compass orientation of the roadway is subject to dispute, then an east-west orientation should be assumed, and Table 2 selected. Next, if the project is downwind of the roadway, look to the upper matrix in the table. If the project is upwind, look to the lower matrix. Now, the appropriate row in the matrix is determined according to peak traffic volume at the roadway near the project.

The traffic volume at the roadway, using the Caltrans data, should be rounded up to the nearest entry in the matrix selected. Finally, the agency or its consultant notes the increased cancer risk shown in the cell that corresponds to the proposed distance from the roadway of the nearest affected receptor. For example, for a new housing development, the appropriate distance is that of the nearest new residence. If the cell is not shaded (the increased risk is less than the evaluation criterion of 400/million, as discussed in the following paragraph), a site specific HRA is not required for the project and no further air quality analysis is required by this protocol. The results of the analysis should be recorded in the environmental documentation or a staff report regarding the project. If the cell is shaded (the increased risk is greater than the evaluation criterion), a site specific HRA should be performed.

Table 1. PM cancer risk (potential incremental cancer cases per million people) north and south of an east-west roadway

Peak Hour Traffic (vehicle/hr)	Receptor Distance from Edge of Nearest Travel Lane (feet)								
	0	10	25	50	100	200	300	400	500
Incremental Cancer Risk per Million: North (downwind)									
4,000	180	168	150	123	93	60	45	36	30
8,000	363	339	300	249	183	120	90	72	63
12,000	543	510	450	372	276	180	135	111	93
16,000	726	678	600	498	366	240	180	147	123
20,000	906	849	750	621	459	300	225	183	153
24,000	1086	1020	903	747	549	360	273	219	183
Incremental Cancer Risk per Million: South (upwind)									
4,000	108	96	81	63	45	30	21	18	15
8,000	216	195	162	129	90	60	45	36	30
12,000	327	291	243	192	138	87	66	54	45
16,000	435	390	324	255	183	117	87	72	60
20,000	543	486	405	318	228	147	111	87	75
24,000	651	582	486	384	273	177	132	105	87

Table 2. PM cancer risk (potential incremental cancer cases per million people) east and west of a north-south roadway

Peak Hour Traffic (vehicle/hr)	Receptor Distance from Edge of Nearest Travel Lane (feet)								
	0	10	25	50	100	200	300	400	500
Incremental Cancer Risk per Million: East (downwind)									
4,000	222	204	174	138	99	63	45	36	30
8,000	444	408	351	279	195	126	93	75	60
12,000	666	612	525	417	294	186	138	111	90
16,000	891	816	702	555	393	249	186	147	123
20,000	1113	1020	876	696	489	312	231	183	153
24,000	1335	1227	1053	834	588	375	279	222	183
Incremental Cancer Risk per Million: West (upwind)									
4,000	147	126	99	72	48	30	24	18	15
8,000	294	252	198	147	99	63	45	36	30
12,000	438	381	300	219	150	93	69	54	45
16,000	585	507	399	294	198	123	90	72	60
20,000	732	633	501	366	249	156	114	90	72
24,000	879	762	600	441	300	186	138	108	87

The evaluation criterion of 400/million was selected as that level of risk corresponding to a 70% reduction from the highest predicted risk in either of the two screening tables. This highest estimated risk is that at the edge of the nearest travel lane to the receptor (distance of 0 feet) for the highest peak traffic volume considered (24,000 vehicle per hour) east (downwind) of a north-south roadway. Thus, this highest risk represents that corresponding to a reasonable worst case siting situation within SMAQMD.

