Health Consultation

HEALTH IMPLICATIONS OF PERCHLORATE CONTAMINATION IN LOCUST BAYOU PRIVATE WELLS

LOCUST BAYOU, CALHOUN COUNTY, ARKANSAS 71701

APRIL 17, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Prepared by:

Arkansas Department of Health and Human Services
Division of Health
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Statement of Issues and Background

Statement of Issues

In March 2005, the Arkansas Department of Health and Human Services' Division of Health (DOH) received a request from the Hazardous Waste Division of the Arkansas Department of Environmental Quality (ADEQ) to evaluate sampling data in order to make a health risk determination regarding the detection of perchlorate. ADEQ and the U.S. Environmental Protection Agency (EPA) personnel collected groundwater for analysis from private wells in an area surrounding Highland Industrial Park, Incorporated near Locust Bayou, Calhoun County, Arkansas (Appendix A, Figure 1). DOH evaluated the groundwater data and prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

In 1999, EPA announced the implementation of their Resource Conservation and Recovery Act (RCRA) Cleanup Reforms that were designed to achieve faster, flexible, and more focused cleanup of RCRA sites. EPA and the states identified 1,712 RCRA facilities to include as the baseline for measuring and tracking progress of EPA's reforms [1]. These sites were selected because of a potential for unacceptable exposure to pollutants and/or for groundwater contamination. Two of these sites, Aerojet-General Corporation (previously owned by Atlantic Research Corporation) and Lockheed Martin Missiles & Fire Control, are located in the Highland Industrial Park. The industrial park is located approximately 5 miles north of Locust Bayou and covers 15,765 acres that contain over 1,000 industrially used buildings [2, 3].

ADEQ and EPA personnel collected groundwater samples in February 2005 from six private wells near the Arkansas community of Locust Bayou. This joint effort was performed in response to ongoing activities related to EPA's RCRA Cleanup Reforms initiative. The area selected by ADEQ and EPA to implement the groundwater-sampling plan corresponds to the general groundwater flow in this area, as it relates to the two sites listed on the RCRA 2005 Cleanup Baseline located in the Highland Industrial Park. In a report completed by Environmental Alliance for Atlantic Research Corporation dated April 30, 2003, it is stated, "The general direction of groundwater flow in the … area is predominantly southwest…" The report further states, "This corresponds with topographic data, perchlorate groundwater plume orientation, and facility-wide groundwater elevation patterns." [4]. To account for seasonal changes, ADEQ re-sampled the wells in October of 2005.

DOH personnel conducted a site visit to Locust Bayou and Highland Industrial Park on September 30, 2005. Census figures for 2000 indicate that in Calhoun County the average family size is three people per household [5]. There were approximately 40 houses observed in the Locust Bayou area, suggesting that approximately 120 people might potentially have been exposed to perchlorate.

DOH mailed letters to six Locust Bayou residents on July 1, 2005. The letters described the level of contamination detected in each resident's private well. ADEQ and/or EPA laboratory results were attached, along with a perchlorate fact sheet that was developed by ADEQ and DOH.

Discussion

In this evaluation of the potential health impact of exposure to contaminated potable water, DOH considered all routes of exposure to groundwater. DOH considered dermal contact (absorption through skin), incidental ingestion (drinking), and inhalation (breathing) as potential routes of exposure (Appendix A, Figure 2). Inhalation exposure to perchlorate in the potable water was eliminated because perchlorate is not volatile (does not become a gas). Exposure pathways consist of the following five elements:

1. A source of contamination,
2. A release mechanism into water, soil, air, food chain (biota) or transfer between media (i.e., the fate and transport of environmental contamination),
3. An exposure point or area (e.g., drinking water well),
4. An exposure route (e.g., ingestion, dermal contact), and
5. A receptor population (i.e., residents, etc.).

