taha
environmental planners

**Memorandum**

TO: Steve Gerhardt, AICP, Senior Planner
333 West Ocean Boulevard, 4th Floor
Long Beach, CA 90802

FROM: Sam Silverman, Senior Associate
Annie Ho, Assistant Planner
Terry A. Hayes Associates Inc.

DATE: April 25, 2013

**Re: Long Beach Crematorium Health Risk Assessment**

Terry A. Hayes Associates Inc. (TAHA) has completed a Health Risk Assessment (HRA) to determine the extent to which crematoriums in the City of Long Beach result in elevated health risks to the surrounding communities. The discussion presents background information on air quality emissions associated with crematoriums, relevant regulatory framework, and the risks associated with air emission depending on the number of burners used at one location and the distance from the source to the nearest land use.

The HRA indicated no acute risk is present for land uses located at any distances of crematoriums in the City of Long Beach. As for chronic risk, land uses located within 50 meters of crematorium with one incinerator would experience significant risk related to the developmental and kidney systems. In addition, significant chronic risk may exist at sensitive land uses located within 100 meters of future crematorium with multiple incinerators. At this distance, the areas affected by chronic exposure include the cardiovascular, developmental, kidney, nervous, respiratory, and dermatological systems. The HRA also indicated that significant carcinogenic risk exists within 200 meters of crematorium. **Figures 1** through **3** illustrate the potential health risks associated with crematoriums in the City of Long Beach.

**Overview of Cremation Activities and Associated Air Emissions**

Cremation is the act of reducing a corpse by burning, generally in a crematorium furnace or crematory fire. An incinerator with two chambers is the most widely used type of cremator. The chambers are heated between 1,500 and 1,800 degrees Fahrenheit and a "cremation case charge" (remains enclosed in a wooden casket/cardboard casket or a body bag) is introduced to the chambers. The cremation case charge is placed on the hearth in a manner that provides for maximum exposure to the cremation burner. During the cremation process, a large part of the body (especially the organs) and other soft tissue in the charge are vaporized and oxidized due to the heat, and the gases are discharged through the exhaust system. This vaporization process eliminates the threat of exposure to infectious disease from deceased persons. All that remains after cremation are dry bone fragments (mostly calcium phosphates and minor minerals). The approximate time for complete cremation is two hours, which may vary depending on weight.



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w e b t a h a . c o m

The cremation process can produce emissions of flyash, smoke, gases, and odor.[1] A poorly designed incinerator with inadequate turbulence, temperatures, and residence time can result in the objectionable emissions. The visible and odor emissions can best be controlled by good design. Almost all incinerators use natural gas as the fuel during the cremation process. As a result, emission factors available for natural gas combustion can be used to estimate part of the total toxic air contaminant emissions generated during the process. In addition to natural gas combustion, there are also emissions attributed to the combustion of the charge.

The products of incineration that cause health concerns include, but are not limited to, various metals such as mercury (Hg), arsenic, cadmium, and lead; dioxins and furans (PCDD/Fs); polychlorinated biphenyls; particulate matter; and hydrochloric acid. PCDD/Fs and Hg are the two pollutants of greatest concern due to their toxicity levels.

PCDD/Fs are a class of organic chemicals that are formed during the cremation process when chlorinated products (e.g., plastics presents in prosthetics or casket) are burned. Exposure to PCDD/Fs are toxic to the liver and potentially result in an adverse affects to the following systems: endocrine, hematopoietic, reproductive and respiratory.

Hg is a naturally-occurring metal that is volatile and vaporizes at a fairly low temperature. Tooth restoration (i.e., dental amalgams) is the primary source of Hg emissions to be released during cremation. The amount of Hg in dental amalgams varies based on the size of the fillings. Consequently, the level of Hg emissions released per cremation of a human body vary considerably. Exposure to Hg can affect the nervous system resulting irritability, tremors, vision or hearing changes, and/or memory problems.

**Regulatory Setting**

The South Coast Air Quality Management District (SCAQMD) has adopted two rules that affect the operation of crematoriums.