Screening Responsibilities and Reporting

1. The project proponent should provide the following information regarding its screening effort to the agency requesting the analysis:

- General project information (town and nearest road intersection of project, map showing relative location of affecting roadway, type of project, project timeline, contact information for project proponent, name of consultant if relevant)
- Roadway compass orientation, project compass orientation
- Distance from the roadway to the nearest receptor
- Peak hour traffic volume and reference/source

2. The local agency or its consultant should screen the project and report the project inputs provided by the proponent as well as the following results:

- Diesel PM risk value at the nearest receptor (rounded up to nearest distance column in the screening table)
- The screening matrix used in the process showing risk varying by distance to roadway

3. Methodology for Completing a Site Specific Health Risk Assessment

The screening evaluation discussed in Section 2 can lead to the need for a local agency or its consultant to complete a full site specific HRA. The recommended methodology to be used in performing a site specific HRA is outlined in the following discussion.

Performing a site specific HRA requires calculating estimated ambient pollutant concentrations resulting from the mass emission rate of a pollutant from a source. For the HRA required according to this protocol, the pollutant source is the exhaust emissions from the vehicle traffic traveling the high traffic volume roadway that will affect a proposed sensitive land use project. The pollutant of interest is diesel PM, although PM10 is used as a proxy for the relative measure of diesel PM at varying distances. The choice to base the HRA on PM10 is further discussed in the Appendix. For a site specific HRA needed in accordance with this guidance, the line source model CAL3QHCR should be used as the dispersion model for estimating ambient concentration as a function of distance from the source. CAL3QHCR is a refined version of the original CALINE (California Line Source Dispersion Model) that was developed as a modeling tool to predict roadside CO concentrations. CAL3QHCR can be used to estimate ambient PM concentrations and to process hourly meteorological data over a year, hourly emissions, traffic volume, and signal data. The model can be obtained from EPA[4].

To run CAL3QHCR, one needs meteorological, traffic, and vehicle emissions data at specified intervals over some time period, such as hourly average data for a year. For meteorological data, SMAQMD can supply data files that contain hourly meteorological data over a year for each of five years (1985, 86, 87, 88, and 89)[5]. These data are considered the "standard SMAQMD met data" for specified use in point source dispersion model analyses performed for the SMAQMD region (e.g., air toxics hot spots analyses to comply with AB 2588). The meteorological data set for 1987 is recommended for use in performing a site specific HRA in accordance with this guidance.

For emissions and traffic data, the local agency or consultant tasked with completing a site specific HRA can employ any documented and defensible source for vehicle emissions and hourly traffic data that represents the local situation near the proposed development project, with the approval of the permitting jurisdiction. For the emissions default, this approach relies on EMFAC2002[6] tabulations for SMAQMD. EMFAC provides a report that gives hourly regulated pollutant emission rates (ton/hr) for the SMAQMD mix of vehicles for a user-designated year. This hourly distribution is the average for that hour over the year. Emission rates and corresponding vehicle miles traveled (VMT) for each hour of the day are given for a number of vehicle types (e.g., light duty passenger cars equipped with and without a 3-way catalyst, heavy-duty diesel trucks, urban buses, and so forth). The total hourly pollutant emission rate and VMT for the SMAQMD mix of vehicles for each hour are also tabulated. For input to CAL3QHCR, the user needs to supply hourly traffic volume (vehicles/hour) and PM emission factor (g/vehicle-mile) data. Table 3 gives the hourly distribution of total PM10 emission rates

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[4] http://www.epa.gov/scram001/dispersion_prefrec.htm, viewed June 2006

[5] ASCII data files SACOAK85.ASC, SACOAK86.ASC, SACOAK87.ASC, SACOAK 88.ASC, and SACOAK89.ASC obtained from B. Krebs of SMAQMD.

[6] EMFAC2002, Ver. 2.2, April 23, 2003. Note: if the local agency determines that a new version of EMFAC has been released, it should check with SMAQMD to determine if this document has been updated and if the new EMFAC version should be used for the HRA.

(g/vehicle-mile) from the EMFAC data for the hourly SMAQMD district-wide vehicle mix in 2006.

