STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
REMEDIATION AND REDEVELOPMENT DIVISION
CALUMET FIELD OFFICE
CALUMET, MICHIGAN

Toxicological Evaluation for the Gay, Michigan Stamp Sand W.O. No. 20083.032.002

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EXECUTIVE SUMMARY

Weston Solutions of Michigan, Inc. (WESTON®) has prepared this Toxicological Evaluation for the Gay, Michigan Stamp Sand in response to a request from the Michigan Department of Environmental Quality (MDEQ), Remediation and Redevelopment Division (RRD), Calumet Field Office under the Level of Effort (LOE) contract (Contract No. 2002).

Copper mining activities conducted in the early 1900s resulted in the generation of massive amounts of a mining waste known as "stamp sand." Widespread reuse for road traction, as well as recreational and construction use of the stamp sand occurs throughout the Keweenaw Peninsula. The purpose of this Toxicological Evaluation is to evaluate the exposure scenarios for stamp sand reuses including road traction, recreational, and construction use. WESTON assessed the impacts on human health and aquatic systems. This Toxicological Evaluation is based on both analytical and bioassessment data from the Keweenaw County Road Commission (KCRC) road traction stockpile and sediment samples from Lake Superior collected near Gay, Michigan. The following tables summarize the outcome of the Toxicological Evaluation and the suitability of reuse scenarios.

GAY, MICHIGAN STAMP SAND HUMAN HEALTH RISK ASSESSMENT	
EXPOSURE SCENARIO	**RISK DETERMINATION[1]**
SOUTHERN AREA RESIDENTIAL (STAMP SAND USE AS ROAD TRACTION)	
Indoor	**ACCEPTABLE**
Outdoor	**ACCEPTABLE**
NORTHERN AREA RESIDENTIAL (STAMP SAND USE AS ROAD TRACTION)	
Indoor	**ACCEPTABLE**
Outdoor	**ACCEPTABLE**
RESIDENTIAL (DRINKING WATER)	
Drinking Water	**UNACCEPTABLE**
SOUTHERN AREA RECREATIONAL (SAND BOX SCENARIO)	
Adult	**ACCEPTABLE**
Child (2-12 years)	**ACCEPTABLE**
NORTHERN AREA RECREATIONAL (SAND BOX SCENARIO)	
Adult	**ACCEPTABLE**
Child (2-12 years)	**ACCEPTABLE**
SOUTHERN AREA CONSTRUCTION WORKER (STAMP SAND USE AS CONSTRUCTION MATERIAL)	
Adult	**ACCEPTABLE**
NORTHERN AREA CONSTRUCTION WORKER (STAMP SAND USE AS CONSTRUCTION MATERIAL)	
Adult	**ACCEPTABLE**

[1] *Exposure of these receptor groups was quantified using the general equations presented by MDEQ in Part 201 Rule R299.5720. The exposure and chemical-specific parameters used by the MDEQ for potential soil exposures (Rule 299.5720) were applied, though adjustments were made to exposure parameters to account for these exposure scenarios as discussed in Section 1.1, 1.2, and 1.3.*

GAY, MICHIGAN STAMP SAND AQUATIC ORGANISM RISK ASSESSMENT *(STAMP SAND USE AS ROAD TRACTION OR IN-PLACE DEPOSIT ADJACENT TO SURFACE WATER)*		
MEDIA	**THREAT/TOXICITY**	**RISK DETERMINATION**
Sediment	Probable Effects Concentrations (PECs) and PEC Quotients exceeded 0.5; Groundwater/Surface Water Interface Protection for surface water is exceeded; acute and chronic effects observed for benthic organisms.	**UNACCEPTABLE**
Surface Water	Copper concentrations in groundwater, pond water, and elutriate water exceeded Rule 57 Water Quality Values; toxicity observed in suspended particulate phase (SPP) tests resulting in no observable effects concentrations (NOECs) between 1 and 10; and acute toxic units (TUa) between 10 and 100.	**UNACCEPTABLE**

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1.0 HUMAN HEALTH EXPOSURE

WESTON evaluated residential, recreational, and construction worker exposure scenarios for this Toxicological Evaluation as summarized in the following table.

Exposure Scenario	Receptors	Exposure Source	Exposure Routes
Residential	Adult/Child	Indoor and outdoor dust from road traction	Ingestion, Dermal Contact, and Inhalation
Recreational	Adult/Child	Recreational vehicle use, paintball "wars", beach use, and sand box use	
Construction Worker	Adult	Stamp sand use as backfill, road base, and other construction materials	

Residential exposures to indoor and outdoor dust may occur as a result of the reuse of stamp sand as traction sand during the winter. Indoor exposure is a result of indoor accumulation of stamp sand during the winter. Outdoor exposure is a result of the year-round, continued presence of stamp sand along roadways, which permits it to become windborne. In addition, the use of power brooms for spring cleaning exacerbates the environmental dispersal of this material.

There are approximately 36 cottages along the southern area of the Gay deposit, with a potential for 100 more cottages. The Gay stamp sand is used heavily for recreational purposes, such as off-road vehicle (ORV) travel, beach and sand box use, and paintball "wars". There are approximately five miles of stamp sand covered shoreline. The Gay deposit is exposed at the surface on the shoreline for recreational beach and "sand box" use. Both children and adults may also be exposed to stamp sand at the beach or in a sand box. The "sand box" scenario is similar to the beach scenario, though the sand box uses may occur more frequently than swimming (on days when the lake is too cold to swim in, etc.). According to MDEQ staff, stamp sand use as a sand box at beachfront cottages is common.

Construction worker exposure to stamp sand may occur when stamp sand is used at construction sites as road base, foundation backfill, etc.

1.1 Exposure Quantification

Residential

Exposure of the residential receptor groups was quantified using the general equations presented by Michigan Department of Environmental Quality (MDEQ) in Part 201 Rule R299.5720. The exposure and chemical-specific parameters used by the MDEQ for potential soil exposures (Rule 299.5720) were applied, though adjustments were made to exposure parameters to account for indoor exposure. An age-adjusted soil ingestion factor (IF) of 89 milligrams (mg)-year/kilograms (kg)-day was used to represent indoor exposure of adults and children to stamp sand. This indoor ingestion factor is based on reducing the total daily soil intake to account for time spent outdoors during waking hours. The mean time a child spends outdoors at a residence is three hours (EPA 2002b) and the mean time an adult spends outdoors at a residence is two hours (EPA 1997).

Recreational

Exposure of the recreational receptor groups was quantified using the general equations presented by MDEQ in Part 201 Rule R299.5720. The exposure and chemical-specific parameters used by the MDEQ for potential soil exposures (Rule 299.5720) were applied, though adjustments were made to exposure parameters to account for recreational exposure. For the recreational exposure, the following exposure factors were used:

- An age-adjusted soil ingestion factor (IF) of 74 mg-year/kg-day was used to represent exposure of children (2 to 12 years of age) to stamp sand.
- The exposure frequency (EF_i) was changed to 52 days/year. This represents potential exposure four times per week during the warmer summer months (June through August) and twice per month during the cooler months of May and September.
- The age-adjusted soil dermal factor (DF) was 310 mg-year/kg-day, which is considered representative of potentially exposed children (2 to 12 years of age).

Construction Worker

Exposure of the construction worker receptor group was quantified using the general equations presented by MDEQ in Part 201 Rule R299.5720. The exposure and chemical-

specific parameters used by the MDEQ for potential soil exposures for commercial subcategory IV (Rule 299.5720) were applied since this subcategory includes a worker population engaged in activities at the property that are highly intensive with respect to soil contact.

1.2 Selection of Constituents of Potential Concern (COPCs)

Stamp sand is a mining waste that contains naturally occurring inorganic constituents that can be generally described as being technologically enhanced by mining activities. The inorganic COPCs measured in stamp sand are aluminum, arsenic, beryllium, chromium, cobalt, copper, lead, lithium, manganese, mercury, nickel, silver, strontium, and zinc.

1.2.1 Source of Data

The MDEQ Remediation and Redevelopment Division (RRD) Pre-remedial Unit of the Superfund Section and the RRD Geological Services Unit (GSU) were mobilized to Gay in September 2003 to collect soil and groundwater samples for site characterization. A total of 274 soil samples were collected from the northern deposit area. The area sampled within the northern deposit area is approximately equivalent to 15 acres, and was chosen due to its location within the site. The sampling area within the northern deposit area is closest to the conveyor which was used to transport sands into Lake Superior at the time of the stamp mill operation. It is anticipated to be the oldest, least disturbed location at Gay, with the highest likelihood of being accessible for excavation and use off site.

The MDEQ also collected 10 groundwater samples from the northern deposit area for analysis of both dissolved and total metals to evaluate the effects of stamp sand on surface water. The groundwater samples were collected directly from the boring using groundwater sample tooling.

The MDEQ collected a total of 24 soil samples from the southern deposit area. This area represents the stamp sand which has accumulated after being eroded from the main deposit.

1.2.2 Use of Data

Average metal concentrations in stamp sand were used for this Toxicological Evaluation. This average concentration was calculated as the 95 percent (%) upper confidence limit (UCL) on the mean using the United States Environmental Protection Agency (U.S. EPA) ProUCL (Version 3.0) software.

In selecting COPCs for a risk assessment, inorganic constituents are typically compared to natural background levels. COPCs are compared to background levels to evaluate if the contaminants are elevated due to anthropogenic activities or are consistent with naturally-occurring concentrations. The following table summarizes 95UCL concentrations for the Gay stamp sand in comparison to Statewide Default Background Levels. The shaded cells indicate that the metals concentrations that exceed the respective Statewide Default Background Level.

95 UCL Concentration in Stamp Sand Compared to Statewide Default Background Levels

COPC	Southern Area 95UCL Concentration	Northern Area 95UCL Concentration	Statewide Default Background Level
Aluminum	**11,791**	**15,872**	*6,900*
Arsenic	1.6	2.7	*5.8*
Beryllium	0.46	0.48	*None Listed*
Chromium	**29**	**29**	*18*
Cobalt	**19**	**23**	*6.8*
Copper	**1,713**	**2,972**	*32*
Lead	Not Detected	2.6	*21*
Lithium	5.8	6.2	*9.8*
Manganese	407	**549**	*440*
Mercury	Not Detected	0.028	*0.13*
Nickel	**27**	**31**	*20*
Silver	**1.3**	**1.8**	*1*
Strontium	13	17	*None Listed*
Zinc	**66**	**75**	*47*

As shown in the table, the 95 percent upper confidence limit (95UCL) concentrations of arsenic, lead, lithium, manganese (southern area), and mercury did not exceed state background levels and background levels have not been established for beryllium and strontium. However, all metals analyzed were retained as COPCs for this risk evaluation.

Tables 1a and 1b provided in **Appendix A** provide a statistical summary of the metals concentrations in stamp sand.

1.3 Exposure Point Concentrations

WESTON used the following calculations to determine exposure point concentrations for use in the human health risk assessment.

Mass Fraction of Soil to Dust

A mass fraction of soil to dust (M_{SD}) variable was used to approximate the concentration of metals in indoor dust based on the concentration of metals in nearby soil. The M_{SD} represents the mass fraction of house dust that is derived from outdoor soil. The default value for M_{SD} recommended by U.S. EPA is 0.70 gram (g) soil/g dust. The dust concentration can be estimated using the calculation in the following table (EPA 1998).

Mass Fraction of Soil to Dust Calculation	
$C_{dust} = M_{SD} \times C_{soil}$	
Where:	**C_{dust}** = indoor dust concentration (microgram (µg) metal/g dust)
	C_{soil} = outdoor soil concentration (µg metal/g soil)
	M_{SD} = mass fraction of soil in dust (g soil/g dust)

Particulate Emission Factor (PEF)

Outdoor air concentrations for the residential scenarios were predicted from stamp sand metals concentrations using a residential PEF as described by MDEQ (1998b):

PEF Calculation	
$PEF = (Q/C) \times 1/(Ew((1-V)) + Ev)$	
Where:	**PEF** = Particulate emission factor, 3.49E+07 cubic meters (m^3)/kg
	Q/C = Dispersion factor, 82.33 g/square meters (m^2)-s per kg/m^3 (default 0.5 acre source)
	Ew = Emission due to wind erosion, 5.5E-07 g/m^2-s
	V = Assumed vegetative cover, 0 (no cover)
	Ev = Emission due to vehicle traffic, 3.68E-07 g/m^2-s (default residential)

This PEF assumes no vegetative cover. A short-term peak particulate level adjustment was performed to account for the use of outdoor power brooms that will increase particulate emissions for the residential scenario. This adjustment was performed by modifying the PEF by a factor of two. Indoor air concentrations were estimated as 30 percent of the outdoor air concentration, following methods used in U.S. EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) model for lead sites (EPA 2002a).

Since particulate emission would be greater for recreational ORV use and for construction activities, a PEF was also calculated following MDEQ 1998b. This PEF accounts for greater emission due to vehicular traffic (with an emission rate due to vehicular traffic of 1.81E-06 g/m^2-s) and also assumes no vegetative cover. A short-term peak particulate level adjustment (using a factor of two) was also performed to account for recreational ORV use and construction activities that will increase particulate emissions. This PEF was applied for both the recreational and construction worker scenarios.

1.4 Toxicity Assessment

Toxicity criteria for the COPCs were obtained from the U.S. EPA's Integrated Risk Information System (IRIS) (EPA, 2004; accessed 31 August 2004). If toxicity criteria were not available from this source, toxicity criteria presented in the Region IX Risk-Based Concentration Tables (EPA Region IX, 2002) were used.

The forms of chromium (Cr) and nickel at the site are unknown. Following U.S. EPA Region IX (2002) recommendations, the slope factor for hexavalent Cr (Cr^{+6}) presented in IRIS was used as the slope factor for total Cr. The reference doses for Cr^{+6} were used since they are more conservative than those for trivalent Cr (Cr^{+3}). The most conservative slope factor for nickel, based on nickel subsulfide, was also used.

1.5 Risk Characterization

In a risk characterization the results of the exposure assessment and the toxicity assessment are integrated to quantitatively evaluate the potential current and future risk to human health. Carcinogenic and noncarcinogenic risks are evaluated for each COPC through each exposure route of concern and for all COPCs through all exposure routes combined. The risk characterization also identifies uncertainties associated with contaminant, toxicity, or exposure assumptions.

1.5.1 Evaluation of Noncarcinogenic Effects

Noncarcinogenic effects are evaluated by comparing the estimated daily intakes of chemical COPCs to reference doses (RfDs). In general, the 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 deleterious effects during a lifetime. The RfD is generally expressed in units of milligrams per kilogram of bodyweight per day (mg/kg/day). This is accomplished by calculating hazard quotients (HQs) and hazard indices (HIs). A HQ for a particular COPC through a given exposure route is the ratio between the estimated daily intake and the applicable RfD, as shown in the following table.

Calculation of Hazard Quotients			
HQ = EDI / RfD			
Where:	**HQ**	=	Hazard quotient (unitless)
	EDI	=	Estimated daily intake (mg/kg-day)
	RfD	=	Reference dose (mg/kg-day)

Screening level HIs are calculated by summing HQs across all exposure pathways for all COPCs to calculate the total HI. If the screening level HI exceeds 1, chemical COPCs are segregated by target organ, and a separate HI value for each effect/target organ is calculated. If the HQ for any chemical or if the HI value for any effect/target organ exceeds 1, noncarcinogenic health effects are considered possible.

1.5.2 Evaluation of Cancer Risks

Cancer risks are estimated as the incremental or excess probability of an individual developing cancer over a lifetime as a result of exposure to a carcinogen. This risk is in addition to the lifetime cancer risk the general, non-exposed population experiences. Cancer risks were calculated for each chemical COPC using the formula in the following table:

Calculation of Cancer Risks	
Risk = EDI x CSF	
Where:	**Risk** = Excess cancer risk (unitless probability)
	EDI = Estimated daily intake (mg/kg-day)
	CSF = Cancer slope factor $(mg/kg\text{-}day)^{-1}$

The total risk each chemical COPC poses is calculated by adding risks posed by the COPC through all exposure routes. The lifetime incremental cancer risk all chemical COPCs posed is estimated by summing risks posed by all chemical COPCs through all exposure routes.

1.5.3 Residential Exposure Scenario Risk Characterization

The exposure and risk calculations for the indoor and outdoor residential exposure scenarios are summarized in the following table.

Residential Exposure Scenario Risk Characterization				
Source	**Area**	**Hazard Indices[1]**	**Cancer Risk[2]**	**Risk Determination**
Indoor Air	Northern	0.3	3E-06	ACCEPTABLE
	Southern	0.2	3E-06	ACCEPTABLE
Outdoor Air	Northern	0.8	9E-06	ACCEPTABLE
	Southern	0.5	7E-06	ACCEPTABLE

[1] A HI less than 1.0 is acceptable.
[2] A cancer risk less than 1E-05 is acceptable.