***$NO_X$ Reductions from Miscellaneous Source (Rule 1147).*** Rule 1147 limits emissions of nitrogen oxides ($NO_X$) from gaseous and liquid fuel fired combustion equipment (e.g., crematories). Any person owning or operating a unit on or after January 1, 2010 shall not operate the unit in a manner that exceeds the applicable $NO_X$ emission limit specified at the time a permit is required for operation of a new, relocated or modified unit. Specifically for crematory, the $NO_X$ emission limit is 30 parts per million or 0.036 pounds per million British thermal unit (BTU).

***New Source Review for Toxic Contaminants (Rule 1401).*** Rule 1401 limits the maximum individual cancer risk (MICR), cancer burden, and noncancer acute and chronic hazard index (HI) from new permit units, relocations, or modifications to existing permit units which emit toxic air contaminants (TACs). Rule 1401 establishes risks for permit units requiring new permits pursuant to Rules 201 or 203.

Rule 1401 also established requirements for HRA for TACs that are listed in the rule. This rule specifies that the MICR shall not exceed one in one million if Toxics Best Available Control Technology (T-BACT) is not installed and ten in one million if T-BACT is installed. The cancer burden shall not exceed 0.5, which is the estimated increase in the occurrence of cancer cases in a population subject to a MICR of greater than or equal to one in one million resulting from exposure to TACs. In addition, both chronic and acute HIs shall not exceed 1.0 for any target organ systems.

[1] Bay Area Air Quality Management District, *Permit Handbook (Section 11.6)*, October 15, 2012.

**Methodology**

A spreadsheet developed by the SCAQMD was used to evaluate maximum individual cancer risk and acute and chronic HIs for people residing within proximity to future crematorium facility operations. Based on consultation with the SCAQMD, the analysis assumed that any future crematory development would be equipped with T-BACT as part of pre-construction permit review needed for compliance with SCAQMD Rule 1401. The following parameters were incorporated in the spreadsheet to perform the HRA:

- Stack height: 25 feet
- Operating schedule: 15 hours of cremation (exclude cleaning time) per day and 365 days per year
- Meteorological station: Long Beach
- Source types: Incinerator and boiler
- Maximum burner rate: 1.5 million BTU
- Acute maximum burn rate: 60 pounds per hour
- Chronic maximum burn rate: 42 pounds per hour

The most widely used crematory consists of two incinerators (i.e., primary and secondary). Based on conversations with existing mortuaries in the City of Long Beach, the primary and secondary chambers operate at 500 and 1 million BTU per hour, respectively. During the cremation process, both the primary and secondary chambers operate simultaneously for a combined 1.5 million BTU per hour. As for the maximum burn rate, the total cremation times vary considerably, ranging from 50 minutes to three hours. Charge size and cause of death are two factors for estimating total cremation time. Based on a typical procedure, the cremation time is anticipated to last at least two and a half hour per charge. Assuming that the average weight of a person is approximately 150 pounds, the maximum burn rate is calculated to be 60 pounds per hour. This maximum burn rate would provide for a conservative acute risk assessment. However, a different maximum burn rate was used for the chronic risk assessment because a crematory equipment operating at 60 pounds per hour would generate approximately 43,200 pounds per month. The AQMD limit of 30,000 pounds per month would be exceeded if a crematory equipment was to operate continuously at 60 pounds per month. To determine the maximum burn rate for chronic risk, the AQMD maximum allowable limit was converted to pounds per hour according to the crematorium operating schedule.

The analysis identifies potential health risks associated with the Acute HI (HIA), Chronic HI (HIC), and cancer risk. The hazard quotient is a ratio of the expected air toxic concentration to its responding reference concentration (i.e., estimate concentration of a continuous inhalation exposure to the human population). HIA is the ratio of the average short term (generally one hour) ambient concentration of an acutely toxic substance(s) divided by the acute reference exposure level set by the Office of Environmental Health Hazard Assessment. If this ratio is above one, then adverse health effects may occur. HIC is the ratio of the average annual ambient concentration of a chronically toxic substance(s) divided by the chronic reference exposure level set by the Office of Environmental Health Hazard Assessment. If this ratio is above one, then adverse health effects may occur. In this analysis, HIA is based upon a maximum one-hour emission level and the HIC is based upon an annual average emission per year. Cancer risk is defined as the probability that an individual will contract cancer usually expressed as so many chances per million persons exposed to a specified concentration of carcinogenic substance(s). The MICR is the probability of developing cancer by an individual exposed to the expected concentrations of all substances in the ambient air over a 70-year period aggregated over the proposed increased potential air toxic emissions.