For a person to be exposed to a contaminant, the exposure pathway must contain all of the elements listed above, resulting in a completed exposure pathway. In some cases, a potential exposure pathway might exist in which at least one of the elements of the exposure pathway is missing, but could exist. Potential pathways indicate that exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Potential exposure pathways refer to those pathways where (1) exposure is documented, but there is not enough information available to determine whether the environmental medium is contaminated, or (2) an environmental medium has been documented as contaminated, but it is unknown whether people have been, or may be, exposed to the medium, or may be exposed in the future. Additionally, an eliminated pathway is one where at least one element of the exposure pathway is missing, and therefore, exposure will never occur [6].

Comparison Values

To assess the potential health risks associated with contaminants at this site, DOH compared contaminant concentrations to health comparison values. Health comparison values, such as the EPA Region 6 - Human Health Medium - Specific Screening Levels (HHMSSL), are media- and chemical-specific concentrations used as screening values in the preliminary identification of site-specific "contaminants of concern". The latter term should not be misinterpreted as an implication of "hazard". As ATSDR uses the phrase, "a contaminant of concern" only to describe a chemical substance detected at the site in

question and selected for further evaluation of potential health effects. Generally, a chemical is selected as a contaminant of concern because its maximum concentration in water, air, or soil at the site exceeds its medium specific comparison value.

While concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. The purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health hazards before they can become actual public health consequences. Thus, comparison values are designed to be preventive, rather than predictive, of adverse health effects. The probability that such effects will actually occur depends, not on environmental concentrations alone, but on unique combinations of site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure.

The following describes various comparison values that were used to select chemicals for further evaluation and to put chemical concentrations into a meaningful frame of reference.

- **ATSDR's Reference dose media evaluation guide (RMEG)** is a concentration of a contaminant in air, water or soil that corresponds to EPA's reference dose for that contaminant when default values for body weight and intake rates are taken into account.
- **EPA Region 6 Human Health Medium - Specific Screening Levels (HHMSSL)** are chemical concentrations that correspond to fixed levels of risk in soil, air and water.
- **EPA's Reference Dose (RfD)** is an estimate of the daily exposure to a contaminant unlikely to cause non-carcinogenic adverse health effects.
- **EPA's Hazard Quotient (HQ)** is a ratio, which can be used to estimate if risk to harmful effects is likely or not due to the contaminant in question.

Perchlorate

Chemical Profile

Perchlorate is both naturally occurring and man-made. Synonyms for perchlorate are perchlorate ion, perchlorate salts, and perchloric acid. Examples of perchlorate salts are sodium perchlorate, ammonium perchlorate, and potassium perchlorate. It is highly soluble in water and can be very mobile in surface and subsurface aqueous systems. Under typical groundwater and surface water conditions, perchlorate contamination may persist for extended periods of time [7].

In the U.S., production of ammonium perchlorate first began in the mid-1940s. Ammonium perchlorate and the other perchlorate salts are used in a wide range of applications, including military explosives, fireworks, matches, lubricants, textile dye

fixing, nuclear reactors, electronic tubes, tanning and finishing leather, rubber manufacturing, electroplating, aluminum refinishing, automobile air bag inflators, paint and enamel production, and pharmaceuticals [7].

High doses of perchlorate can decrease thyroid hormone production by inhibiting the uptake of iodide by the thyroid. Thyroid hormones increase protein synthesis in virtually every body tissue and are critical for normal growth and development of the central nervous system of fetuses and infants [8].

Estimated Daily Exposure

The estimation of the daily exposure dose involves determining contaminant concentrations at points of potential human exposure, and developing assumptions regarding the extent of human exposure in the completed exposure pathways. For this evaluation, the maximum concentration detected for the contaminant perchlorate in groundwater samples collected from private wells in the Locust Bayou area are considered as the concentration at the point of potential exposure. Test results of groundwater samples taken in February 2005 detected perchlorate at a maximum concentration of 2.2 micrograms per liter (µg/L). Samples collected from the same wells in October 2005 did not result in higher concentrations of perchlorate being detected.