A more detailed summary of the exposure and risk calculations is provided in **Tables 2a through 3b** in **Appendix A**. These cancer risks are primarily associated with ingestion of arsenic and the inhalation of Cr. The MDEQ's acceptable level of risk for carcinogens is one- in one-hundred thousand (1E-05). None of the COPCs had individual cancer risk

estimates greater than 1E-05. While arsenic poses a potential outdoor risk of 3E-06 in the northern area, the 95UCL concentration of arsenic is 2.65 mg/kg, which is less than the state background level of 5.8 mg/kg. The species of Cr at the site has not been determined. The risk evaluation assumes a 1:6 ratio of Cr^{+6} to Cr^{+3}, with Cr^{+3} being the primary form of Cr present in the environment. Note that Cr^{+3} is not a carcinogen.

Residential Exposure Scenario Risk Characterization Conclusion

Taking into account the risk calculation for residential indoor and outdoor exposure to stamp sand under this scenario, human exposure to the Gay stamp sand as a result of road traction use is considered acceptable.

1.5.4 Recreational Exposure Scenario Risk Characterization

The exposure and risk calculations for the adult and child recreational exposure scenarios for the southern and northern areas are summarized in the following table.

Recreational Exposure Scenario Risk Characterization				
Receptor	**Area**	**Hazard Indices[1]**	**Cancer Risk[2]**	**Risk Determination**
Adult	Northern	0.2	2E-06	ACCEPTABLE
	Southern	0.1	2E-06	ACCEPTABLE
Child	Northern	0.3	1E-06	ACCEPTABLE
	Southern	0.2	9E-07	ACCEPTABLE

[1] A HI less than 1.0 is acceptable.
[2] A cancer risk less than 1E-05 is acceptable.

A more detailed summary of the exposure and risk calculations is provided in **Tables 4a through 5b** in **Appendix A**. The cancer risks are primarily associated with the inhalation of Cr. The MDEQ's acceptable level of risk for carcinogens is one- in one-hundred thousand (1E-05). None of the COPCs had individual cancer risk estimates greater than 1E-05. The risk evaluation assumes a 1:6 ratio of Cr^{+6} to Cr^{+3}, with Cr^{+3} being the primary form of Cr present in the environment. Note that Cr^{+3} is not a carcinogen.

Recreational Exposure Scenario Risk Characterization Conclusion

Taking into account the risk calculation for this scenario, human exposure to the Gay stamp sand as a result of recreational use is considered acceptable.

1.5.5 Construction Worker Exposure Scenario Risk Characterization

The exposure and risk calculations for the construction work exposure scenario are summarized in the following table.

Construction Worker Exposure Scenario Risk Characterization			
Area	**Hazard Indices[1]**	**Cancer Risk[2]**	**Risk Determination**
Northern	0.7	5E-06	ACCEPTABLE
Southern	0.5	5E-06	ACCEPTABLE

[1] A HI less than 1.0 is acceptable.
[2] A cancer risk less than 1E-05 is acceptable.

A more detailed summary of the exposure and risk calculations is provided in **Tables 6a and 6b** in **Appendix A**. The cancer risks are primarily associated with the inhalation of Cr. The MDEQ's acceptable level of risk for carcinogens is one- in one-hundred thousand (1E-05). None of the COPCs had individual cancer risk estimates greater than 1E-05. The species of Cr at the site has not been determined. The risk evaluation assumes a 1:6 ratio of Cr^{+6} to Cr^{+3}, with Cr^{+3} being the primary form of Cr present in the environment. Note that Cr^{+3} is not a carcinogen.

Construction Worker Exposure Scenario Risk Characterization Conclusion

Taking into account the risk calculation for this scenario, human exposure to the Gay stamp sand as a result of construction reuses (e.g. road base) is considered acceptable.

1.6 Residential Drinking Water Assessment

1.6.1 Soil Data

The MDEQ previously compared the Gay stamp sand data to Part 201 Residential/Commercial I Drinking Water Protection Criteria for soil. These criteria establish soil concentration levels below which organic and inorganic contaminants are not expected to leach and/or migrate to groundwater at levels greater than the Residential/Commercial I Drinking Water Criteria. The following table summarizes concentrations of COPCs detected above Part 201 Residential/Commercial I Drinking Water Protection Criteria.

Soil Samples Exceeding Part 201 Residential/Commercial I Drinking Water Protection Criteria					
Area	**COPC**	**Minimum Concentration**	**Maximum Concentration**	**Number of Samples Exceeding Criteria**	**Residential/Commercial I Drinking Water Protection Criteria**
Southern	Aluminum	6,300	16,000	20	1
	Chromium	14	42	9	30
	Cobalt	710	5,300	124	0.8
	Manganese	210	560	7	1
Northern	Aluminum	11,000	24,000	271	1
	Arsenic	1	15	3	4.6
	Chromium	18	52	127	30
	Cobalt	16	36	271	0.8
	Manganese	290	1,700	159	1

All concentrations in mg/kg.
24 samples were collected from the southern area and 274 samples were collected from the northern area.

Of note, copper, lithium, and silver each exceeded Residential/Commercial I Drinking Water Protection Criteria in two samples each, but the criteria exceedances are considered minor and are not considered indicative of widespread contamination.

A more detailed summary of the soil data comparison to Residential/Commercial I Drinking Water Protection Criteria performed by MDEQ is presented in **Tables 7a** and **7b** in **Appendix A.** To further evaluate the threat to Residential Drinking Water and assess the leaching of the other detected COPCs from soil to groundwater, the MDEQ compared groundwater data to Residential Drinking Water Criteria as discussed below.

1.6.2 Groundwater Data

The MDEQ also compared groundwater sample results for dissolved metals to Part 201 Residential/Commercial I Drinking Water Criteria. The following table summarizes concentrations of COPCs detected above Part 201 Residential/Commercial I Drinking Water Criteria.

Groundwater Samples Exceeding Part 201 Residential/Commercial I Drinking Water Criteria				
COPC	**Minimum Concentration**	**Maximum Concentration**	**Number of Samples Exceeding Criteria**	**Residential/Commercial I Drinking Water Criteria**
Aluminum	56	120	3	50/300
Manganese	56	430	6	50/860

All concentrations in ug/L
Note: the second criteria value is the health based value.

A detailed summary of dissolved groundwater data comparison to Residential/Commercial I Drinking Water Criteria performed by MDEQ is presented in **Table 8** in **Appendix A**.

Residential Drinking Water Assessment Conclusion

Consumption of groundwater that has contact with stamp sand is considered unacceptable as concentrations of aluminum and manganese were detected above Part 201 Residential/Commercial I Drinking Water Criteria. Aluminum and manganese are present in stamp sand at concentrations that are leaching to groundwater above Residential/Commercial I Drinking Water Criteria.

2.0 AQUATIC ORGANISM EXPOSURE

In addition to human exposure to stamp sand, the exposure of aquatic organisms was evaluated for the following scenarios:

- Effects of stamp sand on surface waters as a result of stamp sand surface runoff from use as traction sand.
- Effects of stamp sand on surface water as a result of historic deposits, or runoff from its current location, or from historically being placed in surface waters as fill (e.g., during road or culvert construction).

2.1 RISK ASSESMENT

2.1.1 Ecological Screening Benchmarks for Sediment

To evaluate exposure of aquatic organisms to stamp sand, existing soil contaminant concentrations were compared to ecological screening benchmarks for sediment. "Threshold Effect Concentrations" (TECs) and "Probable Effect Concentrations" (PECs) were used to evaluate potential effects of stamp sand contaminants to benthic macroinvertebrates. The TECs and PECs are from *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (D. MacDonald, et. al.). The MDEQ Water Bureau uses TECs and PECs as screening criteria to evaluate sediment chemistry data. TECs are defined as concentrations below which adverse effects are not expected to occur. PECs are concentrations above which adverse effects are expected to occur more often than not.

A mean PEC quotient was developed for the maximum detected and the 95UCL metal concentrations in the southern and northern areas. The PEC quotient is used to assess sediment that contains complex mixtures of chemical contaminants. To develop the PEC quotient, the concentration of each COPC in a sample is first divided by its PEC. The sum of PEC quotients is then calculated by adding the individual PEC quotients, and the mean PEC quotient is determined from this sum. A mean PEC quotient greater than 0.5 represents a threshold that can be used to accurately classify sediment as either toxic or not toxic.

The following table summarizes the sum of the individual PEC quotients and the mean PEC quotients.

Summary of Individual and Mean PEC Quotients			
Area	**Threshold**	**Sum of Individual PEC Quotients (95 UCL)**	**Mean PEC Quotients (95 UCL)**
Northern	0.5	21	3.0
Southern		13	2.5

The mean PEC quotient exceeded 0.5 for both the maximum and 95UCL concentrations, with copper having the greatest individual PEC quotients in both the southern and northern areas. Maximum detected and 95UCL concentrations of copper exceeded their individual PECs and TECs. Of the remaining COPCs, only the individual PEC for nickel exceeded 0.5 in both the southern and northern areas. Detailed summaries of the PEC quotients for individual COPCs are provided in **Tables 9a and 9b** in **Appendix A**.

For chemicals lacking consensus-based PECs, concentrations were compared to sediment screening benchmarks available at the Oak Ridge National Laboratory (ORNL) Risk Assessment Information System (RAIS) on-line database. The RAIS database provides ecological screening benchmarks for soil, sediment, and surface water obtained from a variety of sources. Sediment screening benchmarks were not available for beryllium, lithium and strontium. The following tables summarize maximum and 95 UCL concentrations that exceeded the screening benchmarks provided in the RAIS for the southern and northern areas, respectively.

Comparison to Alternative Sediment Screening Benchmarks from the RAIS for the Southern Area									
COPC	**Soil Concentration**		**Ontario**		**NOAA**		**R5 ESL**	**FDEP**	
	Max.	**95 UCL**	**Low**	**Severe**	**ER-L**	**ER-M**		**PEL**	**TEL**
Manganese	560	407	**460**	1,100	---	---	---	---	---
Silver	2.6	1.27	---	---	**1**	3.7	**0.5**	**1.77**	**0.73**

Comparison to Alternative Sediment Screening Benchmarks from the RAIS for the Northern Area												
COPC	**Soil Concentration**		**ARCS**			**Ontario**		**NOAA**		**R5 ESL**	**FDEP**	
	Max.	**95 UCL**	**NEC**	**PEC**	**TEC**	**Low**	**Severe**	**ER-L**	**ER-M**		**PEL**	**TEL**
Manganese	1,700	549	**819**	**1,080**	**1,670**	**460**	**1,100**	---	---	---	---	---
Silver	7.7	1.84	---	---	---	---	---	**1**	**3.7**	**0.5**	**1.77**	**0.73**

All concentrations in mg/kg. ARCS = U.S. EPA Assessment and Remediation of Contaminated Sediments NEC = No effect concentration
PEC = probably effects concentration TEC = threshold effects concentration NOAA = National Oceanic and Atmospheric Administration
ER-L = effects range – low ER-M = effect range – median R5 ESL = U.S. EPA Region 5 Ecological Screening Level
FDEP = Florida Department of Environmental Protection PEL = probably effects level TEL = threshold effects level
--- = no benchmark available Bold font and shaded cells indicate the maximum and/or 95 UCL concentration exceed the benchmark.

The maximum and 95UCL concentrations of silver exceeded several screening benchmarks in both the southern and northern areas. The maximum concentration of manganese exceeded its lowest benchmark in the southern area and the maximum and 95UCL concentrations of manganese exceeded its lowest benchmark in the northern area. Detailed summaries of the RAIS screening benchmarks are provided in **Tables 10a** and **10b** in **Appendix A**.

2.1.2 Groundwater Surface Water Interface Protection

Chemical contaminants in stamp sand used as traction sand and from historic deposits or runoff may also migrate to surface water and be released into the water column. To evaluate the effects on aquatic organisms inhabiting the water column (e.g., fish), concentrations of metals in stamp sand were compared to MDEQ's Groundwater Surface Water Interface Protection (GWSIP) criteria and dissolved groundwater concentrations were compared to MDEQ's surface water quality criteria. Dissolved groundwater concentrations (instead of total concentrations) were compared to the surface water quality criteria as the criteria are based on dissolved contaminant concentrations in surface water. Since some of the default GWSIP criteria are based on human health effects, GWSIP values were calculated using water quality standards for the protection of aquatic life. Final chronic values (FCVs), aquatic maximum values (AMVs), and final acute values (FAVs) from MDEQ's Rule 57 surface water quality standards (Rule 323.1057) were used to calculate GWSIP criteria for ecological effects.

FCV is the level of a substance or a mixture of substances that does not allow injurious or debilitating effects in an aquatic organism resulting from repeated long-term exposure to a substance relative to the organism's lifespan. AMV is the highest concentration of a material in the ambient water column to which an aquatic community can be exposed briefly without resulting in unacceptable effects. FAV is the level of a chemical or mixture of chemicals that does not allow the mortality or other specified response of aquatic organisms to exceed 50% when exposed for 96 hours, except where a shorter time period is appropriate for certain species (Rule 323.1043). The following table

summarizes the COPCs concentrations above the GWSIP based on Surface Water Quality Criteria.

COPC Concentrations Above GWSIP						
Area	COPC	Soil Concentration		GWSIP		
		Max.	95 UCL	FCV	AMV	FAV
Southern	Copper	5,300	1,713	**27**	**37**	**74**
	Nickel	44	28	**28**	252	505
	Silver	2.6	1.3	**0.008**	**0.07**	**0.15**
	Zinc	92	66	**61**	**60**	120
Northern	Copper	13,000	2,972	**27**	**37**	**74**
	Nickel	48	32	**28**	252	505
	Silver	7.7	1.8	**0.008**	**0.07**	**0.15**
	Zinc	120	76	**61**	**60**	**120**

All concentrations in mg/kg
Bold font and shaded cells indicate the maximum and/or 95 UCL concentration exceed the GWSIP.

The maximum and 95UCL concentrations of copper and silver in stamp sand in both the southern and northern areas exceeded all ecological-effects based GWSIP criteria. The maximum and 95UCL concentrations of zinc in stamp sand exceeded the GWSIP criteria in both areas based on the FCV and exceeded all ecological-effects based GWSIP criteria in the northern area. The maximum concentration of nickel in the southern area exceeded the GWSIP based on the FCV. Detailed summaries of GWSIP comparison to all COPCs are provided in **Tables 11a** and **11b** in **Appendix A**.

2.1.3 Groundwater Data Comparison to Surface Water Quality Values

Total concentrations of beryllium, chromium, copper, lead, manganese, nickel, silver, and zinc in groundwater exceeded water quality criteria for the protection of aquatic life as summarized in the following table.

COPC (Total)	Groundwater Concentration (ug/L)		Rule 57 Surface Water Quality Values		
	Min.	Max.	FCV	AMV	FAV
Beryllium	1.2	2.5	**0.34**	3.02	6.05
Chromium	58	120	**46**	955	955
Copper	250	22,000	**4.8**	**6.7**	**6.7**
Lead	1.4	13	**4.8**	43	43
Manganese	260	2,600	**976**	**2,105**	4,209
Nickel	5.2	110	**27**	243	243
Silver	1.1	16	**0.06**	**0.54**	**1.1**
Zinc	81	320	**62**	**62**	**62**
COPC (Dissolved)					
Copper	3.1	23	**4.8**	**6.7**	**6.7**

Bold font and shaded cells indicate the Surface Water Quality Value is exceeded for the respective COPC.

However, only dissolved concentrations of copper in groundwater exceeded water quality criteria for the protection of aquatic life. Detailed summaries of the COPCs detected in groundwater with comparison to the Rule 57 Water Quality Values are provided in **Tables 12a** and **12b** in **Appendix A**.

Aquatic Risk Evaluation Conclusion

The aquatic risk evaluation indicated stamp sand poses an unacceptable risk to aquatic life. Therefore, stamp sand discharge to surface water through the re-use as road traction material or in-place discharge via runoff from historic deposits was considered unacceptable pending further evaluation.

2.2 BIOASSESSMENT

2.2.1 Phase I

WESTON performed a bioassessment to further evaluate the toxicity of stamp sand to aquatic life and determine the acceptability of stamp sand reuse as road traction and in-place erosion to surface water from stamp sand deposits. On 21 January 2005, WESTON and MDEQ collected a total of 10 stamp sand samples from the Keweenaw County Road Commission (KCRC) road traction stockpile as the Gay stamp sand is used by the KCRC.

Chemical Analyses

The 10 KCRC stamp sand samples were collected and submitted for total metals analysis at the MDEQ Environmental Laboratory to determine the most appropriate samples for toxicity testing, total organic carbon (TOC) analysis, and grain size distribution (based on the highest and lowest metals concentrations).

Two stamp sand samples (KCRC-6 and KCRC-8) were selected for toxicity testing, TOC, and grain size analyses after WESTON and MDEQ evaluated the total metals results. TOC and grain size distribution are analyses performed to compliment toxicity testing. TOC and grain size parameters provide information related to the causes of

toxicity and how well sediment may retain contaminants. For instance, if toxic effects are observed, but don't appear to be related to contamination, another factor such as the lack of TOC or the composition (grain sizes) of the sediment may contribute to toxicity. Sediment that has higher TOC values tends to retain organic contaminants, and therefore, the contaminants are less available in the aquatic environment.