**Results**

**Tables 1** through **3** present the health risk emission levels for each targeted organ systems based on land uses distances from the crematorium and the number of incinerators. **Tables 4** through **6** summarize the health risk. As shown in Table 4, crematoriums do not pose a significant acute risk to organ systems for land uses located at any distances of crematoriums. As shown in Table 5, land uses located within 50 meters of crematorium with one incinerator experience significant chronic risk to the developmental and nervous systems. For crematorium with two incinerators, land uses located within 50 meters experience significant chronic risk to the cardiovascular, kidney, respiratory, and dermatological systems. In addition, land uses located within 100 meters of crematorium with two incinerators experience significant chronic risk to the developmental and nervous systems. For crematorium with three incinerators, land uses located within 50 meters experience significant chronic risk to the cardiovascular and dermatological systems. Additionally, land uses located within 100 meters of crematorium with three incinerators would experience significant chronic risk to the developmental, kidney, nervous, and respiratory systems. As shown in Table 6, the HRA indicated that significant carcinogenic risk exists within 200 meters of crematorium.

**TABLE 1: HEALTH RISK ASSESSMENT - HAZARD INDEX FOR ACUTE RISK**

| Target Organs | Sensitive Land Uses Distance to Crematorium Facility (Meter) | | | | |
|---|---|---|---|---|---|
| | 25 | 50 | 100 | 200 | 500 |
| **CREMATORIUM FACILITY WITH ONE INCINERATOR** | | | | | |
| Cardiovascular | 0.033 | 0.033 | 0.018 | 0.007 | 0.001 |
| Developmental | 0.179 | 0.179 | 0.096 | 0.036 | 0.008 |
| Eye | 0.016 | 0.015 | 0.008 | 0.003 | 0.001 |
| Hematopoietic (blood) | 7.0E-07 | 3.9E-07 | 2.2E-07 | 8.4E-08 | 4.1E-08 |
| Immune | 0.042 | 0.042 | 0.023 | 0.008 | 0.002 |
| Nervous | 0.179 | 0.179 | 0.096 | 0.036 | 0.008 |
| Reproductive | 8.1E-07 | 4.5E-07 | 2.6E-07 | 9.8E-08 | 4.7E-08 |
| Respiratory | 0.057 | 0.057 | 0.031 | 0.011 | 0.003 |
| **CREMATORIUM FACILITY WITH TWO INCINERATORS** | | | | | |
| Cardiovascular | 0.066 | 0.066 | 0.035 | 0.013 | 0.003 |
| Developmental | 0.357 | 0.358 | 0.192 | 0.071 | 0.016 |
| Eye | 0.031 | 0.031 | 0.017 | 0.006 | 0.001 |
| Hematopoietic (blood) | 1.4E-06 | 7.8E-07 | 4.4E-07 | 1.7E-07 | 8.2E-08 |
| Immune | 0.084 | 0.084 | 0.045 | 0.017 | 0.004 |
| Nervous | 0.358 | 0.357 | 0.192 | 0.071 | 0.016 |
| Reproductive | 1.6E-06 | 9.1E-07 | 5.1E-07 | 2.0E-07 | 9.5E-08 |
| Respiratory | 0.115 | 0.115 | 0.062 | 0.023 | 0.005 |
| **CREMATORIUM FACILITY WITH THREE INCINERATORS** | | | | | |
| Cardiovascular | 0.099 | 0.099 | 0.053 | 0.020 | 0.004 |
| Developmental | 0.536 | 0.537 | 0.289 | 0.107 | 0.024 |
| Eye | 0.047 | 0.046 | 0.025 | 0.009 | 0.002 |
| Hematopoietic (blood) | 2.1E-06 | 1.2E-06 | 6.6E-07 | 2.5E-07 | 1.2E-07 |
| Immune | 0.125 | 0.126 | 0.068 | 0.025 | 0.006 |
| Nervous | 0.537 | 0.536 | 0.289 | 0.107 | 0.024 |
| Reproductive | 2.4E-06 | 1.4E-06 | 7.7E-07 | 2.9E-07 | 1.4E-07 |
| Respiratory | 0.172 | 0.172 | 0.093 | 0.034 | 0.008 |