An exposure pathway to the contaminant perchlorate exists via the incidental ingestion and/or dermal contact with groundwater from private wells (Appendix A, Figure 2). Perchlorate was detected in several private groundwater wells in an area south of Highland Industrial Park, Incorporated near the town of Locust Bayou. The highest level detected in the private wells that were tested was 2.2 µg/L. This level is below ATSDR's RMEG comparison value of 7 µg/L for children and 20 µg/L for an adult. The highest detected level was also below EPA's more conservative technical tool, the HHMSSL value set for perchlorate in tap water at 3.7 µg/L. Tables 1 and 2 of Appendix B provides a summary of the contaminant and its associated comparison values.

Exposure to perchlorate by way of dermal contact with water was calculated, with the result added to the estimated ingestion exposure for a total estimated exposure rate. Because perchlorate does not volatize the indoor air inhalation exposure route is considered an incomplete pathway [9].

Using EPA's Health Quotient (HQ) approach, a non-cancer risk was calculated for perchlorate of 0.11 for a child and 0.09 for an adult (Appendix B, Table 2). A HQ of less than one indicates that harmful effects are not likely [10]. Using the assumptive values described in Appendix C, people using the groundwater wells discussed in this health consultation are not being exposed to levels of contamination through the ingestion and dermal contact of water containing perchlorate that would be expected to cause adverse health effects.

Community Health Concerns

DOH reviewed the sample results provided by ADEQ and EPA and assessed the health risk associated with exposure to perchlorate. DOH followed up by sending letters, sample results, and perchlorate fact sheets to the owners of the wells on July 1, 2005, explaining the results of the tests. DOH responded to a few questions asked by community members concerning the perchlorate fact sheet and groundwater sampling results.

Child Health Considerations

DOH and ATSDR recognize that the unique vulnerabilities of children demand special attention. Critical periods exist during development, particularly during early gestation, but also throughout pregnancy, infancy, childhood and adolescence [11]. Children may exhibit differences in absorption, metabolism, storage, and excretion of toxicants, resulting in higher biologically effective doses to target tissues. Depending on the affected media, they also may be more exposed than adults because of behavior patterns specific to children.

The HHMSSL for perchlorate in tap water is 3.7 µg/L. The highest concentration detected in the private water wells tested in the Locust Bayou area was 2.2 µg/L. At the levels of perchlorate detected during the 2005 sampling events conducted by ADEQ and EPA, children were not exposed to concentrations that would be likely to cause adverse health effects.

Conclusions

Based upon the information reviewed, there was and is a completed exposure pathway to perchlorate contaminated water in the private wells tested in the Locust Bayou area. However, the concentration of perchlorate detected in the private wells tested is below human health comparison values, and therefore, unlikely to cause adverse health effects. DOH has categorized the perchlorate detected in the sampled private wells as *No Apparent Public Health Hazard* under the conditions that existed at the time of the sampling events.

Recommendations

No recommendations are indicated at this time.

Public Health Action Plan

The purpose of the Public Health Action Plan (PHAP) is to ensure that this health consultation not only identifies any public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The PHAP implemented for the private wells containing perchlorate in the area of Locust Bayou is as follows:

Completed Actions

- ADEQ personnel notified DOH personnel of the detection of perchlorate in some private wells near the town of Locust Bayou on March 10, 2005.
- DOH received groundwater sample results from ADEQ on March 21, 2005.
- DOH evaluated sample data collected by ADEQ and EPA in February 2005.
- ADEQ and DOH co-developed a perchlorate fact sheet in April 2005.
- DOH sent letters, sample results, and perchlorate fact sheets out to the owners of the wells on July 1, 2005.
- DOH conducted a site visit on September 30, 2005.
- ADEQ provided DOH, on October 13, 2005, with additional sample data collected on October 3, 2005.
- DOH evaluated sample data collected by ADEQ and EPA in October 2005.
- DOH completed a community needs assessment on October 18, 2005.

Future Activities

- DOH will continue to review available sampling data, as needed.
- DOH will conduct health education in the community as needed, and/or requested.

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Certification

This health consultation for the Locust Bayou site was prepared by the Arkansas Division of Health, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodology and procedure existing at the time the health consultation was initiated. Editorial review was completed by the cooperative agreement partner.

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The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.