The model also takes as input the hourly traffic volume (vehicles/hour) as determined by the relative VMT, which is the ratio of the VMT for the hour to the peak VMT over the 24-hr day. This relative VMT is also shown in Table 3 for each hour. The hourly traffic volume supplied will be the product of the relative VMT in Table 3 with the roadway peak traffic volume, obtained from the Caltrans tabulation as discussed in Section 2.

CAL3QHCR also requires geographical data that defines the calculational domain. The x-y coordinates of the beginning and end of the roadway section being modeled and the link width (mixing zone) of the roadway need to be specified (in feet, arbitrary origin, y axis aligned with north). For example, a six-lane freeway might consist of six 12-ft wide lanes, and a 62-ft wide median, or 134 ft. Add to this an additional 10 ft from the edge of the travel lane nearest to the receptor to account for the wake of moving vehicles, and the total link width becomes 154 ft, for the example. The user should supply to the model the roadway width (including an assumed 10 ft on both sides of the roadway as describe above) applicable to the project site. One also needs to specify the elevation of the roadway compared to the surrounding area. For roadways at grade, this height is 0; for elevated and depressed roadways, this is the positive or negative relative height, respectively. A set of receptors at varying distances from the edge of the nearest travel lane needs to be specified in terms of their x-y coordinates as well. And, the receptor heights, for example 6 ft. if near ground level, need to be defined. All these parameters are specific to the project site subject to the HRA, and need to be defined and noted by the modeler accordingly.

Other parameters needing specification for a CAL3QHCR model run, along with default values, are listed in Table 4. These defaults were used in the calculations that led to screening Tables 1 and 2 discussed in Section 2.

Table 3. EMFAC2002 relative traffic volume and vehicle PM10 emission rates for SMAQMD in 2006 for default inputs into CAL3QHCR

Time of day	Relative VMT	PM10 emission rate, g/vehicle-mile
Hr 00	0.152	0.0480
Hr 01	0.057	0.0643
Hr 02	0.063	0.0578
Hr 03	0.051	0.1417
Hr 04	0.071	0.0513
Hr 05	0.130	0.0560
Hr 06	0.480	0.0456
Hr 07	0.951	0.0269
Hr 08	0.891	0.0287
Hr 09	0.564	0.0453
Hr 10	0.590	0.0371
Hr 11	0.741	0.0345
Hr 12	0.763	0.0287
Hr 13	0.753	0.0291
Hr 14	0.864	0.0253
Hr 15	0.874	0.0250
Hr 16	0.912	0.0280
Hr 17	1.000	0.0219
Hr 18	0.698	0.0157
Hr 19	0.522	0.0140
Hr 20	0.402	0.0272
Hr 21	0.408	0.0268
Hr 22	0.302	0.0242
Hr 23	0.230	0.0159

Table 4. Other CAL3QHCR parameters

Parameter	Default
Calculation averaging time (min)	60
Surface roughness (cm, from 3 to 400, 108 corresponds to single family residential)	108
Settling velocity (cm/s)	0
Deposition velocity (cm/s)	0
Site setting (U=urban, R=rural)	U
Form of traffic volume, emission rate data (1=one hour's data, 2=one week of hourly data)	2
Pollutant (P for PM10 to give output in $\mu g/m^3$)	P
Hourly ambient background concentration ($\mu g/m^3$)	0
Roadway height indicator (AG=at grade, FL=elevated and filled, BR=bridge, DP=depressed)	AG
Roadway height (ft, 0 if AG, relative height if FL, BR, or DP)	0

CAL3QHCR has many other features that allow modeling traffic intersections, traffic signaling, and traffic queuing. Employing these features is quite site-specific. If these features must be employed, the CAL3HQCR users guide[7] should be consulted.

The output from the CAL3QHCR dispersion modeling run will be calculated ambient PM10 concentrations in $\mu g/m^3$ at a defined receptor location. As part of this protocol, the local agency or its consultant should complete the risk assessment for nine receptor distances from the roadway (0, 10, 24, 50, 100, 200, 300, 400, and 500 feet) and one receptor location that is the site of the nearest potentially affected population. For example, for a new housing development this would be the nearest new residence.