The selection of KCRC-6 and KCRC-8 was made based on the highest and lowest concentrations of the metals of concern (copper, nickel, zinc, and manganese) as summarized in the following table. The metals concentrations in all 10 KCRC samples were relatively uniform.

COPC Concentrations Detected in KCRC-6 and KCRC-8

Sample I.D.	Aluminum	Arsenic	Beryllium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Mercury	Nickel	Silver	Strontium	Zinc
KCRC-6	16,000	1.5	0.35	25	20	1,800	<5.0	5.5	370	<0.05	28	1.1	11	77
KCRC-8	16,000	1.3	0.48	25	24	2,700	<5.0	7.0	450	<0.05	27	1.2	14	76

All concentrations in mg/kg

Table 13 in **Appendix A** provides a summary of detected COPCs for all ten samples collected, as well as TOC and grain size information for KCRC -6 and KCRC-8.

Bioassay Results

Because stamp sand is terrestrial in nature and not immediately capable of supporting all aquatic organisms, it was necessary to design an experiment that would separate the effects of the metals contamination from those that are due to the terrestrial nature of the stamp sand. WESTON modified standard testing procedures to permit an aquatic acclimation of the stamp sand over a period of approximately four to six weeks prior to testing. The acclimated results were compared to test results from the unacclimated terrestrial samples.

The testing for the Phase I Bioassessment included suspended phase (SPP) elutriate toxicity tests with the cladoceran, *Ceriodaphnia dubia* (*C. dubia*) under 48-hour

exposures to evaluate acute toxicity within the water column. The testing also included two solid phase (SP) toxicity tests with the amphipod, *Hyalella azteca* (*H. azteca*) and the midge larvae, *Chironomus dilutus (C. dilutus)* to evaluate the acute and chronic effects of stamp sand on benthic organisms. The survival and growth of these latter two species were measured after 10 days of exposure while the amphipod test was also continued and assessed after 28 days of exposure to the stamp sand. All of the samples, except the 28-day *H. azteca* were tested under both acclimated and unacclimated conditions. Results of the Phase I Bioassessment bioassay tests are summarized in the following tables for unacclimated and acclimated stamp sand samples, respectively.

Unacclimated Stamp Sand 10-Day SP *H. azteca* Results		
Sample	**Survival (%)**	**Growth (mg)**
KCRC-6	87.5	0.171
KCRC-8	81.25	0.188

Shaded cells indicate the result was significantly different than at least one of two controls.

Unacclimated Stamp Sand 10-Day SP *C. dilutus* Results		
Sample	**Survival (%)**	**Growth (mg)**
KCRC-6	86.25	0.694
KCRC-8	73.75	0.716

Shaded cells indicate the result was significantly different than at least one of two controls.

Acclimated Stamp Sand 10-Day SP *H. azteca* Results		
Sample	**Survival (%)**	**Growth (mg)**
KCRC-6	96.7	0.123
KCRC-8	90	0.160

Shaded cells indicate the result was significantly different than at least one of two controls.

Acclimated Stamp Sand 28-Day SP *H. azteca* Results		
Sample	**Survival (%)**	**Growth (mg)**
KCRC-6	72	0.251
KCRC-8	88	0.304

Shaded cells indicate the result was significantly different than at least one of two controls.

Acclimated Stamp Sand 10-Day SP *C. dilutus* Results		
Sample	**Survival (%)**	**Growth (mg)**
KCRC-6	67.5	0.535
KCRC-8	78.8	0.548

Shaded cells indicate the result was significantly different than at least one of two controls.

Unacclimated Stamp Sand 48-Hour SPP Results						
Sample	**Percent Survival in Each Elutriate Concentration**			**LC50**	**NOEC**	**TUa**
	10%	**50%**	**100%**			
KCRC-6	92	4	0	23.51	10	10
KCRC-8	96	4	0	23.48	10	10

Acclimated Stamp Sand 48-Hour SPP Results						
Sample	Percent Survival in Each Elutriate Concentration			LC50	NOEC	TUa
	10%	50%	100%			
KCRC-6	75	40	0	29.6	<10	>10
KCRC-8	80	30	0	23.58	10	10

LC50 = median lethal concentration NOEC = no observable effect concentration TUa = toxic units acute (100/NOEC).

Results for samples KCRC-6, KCRC-8, and the controls are further detailed in **Table 14** in **Appendix A**.

Results of the Phase I Bioassessment indicated the SP stamp sand samples from the KCRC had minimal acute impact on the biological test organisms (*H. azteca,* and *C. dilutus*). The relatively small effects were reduced further for the *H. azteca* by acclimation of stamp sand to mimic environmental conditions once the KCRC stamp sand settled to the bottom of lakes and ponds. Some chronic effects (growth) were observed as the growth endpoints were significantly different than the controls in almost every SP test. The conclusion from the Phase I Bioassessment was that, based on the bioassay data, stamp sand from the KCRC was unlikely to have acute effects on benthic organisms. Adverse effects in the water column were not anticipated unless the water column consisted of more than 10% stamp sand.

A complete summary of the methods and results for the Phase I Bioassessment is provided in the *Phase I Bioassay Laboratory Report for the Gay and Point Mills, Michigan Stamp Sand* (WESTON, 2006).

2.2.2 Phase II

Based on MDEQ review of the Phase I Bioassessment results and to further evaluate the effects of the Gay stamp sand in the actual aquatic environment, it was determined that sediment samples from Lake Superior should be collected that represent the erosion of stamp sand from the Gay stamp sand deposit. On 8 September 2005, MDEQ collected five sediment samples (comprised primarily of stamp sand) from Lake Superior near the Gay stamp sand deposit and from the shoreline southward of the Gay stamp sand deposit. Ancillary to the Phase II data collection, MDEQ collected four samples of surface water from stagnant ponds located within the eroded stamp sand shore.

Chemical Analyses

The five sediment samples were collected and submitted for total metals analysis at the MDEQ Environmental Laboratory to evaluate the range of metals concentrations in the samples. Additional sample volume was collected from each sampling location for acid volatile sulfide/simultaneously extracted metals (AVS/SEM), toxicity testing, TOC analysis, and grain size distribution. AVS/SEM analyses were performed to evaluate the bioavailability of metals in stamp sand. Similar to TOC, AVS/SEM provides information related to the how well sediment may retain or release contaminants. However, AVS/SEM provides information related to the retention of metals rather than organics. TOC and grain size distribution were performed according to the rationale described for the Phase I Bioassessment.

Chemical analyses were also performed on sample elutriates. All elutriates were analyzed for total and dissolved metals. Metals were analyzed for sample elutriates to further evaluate the availability of metals in the water column due to the release of metals from stamp sand. Results of the chemical analyses for SP stamp sand and elutriates are summarized in the following tables as well as **Table 15** provided in **Appendix A**.

COPC Concentrations Detected in Lake Superior Sediment														
Sample I.D.	**Aluminum**	**Arsenic**	**Beryllium**	**Chromium**	**Cobalt**	**Copper**	**Lead**	**Lithium**	**Manganese**	**Mercury**	**Nickel**	**Silver**	**Strontium**	**Zinc**
Gay Tox A.	15,000	3.7	0.48	29	24	4,400	---	4.7	440	---	31	1.4	10	81
Gay Tox. B	12,000	2.9	0.4	29	23	3,800	---	5.9	370	---	32	1.3	7.6	76
Gay Tox. C	13,000	4.2	0.37	31	23	3,800	---	6.7	410	---	34	1.3	8.5	75
Gay Tox. D	12,000	1.4	0.38	27	21	1,400	---	5.6	380	---	27	0.9	8.4	76
Gay Tox. E	11,000	1.5	0.37	30	25	1,700	---	6.5	380	---	36	0.9	5.6	82

All concentrations in mg/kg
--- = COPC was not detected

COPC Concentrations Detected in Elutriates Above Rule 57 Water Quality Values								
COPC	**Sample I.D.**					**Rule 57 Water Quality Values**		
	Gay Tox. A	**Gay Tox. B**	**Gay Tox. C**	**Gay Tox. D**	**Gay Tox. E**	**FCV**	**AMV**	**FAV**
Total Metals								
Copper	0.81	0.62	0.44	0.96	0.22	**0.0046**	**0.0065**	**0.013**
Silver	0.0005	0.00042	0.00034	0.00071	---	**0.00006**	**0.00054**	0.0011
Dissolved Metals								
Copper	0.028	0.032	0.02	0.017	0.016	**0.0046**	**0.0065**	**0.013**
Silver	---	---	---	---	---	0.00006	0.00054	0.0011

All concentrations in mg/L
Shaded cells with bold font indicate a Water Quality Value is exceeded
--- = COPC was not detected

COPC Concentrations Detected in Pond Water Above Rule 57 Water Quality Values							
COPC (Total Metals)	**Gay Pond 1**	**Gay Pond 2**	**Gay Pond 3**	**Gay Pond 4**	**Rule 57 Water Quality Values**		
					FCV	**AMV**	**FAV**
Copper	0.230	0.350	0.130	0.083	**0.0046**	**0.0065**	**0.013**

All concentrations in mg/L
Shaded cells with bold font indicate a Water Quality Value is exceeded
--- = COPC was not detected

Concentrations of copper detected in elutriates of the Lake Superior sediment and from the four pond water samples were above both acute and chronic Rule 57 Water Quality Values. This indicates that stamp sand releases metals at concentrations expected to have acute and chronic effects in the water column.

Results of the chemical analyses performed for the four pond water samples are summarized for all COPCs in **Table 16** provided in **Appendix A**.

Bioassay Results

The toxicity testing for the Phase II Bioassessment included SPP elutriate toxicity tests with the cladoceran, *C. dubia* under 48-hour exposures to evaluate acute toxicity in the water column. The testing also included two SP toxicity tests with the amphipod, *H. azteca* and the midge larvae, *C. dilutus* to evaluate the acute and chronic effects of stamp sand on benthic organisms. The survival and growth of these latter two species were measured after 10 days of exposure. All of the samples were tested using standard test procedures. Results of the Phase II Bioassessment bioassay tests are summarized in the following tables and in further detail in **Table 17** in **Appendix A**.

Lake Superior Sediment 10-Day SP *H. azteca* Results		
Sample	**Survival (%)**	**Growth (mg)**
Gay Tox. A	50.00	0.1355
Gay Tox. B	50.00	0.1053
Gay Tox. C	61.25	0.1215
Gay Tox. D	50.00	0.1000
Gay Tox. E	58.75	0.1390

Shaded cells indicate the result was significantly different than at least one of two controls.

Lake Superior Sediment 10-Day SP *C. dilutus* Results		
Sample	**Survival (%)**	**Growth (mg)**
Gay Tox. A	78.75	0.8727
Gay Tox. B	65.00	0.8733
Gay Tox. C	53.75	0.8671
Gay Tox. D	63.75	0.7315
Gay Tox. E	48.75	0.9282

Shaded cells indicate the result was significantly different than at least one of two controls.

Lake Superior Sediment 48-Hour SPP Results							
Sample	**Percent Survival in Each Elutriate Concentration**				**LC50**	**NOEC**	**TUa**
	1%	**10%**	**50%**	**100%**			
Gay Tox. A	96	100	0	0	21.99	10	10
Gay Tox. B	96	100	0	0	22.00	10	10
Gay Tox. C	88	76	0	0	14.75	1	100
Gay Tox. D	84	84	0	0	19.18	10	10
Gay Tox. E	96	88	16	12	23.76	10	10

LC50 = median lethal concentration NOEC = no observable effect concentration TUa = toxic units acute (100/NOEC).

Results of the Phase II Bioassessment indicated the sediment samples collected from Lake Superior near Gay were more toxic to benthic organisms than the KCRC samples collected during the Phase I Bioassessment. In almost all samples, and with each test organism, there were biologically significant effects (toxicity) relative to controls. The variance between the KCRC and Lake Superior sediment samples was unexpected as the Lake Superior sediment sample results are essentially derived from the same stamp sand source as the KCRC samples and the total metals results were similar.

The sediment samples collected from Lake Superior can be considered representative of the effects on aquatic organisms in the natural environment indicating the in-place sediment comprised primarily of stamp sand poses a risk to aquatic life.

The differences in toxicity observed between the KCRC samples and the Lake Superior sediment samples, appear to indicate that laboratory acclimated samples may provide

results that are less detrimental than the natural environment would produce. Collection of additional in-situ sediment from roadside surface water bodies (streams and ditches) would provide the most representative example of the effects of stamp sand used as road traction on aquatic organisms.

A complete summary of methods, results and discussion of the Phase II Bioassessment is provided in the *Phase II Bioassay Laboratory Report for the Gay and Point Mills, Michigan Stamp Sand* (WESTON, 2006)

Bioassessment Conclusion

Reuse of the Gay stamp sand as road traction and runoff/placement of the stamp sand in surface water is considered unacceptable due to the following:

- Samples collected from KCRC showed chronic effects (growth) on benthic organisms;
- Lake Superior sediment samples showed acute and chronic effects (growth) on benthic organisms;
- Elutriations of the KCRC samples and Lake Superior sediment resulted in calculated TUa between 10 and 100;
- Elutriations of the Lake Superior sediment resulted in dissolved copper concentrations above acute and chronic Rule 57 Water Quality Values; and,
- Pond water samples collected from the Lake Superior shoreline resulted in total copper concentrations above acute and chronic Rule 57 Water Quality Values.

Further, the addition of road salt to stamp sand is believed to increase the availability of metals in stamp sand as observed in tests conducted for the Point Mills, Michigan stamp sand. The increase in availability of metals and ultimate increase in toxicity caused by the addition of road salt to stamp sand provides an additional reason why stamp sand reuse as road traction is considered unacceptable.

3.0 CONCLUSIONS

Based on the HI and cancer risks calculated for the COPCs in this Toxicological Evaluation, human exposure to metals in stamp sand from Gay under the residential, recreational, and construction material reuse scenarios is considered to be acceptable. Both the cumulative noncancer and cancer risk estimates for all human receptor groups were at or below the MDEQ's acceptable levels of risk, as summarized below.

Manganese and aluminum were detected in stamp sand samples above Residential/Commercial I Drinking Water Protection Criteria and in groundwater above Residential/Commercial I Drinking Water Criteria. Therefore, consumption of groundwater that comes in contact with stamp sand is considered unacceptable.

GAY, MICHIGAN STAMP SAND HUMAN HEALTH RISK ASSESSMENT	
EXPOSURE SCENARIO	**RISK DETERMINATION[1]**
SOUTHERN AREA RESIDENTIAL (STAMP SAND USE AS ROAD TRACTION)	
Indoor	**ACCEPTABLE**
Outdoor	**ACCEPTABLE**
NORTHERN AREA RESIDENTIAL (STAMP SAND USE AS ROAD TRACTION)	
Indoor	**ACCEPTABLE**
Outdoor	**ACCEPTABLE**
RESIDENTIAL (DRINKING WATER)	
Drinking Water	**UNACCEPTABLE**
SOUTHERN AREA RECREATIONAL (SAND BOX SCENARIO)	
Adult	**ACCEPTABLE**
Child (2-12 years)	**ACCEPTABLE**
NORTHERN AREA RECREATIONAL (SAND BOX SCENARIO)	
Adult	**ACCEPTABLE**
Child (2-12 years)	**ACCEPTABLE**
SOUTHERN AREA CONSTRUCTION WORKER (STAMP SAND USE AS CONSTRUCTION MATERIAL)	
Adult	**ACCEPTABLE**
NORTHERN AREA CONSTRUCTION WORKER (STAMP SAND USE AS CONSTRUCTION MATERIAL)	
Adult	**ACCEPTABLE**

[1] Exposure of these receptor groups was quantified using the general equations presented by MDEQ in Part 201 Rule R299.5720. The exposure and chemical-specific parameters used by the MDEQ for potential soil exposures (Rule 299.5720) were applied, though adjustments were made to exposure parameters to account for these exposure scenarios as discussed in Section 1.1, 1.2, and 1.3.

The comparison of stamp sand soil data and groundwater data to ecological benchmarks, GWSIP, and surface water quality criteria indicated the Gay stamp sand could have detrimental effects on aquatic organisms with copper and silver posing the greatest potential for impact. The Phase I and Phase II Bioassessment confirmed the data comparison and indicated the Gay stamp sand causes acute and chronic effects to benthic organisms. The copper concentrations detected in elutriates of Lake Superior sediment and the pond water samples indicate the Gay stamp sand releases metals that can cause acute and chronic effects in the water column. The TUa calculated for elutriations resulted in TUa between 10 and 100. Therefore, stamp sand reuse as road traction and runoff/placement of the stamp sand in surface water is considered unacceptable.