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Appendices

Appendix A - Figures

Figure 1. Aerial photo of Locust Bayou and the Highland Industrial Park area

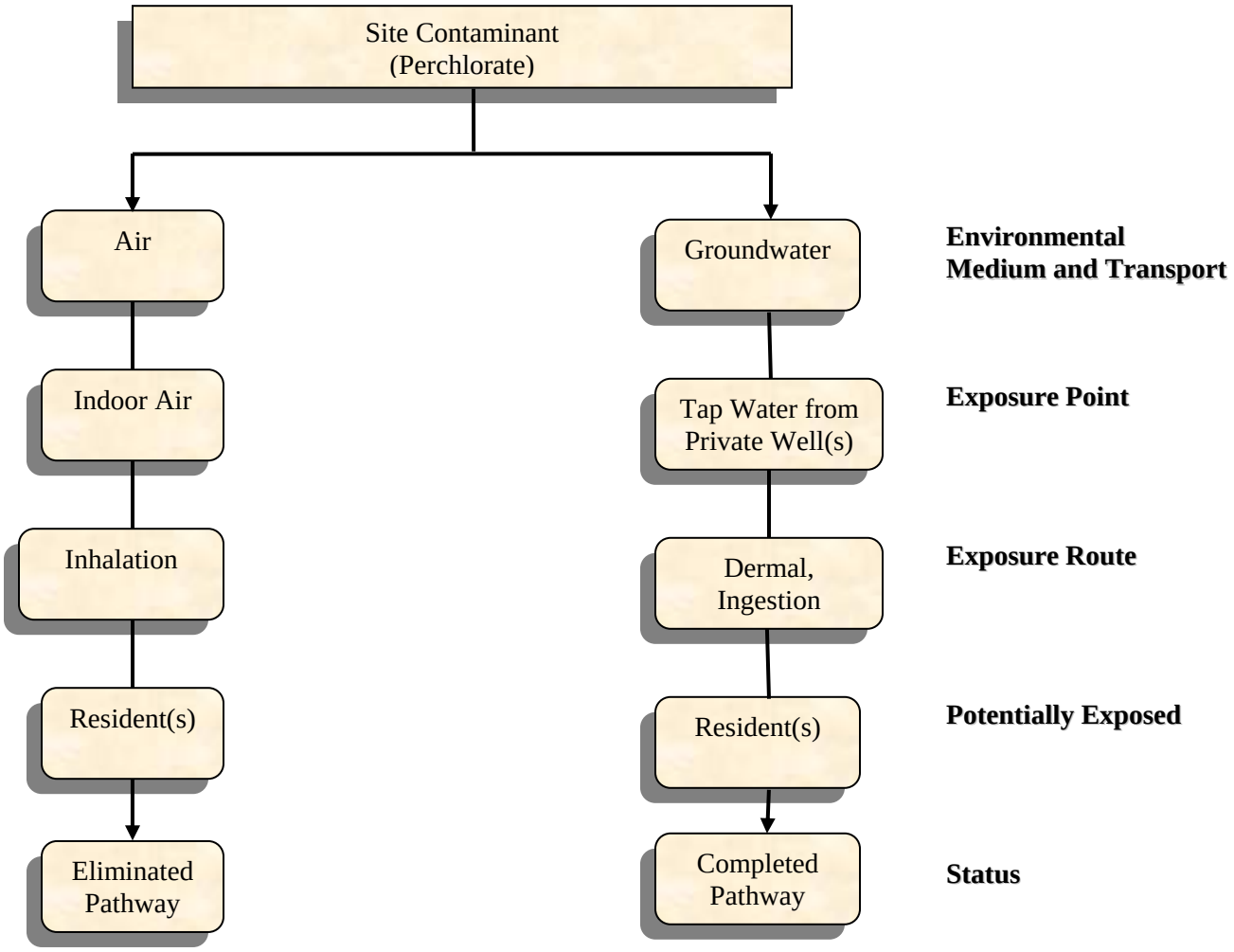

Figure 2. Exposure pathway evaluation

Appendix B - Tables

Table 1. Highest concentration of perchlorate detected in groundwater samples collected by the Arkansas Department of Environmental Quality and/or the U.S. Environmental Protection Agency in the Locust Bayou area during February and October 2005.