Note: A Hazard Index greater than 1.0 is considered a significant risk.
**SOURCE:** Terry A. Hayes Associates Inc., 2013 and Rule 1401 Risk Assessment Program, *Implements AQMD Risk Assessment Guidelines Version 7.0*, December 7, 2012.

| TABLE 2: HEALTH RISK ASSESSMENT - HAZARD INDEX FOR CHRONIC RISK | | | | | |
|---|---|---|---|---|---|
| | Sensitive Land Uses Distance to Crematorium Facility (Meter) | | | | |
| **Target Organs** | **25** | **50** | **100** | **200** | **500** |
| **CREMATORIUM FACILITY WITH ONE INCINERATOR** | | | | | |
| Alimentary (liver) | 0.039 | 0.039 | 0.019 | 0.007 | 0.001 |
| Cardiovascular | 0.650 | 0.650 | 0.323 | 0.117 | 0.024 |
| **Developmental** | **1.408** | **1.408** | 0.700 | 0.253 | 0.053 |
| Endocrine (glands) | 0.039 | 0.039 | 0.019 | 0.007 | 0.001 |
| Hematopoietic (blood) | 0.061 | 0.061 | 0.030 | 0.011 | 0.002 |
| Immune | 0.002 | 0.002 | 0.001 | 0.000 | 0.000 |
| Kidney | 0.785 | 0.785 | 0.390 | 0.141 | 0.029 |
| **Nervous** | **1.369** | **1.369** | 0.681 | 0.246 | 0.051 |
| Reproductive | 0.039 | 0.039 | 0.019 | 0.007 | 0.001 |
| Respiratory | 0.913 | 0.913 | 0.454 | 0.164 | 0.034 |
| Dermatological | 0.650 | 0.650 | 0.323 | 0.117 | 0.024 |
| **CREMATORIUM FACILITY WITH TWO INCINERATORS** | | | | | |
| Alimentary (liver) | 0.077 | 0.077 | 0.038 | 0.014 | 0.003 |
| **Cardiovascular** | **1.300** | **1.300** | 0.646 | 0.233 | 0.049 |
| **Developmental** | **2.815** | **2.815** | **1.400** | 0.505 | 0.105 |
| Endocrine (glands) | 0.077 | 0.077 | 0.038 | 0.014 | 0.003 |
| Hematopoietic (blood) | 0.122 | 0.122 | 0.060 | 0.022 | 0.005 |
| Immune | 0.003 | 0.003 | 0.002 | 0.001 | 0.000 |
| **Kidney** | **1.571** | **1.571** | 0.781 | 0.282 | 0.059 |
| **Nervous** | **2.738** | **2.738** | **1.361** | 0.491 | 0.102 |
| Reproductive | 0.077 | 0.077 | 0.038 | 0.014 | 0.003 |
| **Respiratory** | **1.826** | **1.826** | 0.908 | 0.328 | 0.068 |
| **Dermatological** | **1.300** | **1.300** | 0.646 | 0.233 | 0.049 |
| **CREMATORIUM FACILITY WITH THREE INCINERATORS** | | | | | |
| Alimentary (liver) | 0.116 | 0.116 | 0.058 | 0.021 | 0.004 |
| **Cardiovascular** | **1.950** | **1.950** | 0.970 | 0.350 | 0.073 |
| **Developmental** | **4.223** | **4.223** | 2.099 | 0.758 | 0.158 |
| Endocrine (glands) | 0.116 | 0.116 | 0.058 | 0.021 | 0.004 |
| Hematopoietic (blood) | 0.182 | 0.182 | 0.091 | 0.033 | 0.007 |
| Immune | 0.005 | 0.005 | 0.002 | 0.001 | 0.000 |
| **Kidney** | **2.356** | **2.356** | **1.171** | 0.423 | 0.088 |
| **Nervous** | **4.107** | **4.107** | **2.042** | 0.737 | 0.154 |
| Reproductive | 0.116 | 0.116 | 0.058 | 0.021 | 0.004 |
| **Respiratory** | **2.739** | **2.739** | **1.362** | 0.492 | 0.102 |
| **Dermatological** | **1.950** | **1.950** | 0.970 | 0.350 | 0.073 |

Note: A Hazard Index greater than 1.0 is considered a significant risk.
**SOURCE:** Terry A. Hayes Associates Inc., 2013 and Rule 1401 Risk Assessment Program, *Implements AQMD Risk Assessment Guidelines Version 7.0*, December 7, 2012.