GAY, MICHIGAN STAMP SAND AQUATIC ORGANISM RISK ASSESSMENT
(STAMP SAND USE AS ROAD TRACTION OR IN-PLACE DEPOSIT ADJACENT TO SURFACE WATER)

MEDIA	THREAT/TOXICITY	RISK DETERMINATION
Sediment	PECs and PEC Quotients exceeded 0.5; Groundwater/Surface Water Interface Protection for surface water is exceeded; acute and chronic effects observed for benthic organisms.	**UNACCEPTABLE**
Surface Water	Copper concentrations in groundwater, pond water, and elutriate water exceeded Rule 57 Water Quality Values; toxicity observed in SPP tests resulting in NOECs between 1 and 10; and TUa between 10 and 100.	**UNACCEPTABLE**

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TABLES

Table 1a
Gay Southern Area 2003 Stamp Sand Data Summary
(All concentrations in mg/kg)

Analyte	Detected Samples	Minimum	Maximum	Mean	Standard Deviation	Distribution	95 UCL*	Basis	State Background Level
Aluminum	24	6,300	16,000	10,733	3,024	Normal	11,791	Student's-t UCL	6,900
Arsenic	24	0.9	2.7	1.43	0.4	Gamma	1.6	Approximate gamma UCL	5.8
Beryllium	24	0.27	0.61	0.42	0.1	Normal	0.46	Student's-t UCL	NA
Chromium	24	14	42	26.3	8.98	Normal	29.4	Student's-t UCL	18
Cobalt	24	10	28	17.8	5.48	Normal	19.71	Student's-t UCL	6.8
Copper	24	710	5,300	1,443	908	Gamma	1,713.7	Approximate gamma UCL	32
Lead	0	--	--	--	--	--	--	--	21
Lithium	24	3.1	8	5.30	1.55	Normal	5.8	Student's-t UCL	9.8
Manganese	24	210	560	371	103	Normal	407	Student's-t UCL	440
Mercury	0	--	--	--	--	--	--	--	0.13
Nickel	24	13	44	24.4	8.74	Normal	27.5	Student's-t UCL	20
Silver	24	0.5	2.6	1.06	0.53	Lognormal	1.27	H-UCL	1
Strontium	24	6.2	35	11.20	5.63	Non-parametric	13	Modified-t UCL	NA
Zinc	24	29	92	60	17.65	Normal	66	Student's-t UCL	47

* Calculated using ProUCL version 3.0
NA - Not available.

Table 1b
Gay Northern Area 2003 Stamp Sand Data Summary
(All concentrations in mg/kg)

Analyte	Detected Samples	Minimum	Maximum	Mean	Standard Deviation	Distribution	95 UCL*	Basis	State Background Level
Aluminum	271	11,000	24,000	15,612	2,589	Normal	15,872	Student's-t UCL	6,900
Arsenic	271	1	15.5	1.54	1.1	Non-parametric	2.65	Modified-t UCL	5.8
Beryllium	271	0.24	1.6	0.47	0.11	Non-parametric	0.48	Modified-t UCL	NA
Chromium	271	18	52	28.8	6.15	Non-parametric	29.5	Modified-t UCL	18
Cobalt	271	16	36	22.9	3.35	Non-parametric	23.3	Modified-t UCL	6.8
Copper	271	1,500	13,000	2,863	1,060	Non-parametric	2,972	Modified-t UCL	32
Lead	3	5.1	6.1	2.55	0.40	Non-parametric	2.6	Modified-t UCL	21
Lithium	271	3	10	6.08	1.58	Non-parametric	6.2	Modified-t UCL	9.8
Manganese	271	290	1700	531	175	Non-parametric	549	Modified-t UCL	440
Mercury	13	0.06	0.11	0.027	0.009	Non-parametric	0.028	Modified-t UCL	0.13
Nickel	271	20	48	31	5.54	Non-parametric	31.6	Modified-t UCL	20
Silver	271	0.4	7.7	1.75	0.87	Non-parametric	1.84	Modified-t UCL	1
Strontium	271	7.5	30	16.7	3.78	Non-parametric	17.05	Modified-t UCL	NA
Zinc	271	48	120	74.7	10.4	Non-parametric	75.8	Modified-t UCL	47

* Calculated using ProUCL version 3.0
NA - Not available.

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Table 2a
Indoor Dust Exposure and Risk Calculations
Gay Southern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration				Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Indoor Dust	Outdoor Air	Indoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/kg	mg/m^3	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C indoor dust x IF x AEi x EFi x CF / AT													
Aluminum	NC	11,791	8253.7	2.63E-04	7.89E-05	5.01E-03	1.17E-02			1.0E+00	1.4E-03	--	1.17E-02
Arsenic	C	1.6	1.1018	3.51E-08	1.05E-08	6.68E-07	1.56E-06	1.5E+00	1.5E+01	3.0E-04		1.00E-06	5.20E-03
Beryllium	C	0.46	0.3213	1.02E-08	3.07E-09	1.95E-07	4.55E-07		8.4E+00	2.0E-03	5.7E-06	--	2.27E-04
Chromium*	C	29.4	20.608	6.57E-07	1.97E-07	1.25E-05	2.92E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	13.797	4.40E-07	1.32E-07	8.37E-06	1.95E-05		9.8E+00	2.00E-02	5.7E-06	--	9.77E-04
Copper	NC	1,713.7	1199.59	3.82E-05	1.15E-05	7.28E-04	1.70E-03			4.00E-02		--	4.25E-02
Lead	NC	--	--	--	--	--	--					--	--
Lithium	NC	5.8	4.067	1.30E-07	3.89E-08	2.47E-06	5.76E-06			2.0E-02		--	2.88E-04
Manganese	NC	407	285.11	9.08E-06	2.72E-06	1.73E-04	4.04E-04			2.4E-02	1.4E-05	--	1.68E-02
Mercury	NC	--	--	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	19.25	6.13E-07	1.84E-07	1.17E-05	2.72E-05		1.7E+00	2.0E-02		--	1.36E-03
Silver	NC	1.27	0.889	2.83E-08	8.50E-09	5.39E-07	1.26E-06			5.0E-03		--	2.52E-04
Strontium	NC	13	9.317	2.97E-07	8.90E-08	5.65E-06	1.32E-05			6.0E-01		--	2.20E-05
Zinc	NC	66	46.41	1.48E-06	4.44E-07	2.82E-05	6.57E-05			3.0E-01		--	2.19E-04
											TOTAL	**1.0E-06**	**7.9E-02**
Dermal Absorption = C indoor dust x DF x AEd x EFd x CF / AT													
Aluminum	NC	11,791	8253.7	2.63E-04	7.89E-05	2.79E-03	6.52E-03			1.0E+00	1.4E-03	--	6.52E-03
Arsenic	C	1.6	1.1018	3.51E-08	1.05E-08	1.12E-07	2.61E-07	1.5E+00	1.5E+01	3.0E-04		1.68E-07	8.70E-04
Beryllium	C	0.46	0.3213	1.02E-08	3.07E-09	1.09E-07	2.54E-07		8.4E+00	2.0E-03	5.7E-06	--	1.27E-04
Chromium*	C	29.4	20.608	6.57E-07	1.97E-07	6.98E-06	1.63E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	13.797	4.40E-07	1.32E-07	4.67E-06	1.09E-05		9.8E+00	2.00E-02	5.7E-06	--	5.45E-04
Copper	NC	1,713.7	1199.59	3.82E-05	1.15E-05	4.06E-04	9.47E-04			4.00E-02		--	2.37E-02
Lead	NTV	--	--	--	--	--	--					--	--
Lithium	NC	5.8	4.067	1.30E-07	3.89E-08	1.38E-06	3.21E-06			2.0E-02		--	1.61E-04
Manganese	NC	407	285.11	9.08E-06	2.72E-06	9.65E-05	2.25E-04			2.4E-02	1.4E-05	--	9.38E-03
Mercury	NC	--	--	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	19.25	6.13E-07	1.84E-07	6.52E-06	1.52E-05		1.7E+00	2.0E-02		--	7.60E-04
Silver	NC	1.27	0.889	2.83E-08	8.50E-09	3.01E-07	7.02E-07			5.0E-03		--	1.40E-04
Strontium	NC	13	9.317	2.97E-07	8.90E-08	3.15E-06	7.36E-06			6.0E-01		--	1.23E-05
Zinc	NC	66	46.41	1.48E-06	4.44E-07	1.57E-05	3.67E-05			3.0E-01		--	1.22E-04
											TOTAL	**1.7E-07**	**4.2E-02**
Inhalation Intake = C indoor air x AIF x Efa / AT													
Aluminum	NC	11,791	8253.7	2.63E-04	7.89E-05	1.19E-05	2.77E-05			1.0E+00	1.4E-03	--	1.98E-02
Arsenic	C	1.6	1.1018	3.51E-08	1.05E-08	1.59E-09	3.70E-09	1.5E+00	1.5E+01	3.0E-04		2.39E-08	--
Beryllium	C	0.46	0.3213	1.02E-08	3.07E-09	4.63E-10	1.08E-09		8.4E+00	2.0E-03	5.7E-06	3.89E-09	1.89E-04
Chromium*	C	29.4	20.608	6.57E-07	1.97E-07	2.97E-08	6.93E-08		4.2E+01	3.0E-03	2.2E-06	1.25E-06	--
Cobalt	C	19.71	13.797	4.40E-07	1.32E-07	1.99E-08	4.64E-08		9.8E+00	2.00E-02	5.7E-06	1.95E-07	8.13E-03
Copper	NC	1,713.7	1199.59	3.82E-05	1.15E-05	1.73E-06	4.03E-06			4.00E-02		--	--
Lead	NTV	--	--	--	--	--	--					--	--
Lithium	NC	5.8	4.067	1.30E-07	3.89E-08	5.86E-09	1.37E-08			2.0E-02		--	--
Manganese	NC	407	285.11	9.08E-06	2.72E-06	4.11E-07	9.58E-07			2.4E-02	1.4E-05	--	6.84E-02
Mercury	NC	--	--	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	19.25	6.13E-07	1.84E-07	2.77E-08	6.47E-08		1.7E+00	2.0E-02		--	--
Silver	NC	1.27	0.889	2.83E-08	8.50E-09	1.28E-09	2.99E-09			5.0E-03		--	--
Strontium	NC	13	9.317	2.97E-07	8.90E-08	1.34E-08	3.13E-08			6.0E-01		--	--
Zinc	NC	66	46.41	1.48E-06	4.44E-07	6.68E-08	1.56E-07			3.0E-01		--	--
											TOTAL	**1.5E-06**	**9.7E-02**
										CUMULATIVE HAZARD INDICES		3E-06	2E-01

Parameter		Value	
IF-indoors	Indoor age-adjusted soil ingestion factor (mg-yr/kg-day)	89	based on MDEQ TSD #2
where: IF indoors = [(IR child x FI child x ED child)/BW child] + [(IR adult x FI adult x ED adult)/BW adult]			
DF	Age-adjusted soil dermal factor (mg-year/kg-day)	353	default residential, MDEQ TSD #2
			calculated residential, MDEQ TSD #6; divided by two to account for short term
PEF	Particulate Emission Factor (m3/kg)	4.48E+07	peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	10950	30 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10-6 kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$		chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default residential, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	245	default residential, MDEQ TSD #2
Efi	Ingestion exposure frequency (days/yr)	350	default residential, MDEQ TSD #2
Aed	Dermal absorption efficiency (unitless)	10%	default residential, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIF	Age-adjusted indoor inhalation rate (m3/yr)/(kg/day)	11	Region 9 PRG Table; EPA 2002
Efa	Inhalation exposure frequency (days/yr)	350	default residential, MDEQ TSD #2
IR child	Soil ingestion rate - child (mg/day)	200	default residential, MDEQ TSD #2
IR adult	Soil ingestion rate - adult (mg/day)	100	default residential, MDEQ TSD #2
BW child	Body weight - child (kg)	15	default residential, MDEQ TSD #2
BW adult	Body weight - adult (kg)	70	default residential, MDEQ TSD #2
ED child	Exposure duration - child (yrs)	6	default residential, MDEQ TSD #2
ED adult	Exposure duration - adult (yrs)	24	default residential, MDEQ TSD #2
FI child	Fraction of time indoors - child (unitless); based on 3 hrs outdoors per day and 12 waking hours, 9/12	0.75	CEFH; EPA 2001
FI adult	Fraction of time indoors -adult (unitless); based on 2 hrs outdoors per day and 12 waking hours, 10/12	0.83	EFH; EPA 1997
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration		Pro UCL, Version 3
Indoor Dust	70% of outdoor soil concentration		IEUBK Short Sheet; EPA 1998
Outdoor Air	Outdoor Soil x 1/PEF		default residential, MDEQ TSD #6
Indoor Air	30% of outdoor air concentration		IEUBK Users Guide; EPA 2002
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	8.97E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor (g/m^2-s per kg/m^3)	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion (g/m^2-s)	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic (g/m^2-s)	3.68E-07	default residential; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 2b
Indoor Dust Exposure and Risk Calculations
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration				Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Indoor Dust	Outdoor Air	Indoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/kg	mg/m^3	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C indoor dust x IF x AEi x EFi x CF / AT													
Aluminum	NC	15,872	11110.4	3.54E-04	1.06E-04	6.74E-03	1.57E-02			1.0E+00	1.4E-03	--	1.57E-02
Arsenic	C	2.65	1.855	5.91E-08	1.77E-08	1.13E-06	2.63E-06	1.5E+00	1.5E+01	3.0E-04		1.69E-06	8.75E-03
Beryllium	C	0.48	0.3388	1.08E-08	3.24E-09	2.06E-07	4.80E-07		8.4E+00	2.0E-03	5.7E-06	--	2.40E-04
Chromium*	C	29.5	20.622	6.57E-07	1.97E-07	1.25E-05	2.92E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	16.31	5.20E-07	1.56E-07	9.89E-06	2.31E-05		9.8E+00	2.00E-02	5.7E-06	--	1.15E-03
Copper	NC	2,972	2080.4	6.63E-05	1.99E-05	1.26E-03	2.94E-03			4.00E-02		--	7.36E-02
Lead	NC	2.6	1.813	5.78E-08	1.73E-08	1.10E-06	2.57E-06					--	--
Lithium	NC	6.2	4.368	1.39E-07	4.17E-08	2.65E-06	6.18E-06			2.0E-02		--	3.09E-04
Manganese	NC	549	384.02	1.22E-05	3.67E-06	2.33E-04	5.44E-04			2.4E-02	1.4E-05	--	2.26E-02
Mercury	NC	0.028	0.0196	6.24E-10	1.87E-10	1.19E-08	2.77E-08			3.0E-04		--	9.25E-05
Nickel**	NC	31.6	22.12	7.05E-07	2.11E-07	1.34E-05	3.13E-05		1.7E+00	2.0E-02		--	1.57E-03
Silver	NC	1.84	1.288	4.10E-08	1.23E-08	7.81E-07	1.82E-06			5.0E-03		--	3.65E-04
Strontium	NC	17.05	11.935	3.80E-07	1.14E-07	7.24E-06	1.69E-05			6.0E-01		--	2.82E-05
Zinc	NC	75.8	53.032	1.69E-06	5.07E-07	3.22E-05	7.51E-05			3.0E-01		--	2.50E-04
											TOTAL	**1.7E-06**	**1.2E-01**
Dermal Absorption = C indoor dust x DF x AEd x EFd x CF / AT													
Aluminum	NC	15,872	11110.4	3.54E-04	1.06E-04	3.76E-03	8.78E-03			1.0E+00	1.4E-03	--	8.78E-03
Arsenic	C	2.65	1.855	5.91E-08	1.77E-08	1.88E-07	4.40E-07	1.5E+00	1.5E+01	3.0E-04		2.83E-07	1.47E-03
Beryllium	C	0.48	0.3388	1.08E-08	3.24E-09	1.15E-07	2.68E-07		8.4E+00	2.0E-03	5.7E-06	--	1.34E-04
Chromium*	C	29.5	20.622	6.57E-07	1.97E-07	6.98E-06	1.63E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	16.31	5.20E-07	1.56E-07	5.52E-06	1.29E-05		9.8E+00	2.00E-02	5.7E-06	--	6.44E-04
Copper	NC	2,972	2080.4	6.63E-05	1.99E-05	7.04E-04	1.64E-03			4.00E-02		--	4.11E-02
Lead	NTV	2.6	1.813	5.78E-08	1.73E-08	6.14E-07	1.43E-06					--	--
Lithium	NC	6.2	4.368	1.39E-07	4.17E-08	1.48E-06	3.45E-06			2.0E-02		--	1.72E-04
Manganese	NC	549	384.02	1.22E-05	3.67E-06	1.30E-04	3.03E-04			2.4E-02	1.4E-05	--	1.26E-02
Mercury	NC	0.028	0.0196	6.24E-10	1.87E-10	6.63E-09	1.55E-08			3.0E-04		--	5.16E-05
Nickel**	NC	31.6	22.12	7.05E-07	2.11E-07	7.49E-06	1.75E-05		1.7E+00	2.0E-02		--	8.74E-04
Silver	NC	1.84	1.288	4.10E-08	1.23E-08	4.36E-07	1.02E-06			5.0E-03		--	2.03E-04
Strontium	NC	17.05	11.935	3.80E-07	1.14E-07	4.04E-06	9.43E-06			6.0E-01		--	1.57E-05
Zinc	NC	75.8	53.032	1.69E-06	5.07E-07	1.80E-05	4.19E-05			3.0E-01		--	1.40E-04
											TOTAL	**2.8E-07**	**6.6E-02**
Inhalation Intake = C indoor air x AIF x Efa / AT													
Aluminum	NC	15,872	11110.4	3.54E-04	1.06E-04	1.60E-05	3.73E-05			1.0E+00	1.4E-03	--	2.67E-02
Arsenic	C	2.65	1.855	5.91E-08	1.77E-08	2.67E-09	6.23E-09	1.5E+00	1.5E+01	3.0E-04		4.02E-08	--
Beryllium	C	0.48	0.3388	1.08E-08	3.24E-09	4.88E-10	1.14E-09		8.4E+00	2.0E-03	5.7E-06	4.10E-09	1.99E-04
Chromium*	C	29.5	20.622	6.57E-07	1.97E-07	2.97E-08	6.93E-08		4.2E+01	3.0E-03	2.2E-06	1.25E-06	--
Cobalt	C	23.3	16.31	5.20E-07	1.56E-07	2.35E-08	5.48E-08		9.8E+00	2.00E-02	5.7E-06	2.30E-07	9.62E-03
Copper	NC	2,972	2080.4	6.63E-05	1.99E-05	3.00E-06	6.99E-06			4.00E-02		--	--
Lead	NTV	2.6	1.813	5.78E-08	1.73E-08	2.61E-09	6.09E-09					--	--
Lithium	NC	6.2	4.368	1.39E-07	4.17E-08	6.29E-09	1.47E-08			2.0E-02		--	--
Manganese	NC	549	384.02	1.22E-05	3.67E-06	5.53E-07	1.29E-06			2.4E-02	1.4E-05	--	9.22E-02
Mercury	NC	0.028	0.0196	6.24E-10	1.87E-10	2.82E-11	6.59E-11			3.0E-04		--	--
Nickel**	NC	31.6	22.12	7.05E-07	2.11E-07	3.19E-08	7.43E-08		1.7E+00	2.0E-02		--	--
Silver	NC	1.84	1.288	4.10E-08	1.23E-08	1.85E-09	4.33E-09			5.0E-03		--	--
Strontium	NC	17.05	11.935	3.80E-07	1.14E-07	1.72E-08	4.01E-08			6.0E-01		--	--
Zinc	NC	75.8	53.032	1.69E-06	5.07E-07	7.64E-08	1.78E-07			3.0E-01		--	--
											TOTAL	**1.5E-06**	**1.3E-01**
											CUMULATIVE HAZARD INDICES	3E-06	3E-01