Sample Location Identification	Perchlorate (µg/L)*	Screening Level† (µg/L)*	Coordinates for Sampling Sites		Well Use
ARC-GW-01	ND‡	3.7	N 33°34.293'	W 92°34.851'	All uses including drinking
ARC-GW-02	0.5	3.7	N 33°34.152'	W 92°39.808'	All uses including drinking
ARC-GW-03	2.2	3.7	N 33°33.714'	W 92°40.912'	Livestock/pets, garden/yard irrigation
ARC-GW-04§					
ARC-GW-05	2.1	3.7	N 33°34.082'	W 92°40.501'	All uses including drinking
ARC-GW-06	0.52	3.7	N 33°34.449'	W 92°40.737'	All uses including drinking
ARC-GW-07	ND	3.7	N 33°33.392'	W 92°40.301'	Livestock/pets, garden/yard irrigation
Supply Well-1	ND	3.7	N 33°39.26'	W 92°42.11'	Highland Industrial Park and E. Camden water supply
Supply Well-4	ND	3.7	N 33°39.44'	W 92°43.04'	Highland Industrial Park and E. Camden water supply
Supply Well-5	ND	3.7	N 33°39.36'	W 92°42.07'	Highland Industrial Park and E. Camden water supply
Supply Well-7	ND	3.7	N 33°39.44'	W 92°42.38'	Highland Industrial Park and E. Camden water supply
N-Bayou #8	0.10	3.7	NA¶		Surface water
S-Bayou #11	3.5	3.7	NA¶		Surface water

* µg/L = microgram per liter
† EPA Region 6 - Human Health Medium-Specific Screening Levels are a source of chemical concentrations that correspond to fixed levels of risk in soil, air and water.
‡ ND = Non Detect
§ ARC-GW-04 is a field duplicate of ARC-GW-03
¶ NA = Not Available

Table 2. Perchlorate – Health Effects Evaluation

Hazard Quotient*			Total Estimated Exposure Dose	
Adult (unitless)	Child (unitless)	RfD† (mg/kg-day)‡	Adult (mg/kg-day)	Child (mg/kg-day)
0.09	0.11	7×10^{-4}	6.02×10^{-5}	7.53×10^{-5}

* EPA's Hazard Quotient (HQ) is the average daily intake divided by the reference dose (RfD) and is used to estimate risk. A HQ of less than one indicates that harmful effects are not likely [10].

† EPA's Reference Dose (RfD) = an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

‡ Milligrams per kilograms per day = mg/kg-day

Appendix C - Calculations

Assumptive values were used to estimate the non-cancer risk for the contaminant perchlorate detected in the private groundwater wells sampled by ADEQ and EPA during February and October of 2005. These assumptions were intended to represent the worst-case scenario. The source of the exhibits used in Appendix C is from ATSDR's Public Health Assessment Guidance Manual [6].

Table 3. Parameters used to evaluate human health effects

Parameter		Default Value		Units
		Child	Adult	
Risk				
• Hazard Quotient	HQ	1	1	unitless
Toxicological Parameter				
• Oral Reference Dose	RfD_o	0.0007	0.0007	mg/kg/day
Exposure Parameters - General				
• Average Body Weight	ABW	28	70	kg
• Contaminant Concentration	C	0.0022	0.0022	mg/L
• Exposure Frequency	EF	0.96	0.96	unitless
• Exposure Time	ET	0.33	0.33	hours/day
• Ingestion Rate	IR	1	2	L/day
• Permeability Coefficient	P	0.001	0.001	cm/hr
• Surface Area	SA	12,118	19,400	cm^2
Unit Conversion Factors				
• Unit Conversion Factor	UCF	0.001	0.001	1L/1,000 cm^3

milligrams per kilograms per day = mg/kg-day
kg = kilogram
mg/L = milligrams per liter
L/day= liters per day
cm/hr = centimeters per hour
cm^2 = square centimeters
1L/1,000 cm^3 = one liter per 1,000 cubic centimeters

Calculation of Incidental Water Ingestion

Ingesting contaminated water is one of the most significant exposure pathways at a site. Exhibit 1 (below) illustrates how exposure doses via incidental water ingestion can be estimated. In this analysis of exposure through ingestion, it will be assumed that there is 100% absorption of perchlorate into the body from the amount water that is ingested.