**TABLE 3: HEALTH RISK ASSESSMENT - MAXIMUM INDIVIDUAL CANCER RISK**

| Number of Incinerators | Sensitive Receptors Distance to Crematorium Facility (Meter) | | | | |
|---|---|---|---|---|---|
| | 25 | 50 | 100 | 200 | 500 |
| 1 | 9.5E-05 | 9.5E-05 | 4.7E-05 | 1.7E-05 | 3.5E-06 |
| 2 | 1.9E-04 | 1.9E-04 | 9.4E-05 | 3.4E-05 | 7.1E-06 |
| 3 | 3.8E-04 | 3.8E-04 | 1.9E-04 | 6.8E-05 | 1.4E-05 |

Note: An MICR greater than 1.0E-5 is considered a significant risk.
**SOURCE**: Terry A. Hayes Associates Inc., 2013 and Rule 1401 Risk Assessment Program, *Implements AQMD Risk Assessment Guidelines Version 7.0*, December 7, 2012.

**TABLE 4: HEALTH RISK ASSESSMENT IMPACT - HAZARD INDEX FOR ACUTE RISK /a/**

| Target Organs | Sensitive Land Uses Distance to Crematorium Facility (Meter) | | | | |
|---|---|---|---|---|---|
| | 25 | 50 | 100 | 200 | 500 |
| **CREMATORIUM FACILITY WITH ONE TO THREE INCINERATORS** | | | | | |
| Cardiovascular | No | No | No | No | No |
| Developmental | No | No | No | No | No |
| Eye | No | No | No | No | No |
| Hematopoietic (blood) | No | No | No | No | No |
| Immune | No | No | No | No | No |
| Nervous | No | No | No | No | No |
| Reproductive | No | No | No | No | No |
| Respiratory | No | No | No | No | No |

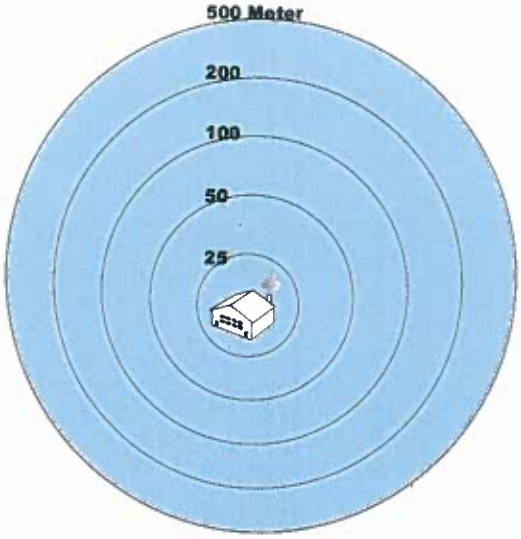
/a/ Rule 1401 specifies that the hazard index for acute cancer risk shall not exceed one for any target organ systems.
**SOURCE**: Terry A. Hayes Associates Inc., 2013