Parameter		Value	
IF-indoors	Indoor age-adjusted soil ingestion factor (mg-yr/kg-day)	89	based on MDEQ TSD #2
where: IF indoors = [(IR child x FI child x ED child)/BW child] + [(IR adult x FI adult x ED adult)/BW adult]			
DF	Age-adjusted soil dermal factor (mg-year/kg-day)	353	default residential, MDEQ TSD #2
			calculated residential, MDEQ TSD #6; divided by two to account for short term
PEF	Particulate Emission Factor (m3/kg)	4.48E+07	peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	10950	30 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10-6 kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$		chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default residential, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	245	default residential, MDEQ TSD #2
Efi	Ingestion exposure frequency (days/yr)	350	default residential, MDEQ TSD #2
Aed	Dermal absorption efficiency (unitless)	10%	default residential, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIF	Age-adjusted indoor inhalation rate (m3/yr)/(kg/day)	11	Region 9 PRG Table; EPA 2002
Efa	Inhalation exposure frequency (days/yr)	350	default residential, MDEQ TSD #2
IR child	Soil ingestion rate - child (mg/day)	200	default residential, MDEQ TSD #2
IR adult	Soil ingestion rate - adult (mg/day)	100	default residential, MDEQ TSD #2
BW child	Body weight - child (kg)	15	default residential, MDEQ TSD #2
BW adult	Body weight - adult (kg)	70	default residential, MDEQ TSD #2
ED child	Exposure duration - child (yrs)	6	default residential, MDEQ TSD #2
ED adult	Exposure duration - adult (yrs)	24	default residential, MDEQ TSD #2
FI child	Fraction of time indoors - child (unitless); based on 3 hrs outdoors per day and 12 waking hours, 9/12	0.75	CEFH; EPA 2001
FI adult	Fraction of time indoors -adult (unitless); based on 2 hrs outdoors per day and 12 waking hours, 10/12	0.83	EFH; EPA 1997
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration		Pro UCL, Version 3
Indoor Dust	70% of outdoor soil concentration		IEUBK Short Sheet; EPA 1998
Outdoor Air	Outdoor Soil x 1/PEF		default residential, MDEQ TSD #6
Indoor Air	30% of outdoor air concentration		IEUBK Users Guide; EPA 2002
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	8.97E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor $(g/m^2\text{-}s$ per $kg/m^3)$	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion $(g/m^2\text{-}s)$	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic $(g/m^2\text{-}s)$	3.68E-07	default residential; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 3a
Outdoor Dust Exposure and Risk Calculations
Gay Southern Area Deposit 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration		Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Outdoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C outdoor soil x IF x AEi x EFi x CF / AT											
Aluminum	NC	11,791	2.63E-04	9.21E-03	2.15E-02			1.0E+00	1.4E-03	--	2.15E-02
Arsenic	C	1.6	3.51E-08	1.23E-06	2.87E-06	1.5E+00	1.5E+01	3.0E-04		1.84E-06	9.56E-03
Beryllium	C	0.46	1.02E-08	3.58E-07	8.36E-07		8.4E+00	2.0E-03	5.7E-06	--	4.18E-04
Chromium*	C	29.4	6.57E-07	2.30E-05	5.36E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	4.40E-07	1.54E-05	3.59E-05		9.8E+00	2.00E-02	5.7E-06	--	1.80E-03
Copper	NC	1,713.7	3.82E-05	1.34E-03	3.12E-03			4.00E-02		--	7.81E-02
Lead	NC	--	--	--	--					--	--
Lithium	NC	5.8	1.30E-07	4.54E-06	1.06E-05			2.0E-02		--	5.29E-04
Manganese	NC	407	9.08E-06	3.18E-04	7.42E-04			2.4E-02	1.4E-05	--	3.09E-02
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	6.13E-07	2.15E-05	5.01E-05		1.7E+00	2.0E-02		--	2.51E-03
Silver	NC	1.27	2.83E-08	9.92E-07	2.31E-06			5.0E-03		--	4.63E-04
Strontium	NC	13	2.97E-07	1.04E-05	2.42E-05			6.0E-01		--	4.04E-05
Zinc	NC	66	1.48E-06	5.18E-05	1.21E-04			3.0E-01		--	4.03E-04
									TOTAL	**1.8E-06**	**1.5E-01**
Dermal Absorption = C outdoor soil x DF x AEd x EFd x CF / AT											
Aluminum	NC	11,791	2.63E-04	3.99E-03	9.31E-03			1.0E+00	1.4E-03	--	9.31E-03
Arsenic	C	1.6	3.51E-08	1.60E-07	3.73E-07	1.5E+00	1.5E+01	3.0E-04		2.40E-07	1.24E-03
Beryllium	C	0.46	1.02E-08	1.55E-07	3.63E-07		8.4E+00	2.0E-03	5.7E-06	--	1.81E-04
Chromium*	C	29.4	6.57E-07	9.97E-06	2.33E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	4.40E-07	6.67E-06	1.56E-05		9.8E+00	2.00E-02	5.7E-06	--	7.78E-04
Copper	NC	1,713.7	3.82E-05	5.80E-04	1.35E-03			4.00E-02		--	3.38E-02
Lead	NTV	--	--	--	--					--	--
Lithium	NC	5.8	1.30E-07	1.97E-06	4.59E-06			2.0E-02		--	2.29E-04
Manganese	NC	407	9.08E-06	1.38E-04	3.22E-04			2.4E-02	1.4E-05	--	1.34E-02
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	6.13E-07	9.31E-06	2.17E-05		1.7E+00	2.0E-02		--	1.09E-03
Silver	NC	1.27	2.83E-08	4.30E-07	1.00E-06			5.0E-03		--	2.01E-04
Strontium	NC	13	2.97E-07	4.51E-06	1.05E-05			6.0E-01		--	1.75E-05
Zinc	NC	66	1.48E-06	2.24E-05	5.24E-05			3.0E-01		--	1.75E-04
									TOTAL	**2.4E-07**	**6.0E-02**
Inhalation Intake = C outdoor air x AIF x Efa / AT											
Aluminum	NC	11,791	2.63E-04	3.96E-05	9.25E-05			1.0E+00	1.4E-03	--	6.60E-02
Arsenic	C	1.6	3.51E-08	5.29E-09	1.23E-08	1.5E+00	1.5E+01	3.0E-04		7.96E-08	--
Beryllium	C	0.46	1.02E-08	1.54E-09	3.60E-09		8.4E+00	2.0E-03	5.7E-06	1.30E-08	6.30E-04
Chromium*	C	29.4	6.57E-07	9.89E-08	2.31E-07		4.2E+01	3.0E-03	2.2E-06	4.16E-06	--
Cobalt	C	19.71	4.40E-07	6.62E-08	1.55E-07		9.8E+00	2.00E-02	5.7E-06	6.49E-07	2.71E-02
Copper	NC	1,713.7	3.82E-05	5.76E-06	1.34E-05			4.00E-02		--	--
Lead	NTV	--	--	--	--					--	--
Lithium	NC	5.8	1.30E-07	1.95E-08	4.56E-08			2.0E-02		--	--
Manganese	NC	407	9.08E-06	1.37E-06	3.19E-06			2.4E-02	1.4E-05	--	2.28E-01
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	6.13E-07	9.24E-08	2.16E-07		1.7E+00	2.0E-02		--	--
Silver	NC	1.27	2.83E-08	4.27E-09	9.96E-09			5.0E-03		--	--
Strontium	NC	13	2.97E-07	4.47E-08	1.04E-07			6.0E-01		--	--
Zinc	NC	66	1.48E-06	2.23E-07	5.20E-07			3.0E-01		--	--
									TOTAL	**4.9E-06**	**3.2E-01**
								CUMULATIVE HAZARD INDICES		7E-06	5E-01

Parameter		Value	
IF	Age-adjusted soil ingestion factor (mg-yr/kg-day)	114	based on MDEQ TSD #2
DF	Age-adjusted soil dermal factor (mg-year/kg-day)	353	default residential, MDEQ TSD #2
			calculated residential, MDEQ TSD #6; divided by two to account for short term
PEF	Particulate Emission Factor (m3/kg)	4.48E+07	peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	10950	30 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10-6 kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$		chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default residential, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	245	default residential, MDEQ TSD #2
Efi	Ingestion exposure frequency (days/yr)	350	default residential, MDEQ TSD #2
Aed	Dermal absorption efficiency (unitless)	10%	default residential, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIF	Age-adjusted inhalation rate (m3/yr)/(kg/day)	11	Region 9 PRG Table; EPA 2002
Efa	Inhalation exposure frequency (days/yr)	350	default residential, MDEQ TSD #2
IR child	Soil ingestion rate - child (mg/day)	200	default residential, MDEQ TSD #2
IR adult	Soil ingestion rate - adult (mg/day)	100	default residential, MDEQ TSD #2
BW child	Body weight - child (kg)	15	default residential, MDEQ TSD #2
BW adult	Body weight - adult (kg)	70	default residential, MDEQ TSD #2
ED child	Exposure duration - child (yrs)	6	default residential, MDEQ TSD #2
ED adult	Exposure duration - adult (yrs)	24	default residential, MDEQ TSD #2
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration		Pro UCL, Version 3
Outdoor Air	Outdoor Soil x 1/PEF		default residential, MDEQ TSD #6
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	8.97E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor $(g/m^2\text{-s per } kg/m^3)$	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion $(g/m^2\text{-s})$	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic $(g/m^2\text{-s})$	3.68E-07	default residential; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 3b
Outdoor Dust Exposure and Risk Calculations
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration		Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Outdoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C outdoor soil x IF x AEi x EFi x CF / AT											
Aluminum	NC	15,872	3.54E-04	1.24E-02	2.89E-02			1.0E+00	1.4E-03	--	2.89E-02
Arsenic	C	2.65	5.91E-08	2.07E-06	4.83E-06	1.5E+00	1.5E+01	3.0E-04		3.10E-06	1.61E-02
Beryllium	C	0.48	1.08E-08	3.78E-07	8.82E-07		8.4E+00	2.0E-03	5.7E-06	--	4.41E-04
Chromium*	C	29.5	6.57E-07	2.30E-05	5.37E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	5.20E-07	1.82E-05	4.25E-05		9.8E+00	2.00E-02	5.7E-06	--	2.12E-03
Copper	NC	2,972	6.63E-05	2.32E-03	5.41E-03			4.00E-02		--	1.35E-01
Lead	NC	2.6	5.78E-08	2.02E-06	4.72E-06					--	--
Lithium	NC	6.2	1.39E-07	4.87E-06	1.14E-05			2.0E-02		--	5.68E-04
Manganese	NC	549	1.22E-05	4.28E-04	1.00E-03			2.4E-02	1.4E-05	--	4.16E-02
Mercury	NC	0.028	6.24E-10	2.19E-08	5.10E-08			3.0E-04		--	1.70E-04
Nickel**	NC	31.6	7.05E-07	2.47E-05	5.76E-05		1.7E+00	2.0E-02		--	2.88E-03
Silver	NC	1.84	4.10E-08	1.44E-06	3.35E-06			5.0E-03		--	6.70E-04
Strontium	NC	17.05	3.80E-07	1.33E-05	3.11E-05			6.0E-01		--	5.18E-05
Zinc	NC	75.8	1.69E-06	5.92E-05	1.38E-04			3.0E-01		--	4.60E-04
									TOTAL	**3.1E-06**	**2.3E-01**
Dermal Absorption = C outdoor soil x DF x AEd x EFd x CF / AT											
Aluminum	NC	15,872	3.54E-04	5.37E-03	1.25E-02			1.0E+00	1.4E-03	--	1.25E-02
Arsenic	C	2.65	5.91E-08	2.69E-07	6.28E-07	1.5E+00	1.5E+01	3.0E-04		4.04E-07	2.09E-03
Beryllium	C	0.48	1.08E-08	1.64E-07	3.82E-07		8.4E+00	2.0E-03	5.7E-06	--	1.91E-04
Chromium*	C	29.5	6.57E-07	9.97E-06	2.33E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	5.20E-07	7.89E-06	1.84E-05		9.8E+00	2.00E-02	5.7E-06	--	9.20E-04
Copper	NC	2,972	6.63E-05	1.01E-03	2.35E-03			4.00E-02		--	5.87E-02
Lead	NTV	2.6	5.78E-08	8.77E-07	2.05E-06					--	--
Lithium	NC	6.2	1.39E-07	2.11E-06	4.93E-06			2.0E-02		--	2.46E-04
Manganese	NC	549	1.22E-05	1.86E-04	4.33E-04			2.4E-02	1.4E-05	--	1.81E-02
Mercury	NC	0.028	6.24E-10	9.48E-09	2.21E-08			3.0E-04		--	7.37E-05
Nickel**	NC	31.6	7.05E-07	1.07E-05	2.50E-05		1.7E+00	2.0E-02		--	1.25E-03
Silver	NC	1.84	4.10E-08	6.23E-07	1.45E-06			5.0E-03		--	2.91E-04
Strontium	NC	17.05	3.80E-07	5.77E-06	1.35E-05			6.0E-01		--	2.24E-05
Zinc	NC	75.8	1.69E-06	2.56E-05	5.98E-05			3.0E-01		--	1.99E-04
									TOTAL	**4.0E-07**	**9.5E-02**
Inhalation Intake = C outdoor air x AIF x Efa / AT											
Aluminum	NC	15,872	3.54E-04	5.33E-05	1.24E-04			1.0E+00	1.4E-03	--	8.89E-02
Arsenic	C	2.65	5.91E-08	8.90E-09	2.08E-08	1.5E+00	1.5E+01	3.0E-04		1.34E-07	--
Beryllium	C	0.48	1.08E-08	1.63E-09	3.79E-09		8.4E+00	2.0E-03	5.7E-06	1.37E-08	6.65E-04
Chromium*	C	29.5	6.57E-07	9.90E-08	2.31E-07		4.2E+01	3.0E-03	2.2E-06	4.16E-06	--
Cobalt	C	23.3	5.20E-07	7.83E-08	1.83E-07		9.8E+00	2.00E-02	5.7E-06	7.67E-07	3.21E-02
Copper	NC	2,972	6.63E-05	9.99E-06	2.33E-05			4.00E-02		--	--
Lead	NTV	2.6	5.78E-08	8.70E-09	2.03E-08					--	--
Lithium	NC	6.2	1.39E-07	2.10E-08	4.89E-08			2.0E-02		--	--
Manganese	NC	549	1.22E-05	1.84E-06	4.30E-06			2.4E-02	1.4E-05	--	3.07E-01
Mercury	NC	0.028	6.24E-10	9.41E-11	2.20E-10			3.0E-04		--	--
Nickel**	NC	31.6	7.05E-07	1.06E-07	2.48E-07		1.7E+00	2.0E-02		--	--
Silver	NC	1.84	4.10E-08	6.18E-09	1.44E-08			5.0E-03		--	--
Strontium	NC	17.05	3.80E-07	5.73E-08	1.34E-07			6.0E-01		--	--
Zinc	NC	75.8	1.69E-06	2.55E-07	5.94E-07			3.0E-01		--	--
									TOTAL	**5.1E-06**	**4.3E-01**
								CUMULATIVE HAZARD INDICES		9E-06	8E-01