Exhibit 1. Exposure Dose Equation – Ingestion of Water

$$\text{Dose (mg/kg/day)} = \frac{(C \times IR \times EF)}{BW}$$

Perchlorate – Adult

D = (C x IR x EF) / BW
D = (0.0022 mg/L x 2 L/day x 0.96) / 70 kg
D = 6.0×10^{-5} mg/kg/day

Perchlorate – Child

D = (C x IR x EF) / BW
D = (0.0022 mg/L x 1 L/day x 0.96) / 28 kg
D = 7.5×10^{-5} mg/kg/day

Calculation of Dermal Contact With Water Dose

Dermal absorption of contaminants in water occurs during bathing, showering, or swimming and may be a significant route of exposure depending on the substance-specific characteristics. The permeability of the skin to a chemical is influenced by the physicochemical properties of the substance, including its molecular weight (size and shape), electrostatic charge, hydrophobicity, and solubility in aqueous and lipid media. In general, chemicals that demonstrate high skin permeability are low in molecular weight, non-ionized, and lipid soluble. Exhibit 2 illustrates how exposure doses via dermal contact with water can be estimated.

Exhibit 2. Exposure Dose Equation – Dermal Contact With Water

$$\text{Dose (mg/kg/day)} = \frac{\text{C x P x SA x ET x UCF}}{\text{BW}}$$

Perchlorate – Adult

D = (C x P x SA x ET x CF) / BW
D = (0.0022 mg/L x 0.001 cm/hr x 19,480 cm^2 x 0.33 hrs/day x 1 L/1,000 cm^3 kg/mg) / 70 kg
D = 2.0×10^{-7} mg/kg/day

Perchlorate – Child

D = (C x P x SA x ET x CF) / BW
D = (0.0022 mg/L x 0.001 cm/hr x 12,118 cm^2 x 0.33 hrs/day x 1 L/1,000 cm^3 kg/mg) / 28 kg
D = 3.1×10^{-7} mg/kg/day

To estimate the total exposure to a specific contaminant from dermal contact and incidental ingestion the dose values are summed.

Perchlorate – Adult

Total Exposure $_{perchlorate}$ = Ingestion $_{perchlorate}$ + Dermal Exposure $_{perchlorate}$
Total Exposure $_{perchlorate}$ = 6.0×10^{-5} mg/kg/day + 2.0×10^{-7} mg/kg/day
Total Exposure $_{perchlorate}$ = 6.02×10^{-5} mg/kg/day

Perchlorate – Child

Total Exposure $_{perchlorate}$ = Ingestion $_{perchlorate}$ + Dermal Exposure $_{perchlorate}$
Total Exposure $_{perchlorate}$ = 7.5×10^{-5} mg/kg/day + 3.1×10^{-7} mg/kg/day
Total Exposure $_{perchlorate}$ = 7.53×10^{-5} mg/kg/day

Calculation of Hazard Quotient (HQ)

Risk can be estimated using the HQ. An HQ is the average daily intake divided by the reference dose (RfD). RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of harmful effects during a lifetime. Exhibit 3 illustrates how to calculate the hazard quotient.

Exhibit 3. Hazard Quotient Equation

HQ = DI / RfD

where,

HQ = Hazard Quotient (unitless)
DI = Daily Intake (mg/kg/day)
RfD = Reference Dose (mg/kg/day)

After the calculation…

If…

HQ > 1.0 then harmful effects may be likely
HQ = 1.0 Not likely to cause harmful effects
HQ < 1.0 Harmful effects not likely

Perchlorate – Adult
HQ = DI / RfD
HQ = 6.02×10^{-5}mg/kg/day / 7×10^{-4}mg/kg/day
HQ = 0.09

Perchlorate – Child
HQ = DI / RfD
HQ = 7.53×10^{-5}mg/kg/day / 7×10^{-4}mg/kg/day
HQ = 0.11