| TABLE 5: HEALTH RISK ASSESSMENT IMPACT- HAZARD INDEX FOR CHRONIC RISK | | | | | |
|---|---|---|---|---|---|
| | Sensitive Land Uses Distance to Crematorium Facility (Meter) | | | | |
| **Target Organs** | **25** | **50** | **100** | **200** | **500** |
| **CREMATORIUM FACILITY WITH ONE INCINERATOR** | | | | | |
| Alimentary (liver) | No | No | No | No | No |
| Cardiovascular | No | No | No | No | No |
| Developmental | **Yes** | **Yes** | No | No | No |
| Endocrine (glands) | No | No | No | No | No |
| Hematopoietic (blood) | No | No | No | No | No |
| Immune | No | No | No | No | No |
| Kidney | No | No | No | No | No |
| Nervous | **Yes** | **Yes** | No | No | No |
| Reproductive | No | No | No | No | No |
| Respiratory | No | No | No | No | No |
| Dermatological | No | No | No | No | No |
| **CREMATORIUM FACILITY WITH TWO INCINERATORS** | | | | | |
| Alimentary (liver) | No | No | No | No | No |
| Cardiovascular | **Yes** | **Yes** | No | No | No |
| Developmental | **Yes** | **Yes** | **Yes** | No | No |
| Endocrine (glands) | No | No | No | No | No |
| Hematopoietic (blood) | No | No | No | No | No |
| Immune | No | No | No | No | No |
| Kidney | **Yes** | **Yes** | No | No | No |
| Nervous | **Yes** | **Yes** | **Yes** | No | No |
| Reproductive | No | No | No | No | No |
| Respiratory | **Yes** | **Yes** | No | No | No |
| Dermatological | **Yes** | **Yes** | No | No | No |
| **CREMATORIUM FACILITY WITH THREE INCINERATORS** | | | | | |
| Alimentary (liver) | No | No | No | No | No |
| Cardiovascular | **Yes** | **Yes** | No | No | No |
| Developmental | **Yes** | **Yes** | **Yes** | No | No |
| Endocrine (glands) | No | No | No | No | No |
| Hematopoietic (blood) | No | No | No | No | No |
| Immune | No | No | No | No | No |
| Kidney | **Yes** | **Yes** | **Yes** | No | No |
| Nervous | **Yes** | **Yes** | **Yes** | No | No |
| Reproductive | No | No | No | No | No |
| Respiratory | **Yes** | **Yes** | **Yes** | No | No |
| Dermatological | **Yes** | **Yes** | No | No | No |

/a/ Rule 1401 specifies that the hazard index for chronic cancer risk shall not exceed one for any target organ systems.
**SOURCE:** Terry A. Hayes Associates Inc., 2013

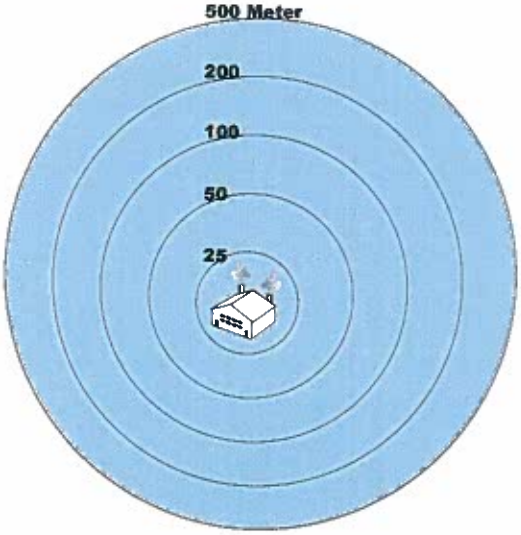
| TABLE 6: HEALTH RISK ASSESSMENT IMPACT - MAXIMUM INDIVIDUAL CANCER RISK | | | | | |
|---|---|---|---|---|---|
| **Number of Incinerators** | Sensitive Receptors Distance to Crematorium Facility (Meter) | | | | |
| | **25** | **50** | **100** | **200** | **500** |
| 1 | **Yes** | **Yes** | **Yes** | **Yes** | No |
| 2 | **Yes** | **Yes** | **Yes** | **Yes** | No |
| 3 | **Yes** | **Yes** | **Yes** | **Yes** | No |

/a/ Rule 1401 specifies that the maximum individual cancer risk shall not exceed one in ten million if T-BACT is installed.
**SOURCE:** Terry A. Hayes Associates Inc., 2013



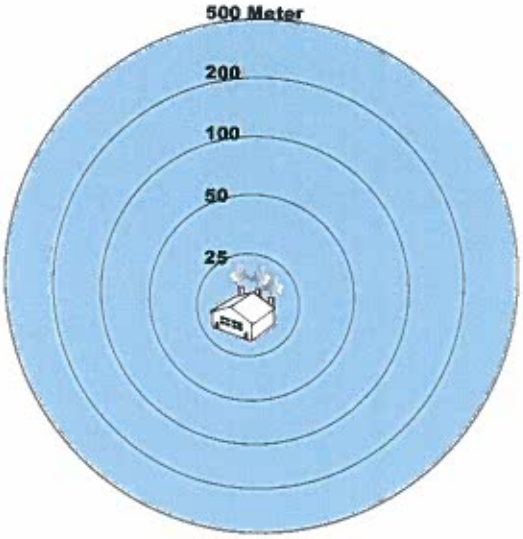

**Crematorium Facility With One Incinerator**

For crematorium with one incinerator, land uses located at any distances would not experience significant acute risk.