Parameter		Value	
IF	Age-adjusted soil ingestion factor (mg-yr/kg-day)	114	based on MDEQ TSD #2
DF	Age-adjusted soil dermal factor (mg-year/kg-day)	353	default residential, MDEQ TSD #2
			calculated residential, MDEQ TSD #6; divided by two to account for short term
PEF	Particulate Emission Factor (m3/kg)	4.48E+07	peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	10950	30 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10-6 kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$		chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default residential, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	245	default residential, MDEQ TSD #2
Efi	Ingestion exposure frequency (days/yr)	350	default residential, MDEQ TSD #2
Aed	Dermal absorption efficiency (unitless)	10%	default residential, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIF	Age-adjusted inhalation rate (m3/yr)/(kg/day)	11	Region 9 PRG Table; EPA 2002
Efa	Inhalation exposure frequency (days/yr)	350	default residential, MDEQ TSD #2
IR child	Soil ingestion rate - child (mg/day)	200	default residential, MDEQ TSD #2
IR adult	Soil ingestion rate - adult (mg/day)	100	default residential, MDEQ TSD #2
BW child	Body weight - child (kg)	15	default residential, MDEQ TSD #2
BW adult	Body weight - adult (kg)	70	default residential, MDEQ TSD #2
ED child	Exposure duration - child (yrs)	6	default residential, MDEQ TSD #2
ED adult	Exposure duration - adult (yrs)	24	default residential, MDEQ TSD #2
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration	--	chemical-specific; Pro UCL, Version 3
Outdoor Air	Outdoor Soil x 1/PEF	--	chemical-specific; calculated residential PEF, MDEQ TSD #6
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	8.97E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor $(g/m^2\text{-}s$ per $kg/m^3)$	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion $(g/m^2\text{-}s)$	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic $(g/m^2\text{-}s)$	3.68E-07	default residential; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 4a
Recreational Exposure and Risk Calculations: Adult
Gay Southern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration		Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Outdoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C outdoor soil x IR x AEi x EFi x ED x CF / AT x BW											
Aluminum	NC	11,791	6.76E-04	5.14E-04	1.20E-03			1.0E+00	1.4E-03	--	1.20E-03
Arsenic	C	1.6	9.02E-08	6.86E-08	1.60E-07	1.5E+00	1.5E+01	3.0E-04		1.03E-07	5.34E-04
Beryllium	C	0.46	2.63E-08	2.00E-08	4.67E-08		8.4E+00	2.0E-03	5.7E-06	--	2.34E-05
Chromium*	C	29.4	1.69E-06	1.28E-06	3.00E-06		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	1.13E-06	8.60E-07	2.01E-06		9.8E+00	2.00E-02	5.7E-06	--	1.00E-04
Copper	NC	1,713.7	9.82E-05	7.47E-05	1.74E-04			4.00E-02		--	4.36E-03
Lead	NC	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	2.53E-07	5.91E-07			2.0E-02		--	2.96E-05
Manganese	NC	407	2.34E-05	1.78E-05	4.14E-05			2.4E-02	1.4E-05	--	1.73E-03
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	1.20E-06	2.80E-06		1.7E+00	2.0E-02		--	1.40E-04
Silver	NC	1.27	7.28E-08	5.54E-08	1.29E-07			5.0E-03		--	2.58E-05
Strontium	NC	13	7.63E-07	5.80E-07	1.35E-06			6.0E-01		--	2.26E-06
Zinc	NC	66	3.80E-06	2.89E-06	6.75E-06			3.0E-01		--	2.25E-05
									TOTAL	**1.0E-07**	**8.2E-03**
Dermal Absorption = C outdoor soil x SA x AF x AEd x EFd x CF / AT x BW											
Aluminum	NC	11,791	6.76E-04	4.18E-04	9.74E-04			1.0E+00	1.4E-03	--	9.74E-04
Arsenic	C	1.6	9.02E-08	1.67E-08	3.90E-08	1.5E+00	1.5E+01	3.0E-04		2.51E-08	1.30E-04
Beryllium	C	0.46	2.63E-08	1.63E-08	3.79E-08		8.4E+00	2.0E-03	5.7E-06	--	1.90E-05
Chromium*	C	29.4	1.69E-06	1.04E-06	2.43E-06		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	1.13E-06	6.98E-07	1.63E-06		9.8E+00	2.00E-02	5.7E-06	--	8.14E-05
Copper	NC	1,713.7	9.82E-05	6.07E-05	1.42E-04			4.00E-02		--	3.54E-03
Lead	NTV	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	2.06E-07	4.80E-07			2.0E-02		--	2.40E-05
Manganese	NC	407	2.34E-05	1.44E-05	3.37E-05			2.4E-02	1.4E-05	--	1.40E-03
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	9.74E-07	2.27E-06		1.7E+00	2.0E-02		--	1.14E-04
Silver	NC	1.27	7.28E-08	4.50E-08	1.05E-07			5.0E-03		--	2.10E-05
Strontium	NC	13	7.63E-07	4.71E-07	1.10E-06			6.0E-01		--	1.83E-06
Zinc	NC	66	3.80E-06	2.35E-06	5.48E-06			3.0E-01		--	1.83E-05
									TOTAL	**2.5E-08**	**6.3E-03**
Inhalation Intake = C outdoor air x AIR x EFa x EDa / AT x BW											
Aluminum	NC	11,791	6.76E-04	1.18E-05	2.75E-05			1.0E+00	1.4E-03	--	1.97E-02
Arsenic	C	1.6	9.02E-08	1.57E-09	3.67E-09	1.5E+00	1.5E+01	3.0E-04		2.37E-08	--
Beryllium	C	0.46	2.63E-08	4.59E-10	1.07E-09		8.4E+00	2.0E-03	5.7E-06	3.86E-09	1.88E-04
Chromium*	C	29.4	1.69E-06	2.94E-08	6.87E-08		4.2E+01	3.0E-03	2.2E-06	1.24E-06	--
Cobalt	C	19.71	1.13E-06	1.97E-08	4.60E-08		9.8E+00	2.00E-02	5.7E-06	1.93E-07	8.07E-03
Copper	NC	1,713.7	9.82E-05	1.71E-06	4.00E-06			4.00E-02		--	--
Lead	NTV	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	5.81E-09	1.36E-08			2.0E-02		--	--
Manganese	NC	407	2.34E-05	4.07E-07	9.50E-07			2.4E-02	1.4E-05	--	6.79E-02
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	2.75E-08	6.42E-08		1.7E+00	2.0E-02		--	--
Silver	NC	1.27	7.28E-08	1.27E-09	2.96E-09			5.0E-03		--	--
Strontium	NC	13	7.63E-07	1.33E-08	3.11E-08			6.0E-01		--	--
Zinc	NC	66	3.80E-06	6.63E-08	1.55E-07			3.0E-01		--	--
									TOTAL	**1.5E-06**	**9.6E-02**
									CUMULATIVE HAZARD INDICES	2E-06	1E-01

Parameter		Value	
IR	Adult soil ingestion rate (mg/day)	100	default residential, MDEQ TSD #2
SA	Adult surface area	5800	default residential, MDEQ TSD #2
			calculated based on MDEQ TSD #6; divided by two to account for short term
PEF	Particulate Emission Factor (m^3/kg)	1.74E+07	peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	10950	10 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10^{-6} kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$	--	chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default residential, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Efi	Ingestion exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Aed	Dermal absorption efficiency (unitless)	10%	default residential, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIR	Adult inhalation rate (m^3/day)	20	default residential, MDEQ TSD #2
Efa	Inhalation exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
BWa	Adult body weight (kg)	70	default residential, MDEQ TSD #2
EDa	Exposure duration (yrs)	30	default residential, MDEQ TSD #2
AF	Adherance factor (mg/cm^2)	0.07	default residential, MDEQ TSD #2
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration	--	chemical-specific; Pro UCL, Version 3
Outdoor Air	Outdoor Soil x 1/PEF	--	chemical-specific; default residential PEF, MDEQ TSD #6
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	3.49E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor (g/m^2-s per kg/m^3)	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion (g/m^2-s)	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic (g/m^2-s)	1.81E-06	defaul commercial/industrial; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 4b
Recreational Exposure and Risk Calculations: Adult
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration		Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Outdoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C outdoor soil x IR x AEi x EFi x ED x CF / AT x BW											
Aluminum	NC	15,872	9.10E-04	6.92E-04	1.62E-03			1.0E+00	1.4E-03	--	1.62E-03
Arsenic	C	2.65	1.52E-07	1.16E-07	2.70E-07	1.5E+00	1.5E+01	3.0E-04		1.73E-07	8.99E-04
Beryllium	C	0.48	2.77E-08	2.11E-08	4.93E-08		8.4E+00	2.0E-03	5.7E-06	--	2.46E-05
Chromium*	C	29.5	1.69E-06	1.28E-06	3.00E-06		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	1.34E-06	1.02E-06	2.37E-06		9.8E+00	2.00E-02	5.7E-06	--	1.19E-04
Copper	NC	2,972	1.70E-04	1.30E-04	3.02E-04			4.00E-02		--	7.56E-03
Lead	NC	2.6	1.48E-07	1.13E-07	2.64E-07					--	--
Lithium	NC	6.2	3.58E-07	2.72E-07	6.35E-07			2.0E-02		--	3.17E-05
Manganese	NC	549	3.15E-05	2.39E-05	5.58E-05			2.4E-02	1.4E-05	--	2.33E-03
Mercury	NC	0.028	1.61E-09	1.22E-09	2.85E-09			3.0E-04		--	9.50E-06
Nickel**	NC	31.6	1.81E-06	1.38E-06	3.22E-06		1.7E+00	2.0E-02		--	1.61E-04
Silver	NC	1.84	1.05E-07	8.02E-08	1.87E-07			5.0E-03		--	3.74E-05
Strontium	NC	17.05	9.77E-07	7.44E-07	1.74E-06			6.0E-01		--	2.89E-06
Zinc	NC	75.8	4.34E-06	3.30E-06	7.71E-06			3.0E-01		--	2.57E-05
									TOTAL	**1.7E-07**	**1.3E-02**
Dermal Absorption = C outdoor soil x SA x AF x AEd x EFd x CF / AT x BW											
Aluminum	NC	15,872	9.10E-04	5.62E-04	1.31E-03			1.0E+00	1.4E-03	--	1.31E-03
Arsenic	C	2.65	1.52E-07	2.82E-08	6.57E-08	1.5E+00	1.5E+01	3.0E-04		4.22E-08	2.19E-04
Beryllium	C	0.48	2.77E-08	1.71E-08	4.00E-08		8.4E+00	2.0E-03	5.7E-06	--	2.00E-05
Chromium*	C	29.5	1.69E-06	1.04E-06	2.43E-06		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	1.34E-06	8.25E-07	1.93E-06		9.8E+00	2.00E-02	5.7E-06	--	9.63E-05
Copper	NC	2,972	1.70E-04	1.05E-04	2.46E-04			4.00E-02		--	6.14E-03
Lead	NTV	2.6	1.48E-07	9.17E-08	2.14E-07					--	--
Lithium	NC	6.2	3.58E-07	2.21E-07	5.16E-07			2.0E-02		--	2.58E-05
Manganese	NC	549	3.15E-05	1.94E-05	4.53E-05			2.4E-02	1.4E-05	--	1.89E-03
Mercury	NC	0.028	1.61E-09	9.92E-10	2.31E-09			3.0E-04		--	7.71E-06
Nickel**	NC	31.6	1.81E-06	1.12E-06	2.61E-06		1.7E+00	2.0E-02		--	1.31E-04
Silver	NC	1.84	1.05E-07	6.52E-08	1.52E-07			5.0E-03		--	3.04E-05
Strontium	NC	17.05	9.77E-07	6.04E-07	1.41E-06			6.0E-01		--	2.35E-06
Zinc	NC	75.8	4.34E-06	2.68E-06	6.26E-06			3.0E-01		--	2.09E-05
									TOTAL	**4.2E-08**	**9.9E-03**
Inhalation Intake = C outdoor air x AIR x EFa x EDa / AT x BW											
Aluminum	NC	15,872	9.10E-04	1.59E-05	3.70E-05			1.0E+00	1.4E-03	--	2.65E-02
Arsenic	C	2.65	1.52E-07	2.65E-09	6.18E-09	1.5E+00	1.5E+01	3.0E-04		3.99E-08	--
Beryllium	C	0.48	2.77E-08	4.84E-10	1.13E-09		8.4E+00	2.0E-03	5.7E-06	4.07E-09	1.98E-04
Chromium*	C	29.5	1.69E-06	2.95E-08	6.87E-08		4.2E+01	3.0E-03	2.2E-06	1.24E-06	--
Cobalt	C	23.3	1.34E-06	2.33E-08	5.44E-08		9.8E+00	2.00E-02	5.7E-06	2.28E-07	9.54E-03
Copper	NC	2,972	1.70E-04	2.97E-06	6.94E-06			4.00E-02		--	--
Lead	NTV	2.6	1.48E-07	2.59E-09	6.04E-09					--	--
Lithium	NC	6.2	3.58E-07	6.24E-09	1.46E-08			2.0E-02		--	--
Manganese	NC	549	3.15E-05	5.49E-07	1.28E-06			2.4E-02	1.4E-05	--	9.14E-02
Mercury	NC	0.028	1.61E-09	2.80E-11	6.53E-11			3.0E-04		--	--
Nickel**	NC	31.6	1.81E-06	3.16E-08	7.37E-08		1.7E+00	2.0E-02		--	--
Silver	NC	1.84	1.05E-07	1.84E-09	4.29E-09			5.0E-03		--	--
Strontium	NC	17.05	9.77E-07	1.71E-08	3.98E-08			6.0E-01		--	--
Zinc	NC	75.8	4.34E-06	7.58E-08	1.77E-07			3.0E-01		--	--
									TOTAL	**1.5E-06**	**1.3E-01**
								CUMULATIVE HAZARD INDICES		2E-06	2E-01