The next step is to calculate the potential increased cancer risk for the project at the specified distances (0, 10, etc.). The PM10 concentration modeled from CAL3QHCR at the site is used in conjunction with the diesel PM unit risk factor established by the State of California Office of Environmental Health Hazard Assessment (OEHHA) to determine the incremental increased cancer risk. The diesel PM unit risk factor is a value established via lab studies and represents the increased chance of developing cancer based on concentration exposure. The value incorporates many worst case assumptions including a constant exposure to diesel PM (24 hours a day) and a 70 year life span. The value for diesel PM as established by OEHHA is 3×10^{-4} per $\mu g/m^3$.[8] The unit risk factor is multiplied by the concentration results from CAL3QHCR to determine the increased cancer risk. The calculated value represents the increased chance of developing cancer over a person's lifetime. Increased cancer risk is typically discussed and presented in increased number of cases per one million people. To convert the calculated risk into typically discussed terminology, the calculated risk is then multiplied by one million (1×10^6) and the denominator is changed from per person to per one million people. A sample calculation is performed below for reference.

Concentration at 100 feet $0.0025\ \mu g/m^3$
Unit risk factor for diesel PM $3 \times 10^{-4}\ (\mu g/m^3)^{-1}$
Calculated increased risk = $(0.0025\ \mu g/m^3) * (3 \times 10^{-4}\ (\mu g/m^3)^{-1}) * (1 \times 10^6)$
= 0.75 cases per million people

The risk vs. distance matrix for a group of distances is the resulting data set that the local agency or its consultant should report.

[7] User's Guide to CAL3QHC Version 2.0, EPA-454/R-92-006 (Revised, with CAL3QHCR addendum), September 1995.
[8] Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values, can be obtained from www.arb.ca.gov/toxics/healthval/healthval.htm, April 2005

4. Site Specific HRA Reporting

In the report of the HRA results, detail on the dispersion modeling inputs as well as the risk results by distance should be provided.

Site Specific HRA Reporting

At a minimum the HRA report should include the same information reported in the screening evaluation as well as the following:

- Emissions input data and calculation year for PM10, if different from Table 3. (Note: the EMFAC planning inventory should be referenced – if EMFAC is not used for emissions data, a detailed explanation must be provided; calculation year should represent the first calendar year of exposure)
- List of CAL3QHCR parameters used in the modeling, in the format of Table 4; explanation or references for parameters
- Name and source of meteorological data set used in CAL3QHCR
- Matrix indicating varying cancer risk per million from 0 to 500 feet from modeled roadway for PM10 (0, 10, 24, 50, 100, 200, 300, 400, and 500 feet)
- Incremental cancer risk value for the project point nearest the roadway based on PM10.

5. Resources

The following are sources of information for use by the local agency or its consultant that may prove useful in the risk screening and site specific HRA process:

- The Caltrans website reports peak traffic volumes at various intersection or milepost locations for all numbered roadways in the state: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/
- Vehicle population and emission factor data are provided by the ARB's emission factor model; the most recent version is EMFAC2002, Ver. 2.2, April 23, 2003: http://www.arb.ca.gov/msei/onroad/latest_version.htm.
- The line source dispersion model CAL3QHCR can be obtained from the EPA website: http://www.epa.gov/scram001/dispersion_prefrec.htm. User guides for employing the model can be found on the same website
- Cancer unit risk factors are provided by ARB on the following website: www.arb.ca.gov/toxics/healthval/healthval.htm

Appendix

The following is extracted from a report prepared by TIAX that provides more discussion of the health risk assessment screening and site specific evaluation process. The discussion also provides the technical background and procedure justification for the evaluation protocol described in the main body of this report.