**Crematorium Facility With Two Incinerators**

For crematorium with two incinerator, land uses located at any distances would not experience significant acute risk.




**Crematorium Facility With Three Incinerators**

For crematorium with three incinerators, land uses located at any distances would not experience significant acute risk.

LEGEND:

Area With No Acute Risk

SOURCE: TAHA, 2013

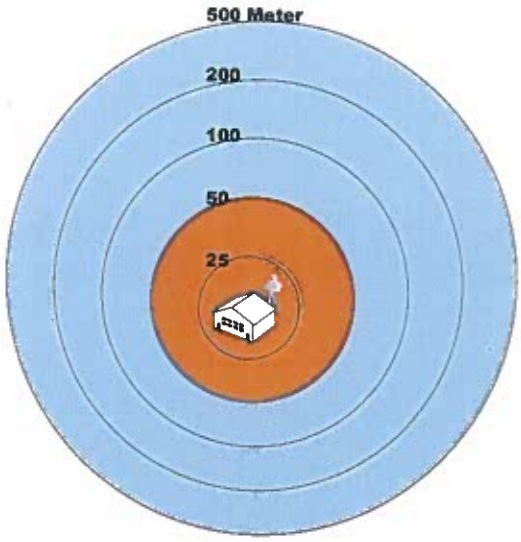
taha 2013-045

City of Long Beach Crematorium Health Risk Assessment

CITY OF LONG BEACH

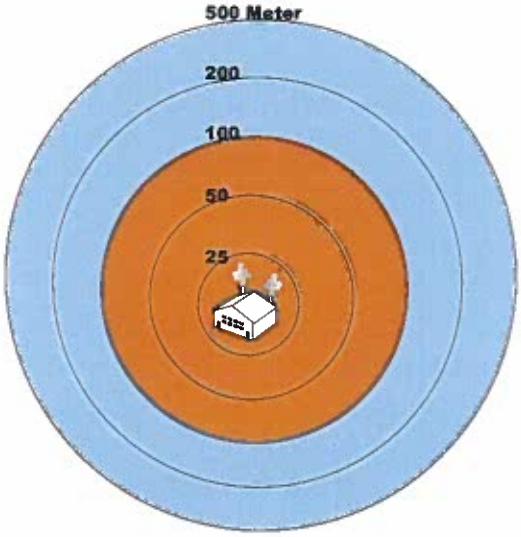
*FIGURE 1*

HAZARD INDEX FOR ACUTE RISK AT MULTIPLE SENSITIVE RECEPTORS DISTANCE



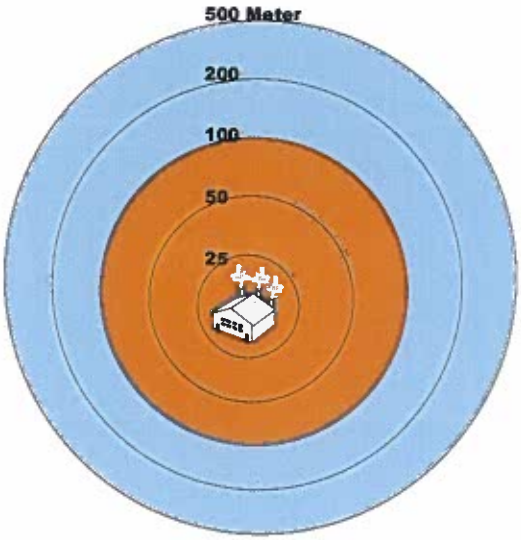

**Crematorium Facility With One Incinerator**

For crematorium with one incinerator, land uses located within 50 meters would experience significant chronic risk.




**Crematorium Facility With Two Incinerators**

For crematorium with two incinerators, land uses located within 100 meters would experience significant chronic risk.