Parameter		Value	
IR	Adult soil ingestion rate (mg/day)	100	default residential, MDEQ TSD #2
SA	Adult surface area	5800	default residential, MDEQ TSD #2
			calculated based on MDEQ TSD #6; divided by two to account for short term
PEF	Particulate Emission Factor (m^3/kg)	1.74E+07	peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	10950	10 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10^{-6} kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$	--	chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default residential, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Efi	Ingestion exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Aed	Dermal absorption efficiency (unitless)	10%	default residential, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIR	Adult inhalation rate (m^3/day)	20	default residential, MDEQ TSD #2
Efa	Inhalation exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
BWa	Adult body weight (kg)	70	default residential, MDEQ TSD #2
EDa	Exposure duration (yrs)	30	default residential, MDEQ TSD #2
AF	Adherance factor (mg/cm^2)	0.07	default residential, MDEQ TSD #2
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration	--	chemical-specific; Pro UCL, Version 3
Outdoor Air	Outdoor Soil x 1/PEF	--	chemical-specific; default residential PEF, MDEQ TSD #6
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	3.49E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor (g/m^2-s per kg/m^3)	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion (g/m^2-s)	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic (g/m^2-s)	1.81E-06	defaul commercial/industrial; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 5a
Recreational Exposure and Risk Calculations: Child
Gay Southern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration		Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Outdoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C outdoor soil x IF x AEi x EFi x CF / AT											
Aluminum	NC	11,791	6.76E-04	8.88E-04	6.22E-03			1.0E+00	1.4E-03	--	6.22E-03
Arsenic	C	1.6	9.02E-08	1.19E-07	8.30E-07	1.5E+00	1.5E+01	3.0E-04		1.78E-07	2.77E-03
Beryllium	C	0.46	2.63E-08	3.46E-08	2.42E-07		8.4E+00	2.0E-03	5.7E-06	--	1.21E-04
Chromium*	C	29.4	1.69E-06	2.22E-06	1.55E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	1.13E-06	1.48E-06	1.04E-05		9.8E+00	2.00E-02	5.7E-06	--	5.19E-04
Copper	NC	1,713.7	9.82E-05	1.29E-04	9.03E-04			4.00E-02		--	2.26E-02
Lead	NC	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	4.38E-07	3.06E-06			2.0E-02		--	1.53E-04
Manganese	NC	407	2.34E-05	3.07E-05	2.15E-04			2.4E-02	1.4E-05	--	8.95E-03
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	2.07E-06	1.45E-05		1.7E+00	2.0E-02		--	7.25E-04
Silver	NC	1.27	7.28E-08	9.56E-08	6.69E-07			5.0E-03		--	1.34E-04
Strontium	NC	13	7.63E-07	1.00E-06	7.02E-06			6.0E-01		--	1.17E-05
Zinc	NC	66	3.80E-06	4.99E-06	3.49E-05			3.0E-01		--	1.16E-04
									TOTAL	**1.8E-07**	**4.2E-02**
Dermal Absorption = C outdoor soil x DF x AEd x EFd x CF / AT											
Aluminum	NC	11,791	6.76E-04	7.44E-04	5.21E-03			1.0E+00	1.4E-03	--	5.21E-03
Arsenic	C	1.6	9.02E-08	2.98E-08	2.09E-07	1.5E+00	1.5E+01	3.0E-04		4.47E-08	6.95E-04
Beryllium	C	0.46	2.63E-08	2.90E-08	2.03E-07		8.4E+00	2.0E-03	5.7E-06	--	1.01E-04
Chromium*	C	29.4	1.69E-06	1.86E-06	1.30E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	1.13E-06	1.24E-06	8.70E-06		9.8E+00	2.00E-02	5.7E-06	--	4.35E-04
Copper	NC	1,713.7	9.82E-05	1.08E-04	7.57E-04			4.00E-02		--	1.89E-02
Lead	NTV	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	3.67E-07	2.57E-06			2.0E-02		--	1.28E-04
Manganese	NC	407	2.34E-05	2.57E-05	1.80E-04			2.4E-02	1.4E-05	--	7.50E-03
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	1.74E-06	1.21E-05		1.7E+00	2.0E-02		--	6.07E-04
Silver	NC	1.27	7.28E-08	8.01E-08	5.61E-07			5.0E-03		--	1.12E-04
Strontium	NC	13	7.63E-07	8.40E-07	5.88E-06			6.0E-01		--	9.80E-06
Zinc	NC	66	3.80E-06	4.18E-06	2.93E-05			3.0E-01		--	9.76E-05
									TOTAL	**4.5E-08**	**3.4E-02**
Inhalation Intake = C outdoor air x AIF x Efa / AT											
Aluminum	NC	11,791	6.76E-04	5.09E-06	3.56E-05			1.0E+00	1.4E-03	--	2.55E-02
Arsenic	C	1.6	9.02E-08	6.80E-10	4.76E-09	1.5E+00	1.5E+01	3.0E-04		1.02E-08	--
Beryllium	C	0.46	2.63E-08	1.98E-10	1.39E-09		8.4E+00	2.0E-03	5.7E-06	1.66E-09	2.43E-04
Chromium*	C	29.4	1.69E-06	1.27E-08	8.90E-08		4.2E+01	3.0E-03	2.2E-06	5.34E-07	--
Cobalt	C	19.71	1.13E-06	8.51E-09	5.96E-08		9.8E+00	2.00E-02	5.7E-06	8.34E-08	1.04E-02
Copper	NC	1,713.7	9.82E-05	7.40E-07	5.18E-06			4.00E-02		--	--
Lead	NTV	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	2.51E-09	1.76E-08			2.0E-02		--	--
Manganese	NC	407	2.34E-05	1.76E-07	1.23E-06			2.4E-02	1.4E-05	--	8.79E-02
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	1.19E-08	8.31E-08		1.7E+00	2.0E-02		--	--
Silver	NC	1.27	7.28E-08	5.48E-10	3.84E-09			5.0E-03		--	--
Strontium	NC	13	7.63E-07	5.75E-09	4.02E-08			6.0E-01		--	--
Zinc	NC	66	3.80E-06	2.86E-08	2.00E-07			3.0E-01		--	--
									TOTAL	**6.3E-07**	**1.2E-01**
									CUMULATIVE HAZARD INDICES	9E-07	2E-01

Parameter		Value	
IF	Age-adjusted soil ingestion factor (mg-yr/kg-day)	74	Based on 2 - 12 year old children, where: IF = (200 mg/day x 10 yrs) / 27 kg
DF	Age-adjusted soil dermal factor (mg-year/kg-day)	310	Based on 2 - 12 year old children, where: DF = (4190 cm^3 x 1 event/day x 0.2 mg/cm^2 x 10 yrs) / 27 kg calculated based on MDEQ TSD #6; divided by two to account for short term
PEF	Particulate Emission Factor (m^3/kg)	1.74E+07	peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	3650	10 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10^{-6} kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$	--	chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default residential, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Efi	Ingestion exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Aed	Dermal absorption efficiency (unitless)	10%	default residential, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIF	Age-adjusted inhalation rate $(m^3/yr)/(kg/day)$	3.7	Based on 2 - 12 year old children; where: AIF = (10 m^3/day x 10 yrs)/ 27 kg
Efa	Inhalation exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration	--	chemical-specific; Pro UCL, Version 3
Outdoor Air	Outdoor Soil x 1/PEF	--	chemical-specific; default residential PEF, MDEQ TSD #6
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	3.49E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor (g/m^2-s per kg/m^3)	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion (g/m^2-s)	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic (g/m^2-s)	1.81E-06	defaul commercial/industrial; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 5b
Recreational Exposure and Risk Calculations: Child
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration		Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Outdoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C outdoor soil x IF x AEi x EFi x CF / AT											
Aluminum	NC	15,872	9.10E-04	1.20E-03	8.37E-03			1.0E+00	1.4E-03	--	8.37E-03
Arsenic	C	2.65	1.52E-07	2.00E-07	1.40E-06	1.5E+00	1.5E+01	3.0E-04		2.99E-07	4.66E-03
Beryllium	C	0.48	2.77E-08	3.64E-08	2.55E-07		8.4E+00	2.0E-03	5.7E-06	--	1.28E-04
Chromium*	C	29.5	1.69E-06	2.22E-06	1.55E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	1.34E-06	1.75E-06	1.23E-05		9.8E+00	2.00E-02	5.7E-06	--	6.14E-04
Copper	NC	2,972	1.70E-04	2.24E-04	1.57E-03			4.00E-02		--	3.92E-02
Lead	NC	2.6	1.48E-07	1.95E-07	1.37E-06					--	--
Lithium	NC	6.2	3.58E-07	4.70E-07	3.29E-06			2.0E-02		--	1.64E-04
Manganese	NC	549	3.15E-05	4.13E-05	2.89E-04			2.4E-02	1.4E-05	--	1.20E-02
Mercury	NC	0.028	1.61E-09	2.11E-09	1.48E-08			3.0E-04		--	4.92E-05
Nickel**	NC	31.6	1.81E-06	2.38E-06	1.67E-05		1.7E+00	2.0E-02		--	8.33E-04
Silver	NC	1.84	1.05E-07	1.39E-07	9.70E-07			5.0E-03		--	1.94E-04
Strontium	NC	17.05	9.77E-07	1.28E-06	8.99E-06			6.0E-01		--	1.50E-05
Zinc	NC	75.8	4.34E-06	5.70E-06	3.99E-05			3.0E-01		--	1.33E-04
									TOTAL	**3.0E-07**	**6.6E-02**
Dermal Absorption = C outdoor soil x DF x AEd x EFd x CF / AT											
Aluminum	NC	15,872	9.10E-04	1.00E-03	7.01E-03			1.0E+00	1.4E-03	--	7.01E-03
Arsenic	C	2.65	1.52E-07	5.02E-08	3.51E-07	1.5E+00	1.5E+01	3.0E-04		7.52E-08	1.17E-03
Beryllium	C	0.48	2.77E-08	3.05E-08	2.14E-07		8.4E+00	2.0E-03	5.7E-06	--	1.07E-04
Chromium*	C	29.5	1.69E-06	1.86E-06	1.30E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	1.34E-06	1.47E-06	1.03E-05		9.8E+00	2.00E-02	5.7E-06	--	5.15E-04
Copper	NC	2,972	1.70E-04	1.88E-04	1.31E-03			4.00E-02		--	3.28E-02
Lead	NTV	2.6	1.48E-07	1.63E-07	1.14E-06					--	--
Lithium	NC	6.2	3.58E-07	3.94E-07	2.76E-06			2.0E-02		--	1.38E-04
Manganese	NC	549	3.15E-05	3.46E-05	2.42E-04			2.4E-02	1.4E-05	--	1.01E-02
Mercury	NC	0.028	1.61E-09	1.77E-09	1.24E-08			3.0E-04		--	4.12E-05
Nickel**	NC	31.6	1.81E-06	1.99E-06	1.40E-05		1.7E+00	2.0E-02		--	6.98E-04
Silver	NC	1.84	1.05E-07	1.16E-07	8.13E-07			5.0E-03		--	1.63E-04
Strontium	NC	17.05	9.77E-07	1.08E-06	7.53E-06			6.0E-01		--	1.26E-05
Zinc	NC	75.8	4.34E-06	4.78E-06	3.35E-05			3.0E-01		--	1.12E-04
									TOTAL	**7.5E-08**	**5.3E-02**
Inhalation Intake = C outdoor air x AIF x Efa / AT											
Aluminum	NC	15,872	9.10E-04	6.85E-06	4.80E-05			1.0E+00	1.4E-03	--	3.43E-02
Arsenic	C	2.65	1.52E-07	1.14E-09	8.01E-09	1.5E+00	1.5E+01	3.0E-04		1.72E-08	--
Beryllium	C	0.48	2.77E-08	2.09E-10	1.46E-09		8.4E+00	2.0E-03	5.7E-06	1.76E-09	2.56E-04
Chromium*	C	29.5	1.69E-06	1.27E-08	8.90E-08		4.2E+01	3.0E-03	2.2E-06	5.34E-07	--
Cobalt	C	23.3	1.34E-06	1.01E-08	7.04E-08		9.8E+00	2.00E-02	5.7E-06	9.86E-08	1.24E-02
Copper	NC	2,972	1.70E-04	1.28E-06	8.98E-06			4.00E-02		--	--
Lead	NTV	2.6	1.48E-07	1.12E-09	7.83E-09					--	--
Lithium	NC	6.2	3.58E-07	2.69E-09	1.89E-08			2.0E-02		--	--
Manganese	NC	549	3.15E-05	2.37E-07	1.66E-06			2.4E-02	1.4E-05	--	1.18E-01
Mercury	NC	0.028	1.61E-09	1.21E-11	8.46E-11			3.0E-04		--	--
Nickel**	NC	31.6	1.81E-06	1.36E-08	9.55E-08		1.7E+00	2.0E-02		--	--
Silver	NC	1.84	1.05E-07	7.94E-10	5.56E-09			5.0E-03		--	--
Strontium	NC	17.05	9.77E-07	7.36E-09	5.15E-08			6.0E-01		--	--
Zinc	NC	75.8	4.34E-06	3.27E-08	2.29E-07			3.0E-01		--	--
									TOTAL	**6.5E-07**	**1.7E-01**
									CUMULATIVE HAZARD INDICES	1E-06	3E-01

Parameter		Value	
IF	Age-adjusted soil ingestion factor (mg-yr/kg-day)	74	Based on 2 - 12 year old children, where: IF = (200 mg/day x 10 yrs) / 27 kg
DF	Age-adjusted soil dermal factor (mg-year/kg-day)	310	Based on 2 - 12 year old children, where: DF = (4190 cm^3 x 1 event/day x 0.2 mg/cm^2 x 10 yrs) / 27 kg calculated based on MDEQ TSD #6; divided by two to account for short term
PEF	Particulate Emission Factor (m^3/kg)	1.74E+07	peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	3650	10 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10^{-6} kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$	--	chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default residential, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Efi	Ingestion exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Aed	Dermal absorption efficiency (unitless)	10%	default residential, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIF	Age-adjusted inhalation rate $(m^3/yr)/(kg/day)$	3.7	Based on 2 - 12 year old children; where: AIF = (10 m^3/day x 10 yrs)/ 27 kg
Efa	Inhalation exposure frequency (days/yr)	52	4 times per week (June - August); 2 times per month (May and September)
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration	--	chemical-specific; Pro UCL, Version 3
Outdoor Air	Outdoor Soil x 1/PEF	--	chemical-specific; default residential PEF, MDEQ TSD #6
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	3.49E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor (g/m^2-s per kg/m^3)	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion (g/m^2-s)	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic (g/m^2-s)	1.81E-06	defaul commercial/industrial; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 6a
Construction Worker Exposure and Risk Calculations: Adult
Gay Southern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration		Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Outdoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C outdoor soil x IR x AEi x EFi x CF x ED/ AT x BW											
Aluminum	NC	11,791	6.76E-04	8.48E-04	2.83E-03			1.0E+00	1.4E-03	--	2.83E-03
Arsenic	C	1.6	9.02E-08	1.13E-07	3.77E-07	1.5E+00	1.5E+01	3.0E-04		1.70E-07	1.26E-03
Beryllium	C	0.46	2.63E-08	3.30E-08	1.10E-07		8.4E+00	2.0E-03	5.7E-06	--	5.50E-05
Chromium*	C	29.4	1.69E-06	2.12E-06	7.06E-06		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	1.13E-06	1.42E-06	4.73E-06		9.8E+00	2.00E-02	5.7E-06	--	2.36E-04
Copper	NC	1,713.7	9.82E-05	1.23E-04	4.11E-04			4.00E-02		--	1.03E-02
Lead	NC	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	4.18E-07	1.39E-06			2.0E-02		--	6.96E-05
Manganese	NC	407	2.34E-05	2.93E-05	9.76E-05			2.4E-02	1.4E-05	--	4.07E-03
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	1.98E-06	6.59E-06		1.7E+00	2.0E-02		--	3.30E-04
Silver	NC	1.27	7.28E-08	9.13E-08	3.04E-07			5.0E-03		--	6.09E-05
Strontium	NC	13	7.63E-07	9.57E-07	3.19E-06			6.0E-01		--	5.32E-06
Zinc	NC	66	3.80E-06	4.77E-06	1.59E-05			3.0E-01		--	5.30E-05
									TOTAL	**1.7E-07**	**1.9E-02**
Dermal Absorption = C outdoor soil x SA x AF x AEd x EFd x CF x ED / AT x BW											
Aluminum	NC	11,791	6.76E-04	1.46E-03	4.87E-03			1.0E+00	1.4E-03	--	4.87E-03
Arsenic	C	1.6	9.02E-08	5.85E-08	1.95E-07	1.5E+00	1.5E+01	3.0E-04		8.78E-08	6.51E-04
Beryllium	C	0.46	2.63E-08	5.69E-08	1.90E-07		8.4E+00	2.0E-03	5.7E-06	--	9.49E-05
Chromium*	C	29.4	1.69E-06	3.65E-06	1.22E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	19.71	1.13E-06	2.44E-06	8.15E-06		9.8E+00	2.00E-02	5.7E-06	--	4.07E-04
Copper	NC	1,713.7	9.82E-05	2.12E-04	7.08E-04			4.00E-02		--	1.77E-02
Lead	NTV	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	7.20E-07	2.40E-06			2.0E-02		--	1.20E-04
Manganese	NC	407	2.34E-05	5.05E-05	1.68E-04			2.4E-02	1.4E-05	--	7.01E-03
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	3.41E-06	1.14E-05		1.7E+00	2.0E-02		--	5.68E-04
Silver	NC	1.27	7.28E-08	1.57E-07	5.25E-07			5.0E-03		--	1.05E-04
Strontium	NC	13	7.63E-07	1.65E-06	5.50E-06			6.0E-01		--	9.17E-06
Zinc	NC	66	3.80E-06	8.22E-06	2.74E-05			3.0E-01		--	9.13E-05
									TOTAL	**8.8E-08**	**3.2E-02**
Inhalation Intake = C outdoor air x AIR x Efa x ED / AT x BW											
Aluminum	NC	11,791	6.76E-04	3.89E-05	1.30E-04			1.0E+00	1.4E-03	--	9.26E-02
Arsenic	C	1.6	9.02E-08	5.19E-09	1.73E-08	1.5E+00	1.5E+01	3.0E-04		7.81E-08	--
Beryllium	C	0.46	2.63E-08	1.51E-09	5.05E-09		8.4E+00	2.0E-03	5.7E-06	1.27E-08	8.84E-04
Chromium*	C	29.4	1.69E-06	9.71E-08	3.24E-07		4.2E+01	3.0E-03	2.2E-06	4.08E-06	--
Cobalt	C	19.71	1.13E-06	6.50E-08	2.17E-07		9.8E+00	2.00E-02	5.7E-06	6.37E-07	3.80E-02
Copper	NC	1,713.7	9.82E-05	5.65E-06	1.88E-05			4.00E-02		--	--
Lead	NTV	--	--	--	--					--	--
Lithium	NC	5.8	3.33E-07	1.92E-08	6.39E-08			2.0E-02		--	--
Manganese	NC	407	2.34E-05	1.34E-06	4.48E-06			2.4E-02	1.4E-05	--	3.20E-01
Mercury	NC	--	--	--	--			3.0E-04		--	--
Nickel**	NC	27.5	1.58E-06	9.07E-08	3.02E-07		1.7E+00	2.0E-02		--	--
Silver	NC	1.27	7.28E-08	4.19E-09	1.40E-08			5.0E-03		--	--
Strontium	NC	13	7.63E-07	4.39E-08	1.46E-07			6.0E-01		--	--
Zinc	NC	66	3.80E-06	2.19E-07	7.29E-07			3.0E-01		--	--
									TOTAL	**4.8E-06**	**4.5E-01**
								CUMULATIVE HAZARD INDICES		5E-06	5E-01