**Crematorium Facility With Three Incinerators**

For crematorium with three incinerators, land uses located within 100 meters would experience significant chronic risk.

LEGEND:

- Area With No Chronic Risk
- Area With Chronic Risk

SOURCE: TAHA, 2013

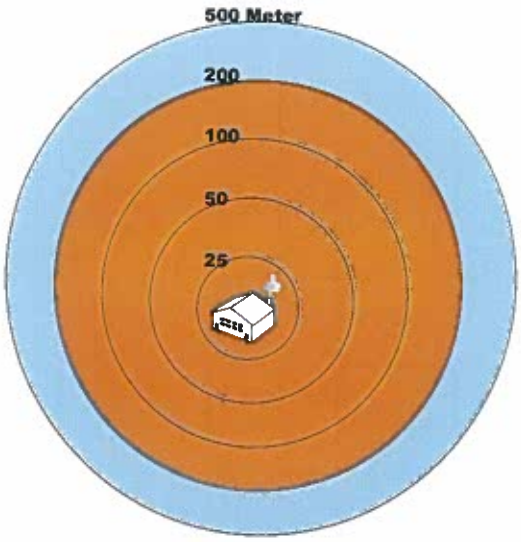
taha 2013-045

City of Long Beach Crematorium Health Risk Assessment

CITY OF LONG BEACH

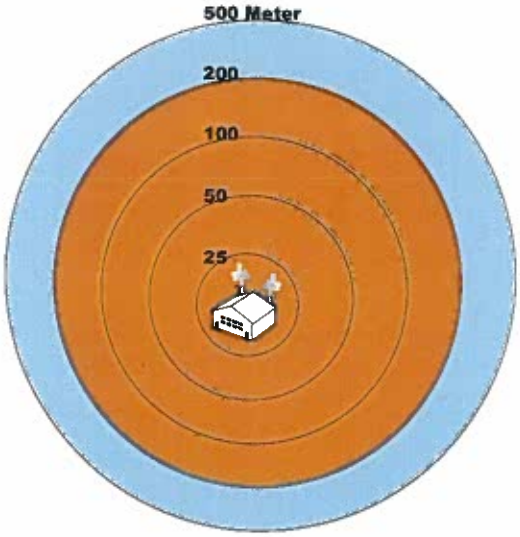
*FIGURE 2*

HAZARD INDEX FOR CHRONIC RISK AT MULTIPLE SENSITIVE RECEPTORS DISTANCE



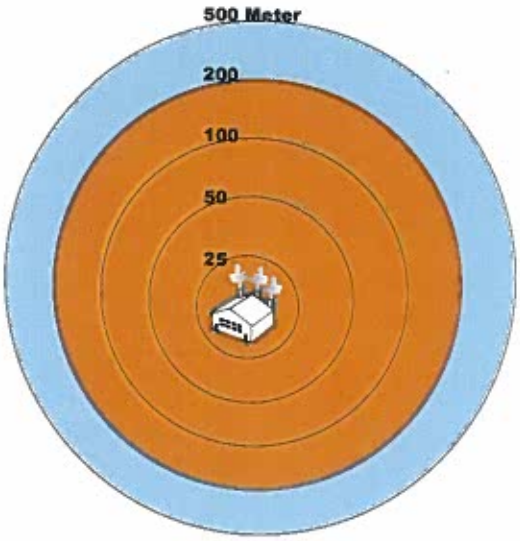

**Crematorium Facility With One Incinerator**

For crematorium with one incinerator, land uses located within 200 meters would experience significant carcinogenic risk.




**Crematorium Facility With Two Incinerators**

For crematorium with two incinerators, land uses located within 200 meters would experience significant carcinogenic risk.




**Crematorium Facility With Three Incinerators**

For crematorium with three incinerators, land uses located within 200 meters would experience significant carcinogenic risk.

LEGEND:

Area With No Carcinogenic Risk
Area With Carcinogenic Risk

SOURCE: TAHA, 2013

taha 2013-045

City of Long Beach Crematorium Health Risk Assessment

CITY OF LONG BEACH

*FIGURE 3*

CARCINOGENIC RISK AT MULTIPLE SENSITIVE RECEPTORS DISTANCE