Parameter		Value	
IR	Adult soil ingestion rate (mg/day)	50	default commercial/industrial subcategory IV, MDEQ TSD #2
SA	Adult surface area	3300	default commercial/industrial subcategory IV, MDEQ TSD #2
PEF	Particulate Emission Factor (m3/kg)	1.74E+07	calculated commercial/industrial, MDEQ TSD #6; divided by two to account for short term peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	7665	21 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10-6 kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$	--	chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default commercial/industrial subcategory IV, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	160	default commercial/industrial subcategory IV, MDEQ TSD #2
Efi	Ingestion exposure frequency (days/yr)	245	default commercial/industrial subcategory IV, MDEQ TSD #2
Aed	Dermal absorption efficiency (unitless)	10%	default commercial/industrial subcategory IV, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIR	Adult inhalation rate (m^3/day)	20	default commercial/industrial subcategory IV, MDEQ TSD #2
Efa	Inhalation exposure frequency (days/yr)	245	default commercial/industrial subcategory IV, MDEQ TSD #2
BWa	Adult body weight (kg)	70	default commercial/industrial subcategory IV, MDEQ TSD #2
EDa	Exposure duration (yrs)	21	default commercial/industrial subcategory IV, MDEQ TSD #2
AF	Adherance factor (mg/cm^2)	0.2	default commercial/industrial subcategory IV, MDEQ TSD #2
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration	--	chemical-specific; Pro UCL, Version 3
Outdoor Air	Outdoor Soil x 1/PEF	--	chemical-specific; default commercial/industrial PEF, MDEQ TSD #6
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	3.49E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor (g/m^2-s per kg/m^3)	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion (g/m^2-s)	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic (g/m^2-s)	1.81E-06	defaul commercial/industrial; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 6b
Construction Worker Exposure and Risk Calculations: Adult
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

Chemical	Carcinogen (C) or Noncarcinogen (NC)	Exposure Point Concentration		Intake (mg/kg-day)		Slope Factor		Reference Dose		Cancer Risk	Noncancer Hazard Quotient
		Outdoor Soil	Outdoor Air	Carcinogens	Noncarcinogens	Oral	Inhalation	Oral	Inhalation	Intake x SF	Intake / RfD
		mg/kg	mg/m^3	mg/kg-day	mg/kg-day	$(mg/kg\text{-}day)^{-1}$	$(mg/kg\text{-}day)^{-1}$	mg/kg-day	mg/kg-day	unitless	unitless
Ingestion Intake = C outdoor soil x IR x AEi x EFi x CF x ED/ AT x BW											
Aluminum	NC	15,872	9.10E-04	1.14E-03	3.80E-03			1.0E+00	1.4E-03	--	3.80E-03
Arsenic	C	2.65	1.52E-07	1.91E-07	6.35E-07	1.5E+00	1.5E+01	3.0E-04		2.86E-07	2.12E-03
Beryllium	C	0.48	2.77E-08	3.48E-08	1.16E-07		8.4E+00	2.0E-03	5.7E-06	--	5.80E-05
Chromium*	C	29.5	1.69E-06	2.12E-06	7.06E-06		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	1.34E-06	1.68E-06	5.59E-06		9.8E+00	2.00E-02	5.7E-06	--	2.79E-04
Copper	NC	2,972	1.70E-04	2.14E-04	7.12E-04			4.00E-02		--	1.78E-02
Lead	NC	2.6	1.48E-07	1.86E-07	6.21E-07					--	--
Lithium	NC	6.2	3.58E-07	4.49E-07	1.50E-06			2.0E-02		--	7.48E-05
Manganese	NC	549	3.15E-05	3.95E-05	1.32E-04			2.4E-02	1.4E-05	--	5.48E-03
Mercury	NC	0.028	1.61E-09	2.01E-09	6.71E-09			3.0E-04		--	2.24E-05
Nickel**	NC	31.6	1.81E-06	2.27E-06	7.58E-06		1.7E+00	2.0E-02		--	3.79E-04
Silver	NC	1.84	1.05E-07	1.32E-07	4.41E-07			5.0E-03		--	8.82E-05
Strontium	NC	17.05	9.77E-07	1.23E-06	4.09E-06			6.0E-01		--	6.81E-06
Zinc	NC	75.8	4.34E-06	5.45E-06	1.82E-05			3.0E-01		--	6.05E-05
									TOTAL	**2.9E-07**	**3.0E-02**
Dermal Absorption = C outdoor soil x SA x AF x AEd x EFd x CF x ED / AT x BW											
Aluminum	NC	15,872	9.10E-04	1.97E-03	6.56E-03			1.0E+00	1.4E-03	--	6.56E-03
Arsenic	C	2.65	1.52E-07	9.86E-08	3.29E-07	1.5E+00	1.5E+01	3.0E-04		1.48E-07	1.10E-03
Beryllium	C	0.48	2.77E-08	6.00E-08	2.00E-07		8.4E+00	2.0E-03	5.7E-06	--	1.00E-04
Chromium*	C	29.5	1.69E-06	3.65E-06	1.22E-05		4.2E+01	3.0E-03	2.2E-06	--	--
Cobalt	C	23.3	1.34E-06	2.89E-06	9.63E-06		9.8E+00	2.00E-02	5.7E-06	--	4.82E-04
Copper	NC	2,972	1.70E-04	3.69E-04	1.23E-03			4.00E-02		--	3.07E-02
Lead	NTV	2.6	1.48E-07	3.21E-07	1.07E-06					--	--
Lithium	NC	6.2	3.58E-07	7.74E-07	2.58E-06			2.0E-02		--	1.29E-04
Manganese	NC	549	3.15E-05	6.80E-05	2.27E-04			2.4E-02	1.4E-05	--	9.45E-03
Mercury	NC	0.028	1.61E-09	3.47E-09	1.16E-08			3.0E-04		--	3.86E-05
Nickel**	NC	31.6	1.81E-06	3.92E-06	1.31E-05		1.7E+00	2.0E-02		--	6.53E-04
Silver	NC	1.84	1.05E-07	2.28E-07	7.60E-07			5.0E-03		--	1.52E-04
Strontium	NC	17.05	9.77E-07	2.11E-06	7.05E-06			6.0E-01		--	1.17E-05
Zinc	NC	75.8	4.34E-06	9.39E-06	3.13E-05			3.0E-01		--	1.04E-04
									TOTAL	**1.5E-07**	**4.9E-02**
Inhalation Intake = C outdoor air x AIR x Efa x ED / AT x BW											
Aluminum	NC	15,872	9.10E-04	5.24E-05	1.75E-04			1.0E+00	1.4E-03	--	1.25E-01
Arsenic	C	2.65	1.52E-07	8.74E-09	2.91E-08	1.5E+00	1.5E+01	3.0E-04		1.32E-07	--
Beryllium	C	0.48	2.77E-08	1.60E-09	5.32E-09		8.4E+00	2.0E-03	5.7E-06	1.34E-08	9.32E-04
Chromium*	C	29.5	1.69E-06	9.72E-08	3.24E-07		4.2E+01	3.0E-03	2.2E-06	4.08E-06	--
Cobalt	C	23.3	1.34E-06	7.69E-08	2.56E-07		9.8E+00	2.00E-02	5.7E-06	7.53E-07	4.49E-02
Copper	NC	2,972	1.70E-04	9.80E-06	3.27E-05			4.00E-02		--	--
Lead	NTV	2.6	1.48E-07	8.54E-09	2.85E-08					--	--
Lithium	NC	6.2	3.58E-07	2.06E-08	6.86E-08			2.0E-02		--	--
Manganese	NC	549	3.15E-05	1.81E-06	6.03E-06			2.4E-02	1.4E-05	--	4.31E-01
Mercury	NC	0.028	1.61E-09	9.24E-11	3.08E-10			3.0E-04		--	--
Nickel**	NC	31.6	1.81E-06	1.04E-07	3.47E-07		1.7E+00	2.0E-02		--	--
Silver	NC	1.84	1.05E-07	6.07E-09	2.02E-08			5.0E-03		--	--
Strontium	NC	17.05	9.77E-07	5.62E-08	1.87E-07			6.0E-01		--	--
Zinc	NC	75.8	4.34E-06	2.50E-07	8.33E-07			3.0E-01		--	--
									TOTAL	**5.0E-06**	**6.0E-01**
									CUMULATIVE HAZARD INDICES	5E-06	7E-01

Parameter		Value	
IR	Adult soil ingestion rate (mg/day)	50	default commercial/industrial subcategory IV, MDEQ TSD #2
SA	Adult surface area	3300	default commercial/industrial subcategory IV, MDEQ TSD #2
PEF	Particulate Emission Factor (m3/kg)	1.74E+07	calculated commercial/industrial, MDEQ TSD #6; divided by two to account for short term peak particulate levels
Atc	Averaging time (days)	2.56E+04	70 years x 365 days/yr
Atnc	Averaging time (days)	7665	21 years x 365 days/yr
CF	Conversion factor (kg/mg)	1.00E-06	10-6 kg/mg
SF	Oral slope factor $(mg/kg\text{-}day)^{-1}$	--	chemical specific; IRIS
Aei	Ingestion absorption efficiency (unitless)	50%	default commercial/industrial subcategory IV, MDEQ TSD #2
Efd	Dermal exposure frequency (days/yr)	160	default commercial/industrial subcategory IV, MDEQ TSD #2
Efi	Ingestion exposure frequency (days/yr)	245	default commercial/industrial subcategory IV, MDEQ TSD #2
Aed	Dermal absorption efficiency (unitless)	10%	default commercial/industrial subcategory IV, MDEQ TSD #2
		0.03	Arsenic; RAGS Part E
		0.001	Cadmium; RAGS Part E
AIR	Adult inhalation rate (m^3/day)	20	default commercial/industrial subcategory IV, MDEQ TSD #2
Efa	Inhalation exposure frequency (days/yr)	245	default commercial/industrial subcategory IV, MDEQ TSD #2
BWa	Adult body weight (kg)	70	default commercial/industrial subcategory IV, MDEQ TSD #2
EDa	Exposure duration (yrs)	21	default commercial/industrial subcategory IV, MDEQ TSD #2
AF	Adherance factor (mg/cm^2)	0.2	default commercial/industrial subcategory IV, MDEQ TSD #2
Exposure Point Concentrations			
Outdoor Soil	95 UCL concentration	--	chemical-specific; Pro UCL, Version 3
Outdoor Air	Outdoor Soil x 1/PEF	--	chemical-specific; default commercial/industrial PEF, MDEQ TSD #6
PEF	Particulate Emission Factor (m^3/kg) = Q/C x 1/ (Ew ((1-V) + Ev)	3.49E+07	calculated value; MDEQ TSD #6
Q/C	Dispersion factor (g/m^2-s per kg/m^3)	82.33	default; 0.5 acre source size, MDEQ TSD #6
Ew	Emission due to wind erosion (g/m^2-s)	5.50E-07	default; MDEQ TSD #6
V	Assumed vegetative cover	0	assumes no cover
Ev	Emission due to vehicle traffic (g/m^2-s)	1.81E-06	defaul commercial/industrial; MDEQ TSD #6

* Oral and inhalation RfD for chromium based on hexavalent chromium.
** Inhalation slope factor based on nickel subsulfide.

mg/kg = milligrams per kilogram
mg/m3 = millimeters per cubic meter
RfD = reference dose
UCL = upper confidence limit

Table 7a
Soil Sample Results Above Residential Drinking Water Protection Criteria
Gay Southern Area 2003 Stamp Sand Soil Quality Evaluation

	GB1	GB10	GB11	GB12	GB13	GB14	GB15	GB16	GB17	GB18		
	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	***DWPC***	
Analytes (mg/kg)												***State Background***
Aluminum	14,000	8,200	11,000	6,300	6,700	8,300	6,900	6,400	8,700	8,800	*1*	*6,900*
Arsenic	1.7	1.1	1.4	1	1.4	1	1.2	0.9	1.1	1.2	*4.6*	*5.8*
Beryllium	0.37	0.33	0.47	0.28	0.29	0.37	0.33	0.27	0.39	0.35	*51*	*NA*
Chromium	32	20	27	14	16	19	17	16	21	16	*30*	*NA*
Cobalt	22	14	18	10	11	14	12	11	15	11	*0.8*	*6.8*
Copper	1,300	970	1,700	710	740	850	880	800	970	1,100	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	6.8	4.1	5.2	3.1	3.5	4	3.5	3.3	4.1	3.9	*3.4*	*9.8*
Manganese	410	300	410	210	230	270	250	240	300	290	*1*	*440*
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	*1.7*	*0.13*
Nickel	33	18	24	13	15	19	15	15	19	15	*100*	*20*
Silver	1.2	0.7	1.2	0.5	0.5	0.7	0.7	0.6	0.7	0.6	*4.5*	*1*
Strontium	9.6	8	10	7.7	7.3	9.2	7.4	6.2	9.5	6.9	*92*	*NA*
Zinc	67	48	61	37	41	50	42	39	53	29	*2,400*	*47*

	GB19	GB2	GB20	GB21	GB22	GB23	GB24	GB3	GB4	GB5		
	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	8/21/2003	***DWPC***	
Analytes (mg/kg)												***State Background***
Aluminum	8,700	14,000	9,600	10,000	13,000	11,000	12,000	14,000	16,000	16,000	*1*	*6,900*
Arsenic	1.2	2.1	1.3	1.1	1.4	1.6	1.6	2.7	1.8	1.7	*4.6*	*5.8*
Beryllium	0.37	0.4	0.36	0.41	0.56	0.48	0.51	0.43	0.6	0.59	*51*	*NA*
Chromium	21	33	19	23	32	24	30	37	41	42	*30*	*NA*
Cobalt	14	23	14	17	22	17	21	21	28	26	*0.8*	*6.8*
Copper	1,100	1,500	1,100	1,300	1,900	1,400	1,800	5,300	1,200	2,000	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	4.1	7.2	4.4	4.7	6.3	4.9	5.5	8	7.9	7.1	*3.4*	*9.8*
Manganese	310	410	330	360	480	390	450	400	530	520	*1*	*440*
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	*1.7*	*0.13*
Nickel	18	34	17	22	29	22	28	33	44	35	*100*	*20*
Silver	0.8	1.6	0.8	0.8	2	0.8	1.7	2.6	0.7	1.6	*4.5*	*1*
Strontium	8.6	10	8.5	11	13	11	13	35	13	14	*92*	*NA*
Zinc	51	70	48	57	76	61	71	65	92	89	*2,400*	*47*

	GB6	GB7	GB8	GB9		
	8/21/2003	8/21/2003	8/21/2003	8/21/2003	***DWPC***	***State Background***
Analytes (mg/kg)						
Aluminum	14,000	13,000	9,000	12,000	*1*	*6,900*
Arsenic	1.5	1.6	1.2	1.6	*4.6*	*5.8*
Beryllium	0.61	0.55	0.36	0.46	*51*	*NA*
Chromium	42	36	22	31	*30*	*NA*
Cobalt	27	24	15	20	*0.8*	*6.8*
Copper	1,900	1,400	1,100	1,600	*5,800*	*32*
Lead	<5	<5	<5	<5	*700*	*21*
Lithium	7.1	6.3	4.8	6.6	*3.4*	*9.8*
Manganese	560	500	310	450	*1*	*440*
Mercury	<0.05	<0.05	<0.05	<0.05	*1.7*	*0.13*
Nickel	39	32	20	27	*100*	*20*
Silver	1.5	1	0.8	1.3	*4.5*	*1*
Strontium	14	14	9.1	13	*92*	*NA*
Zinc	90	80	51	75	*2,400*	*47*

exceeds Residential/Commercial I Drinking Water Protection Criteria (DWPC)
For some samples, DWPC was exceeded, but the State Background criteria was not exceeded. Therefore, these samples are not shaded.
mg/kg = milligrams per kilogram
Note: Data summary was completed by MDEQ and updated by WESTON

for printing table 7b, pages 47-49 set pages to 80%, landscape, legal size paper

Table 7b
Soil Sample Results Above Residential Drinking Water Protection Criteria
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

Analytes (mg/kg)	GB2 0' 9/17/2003	GB2 12' 9/17/2003	GB2 16' 9/17/2003	GB2 20' 9/17/2003	GB2 26' 9/17/2003	GB2 4' 9/17/2003	GB2 8' 9/17/2003	GB3 0' 9/17/2003	GB3 12' 9/17/2003	GB3 16' 9/17/2003	GB3 19' 9/17/2003	GB3 23' 9/17/2003	GB3 4' 9/17/2003	GB3 8' 9/17/2003	GB4 0' 9/17/2003	GB4 12' 9/17/2003	GB4 16' 9/17/2003	GB4 18' 9/17/2003	GB4 4' 9/17/2003	GB4 8' 9/17/2003	GB5 0' 9/17/2003	GB5 10' 9/17/2003	GB5 4 9/17/2003	GB5 8' 9/17/2003	GB6 0' 9/17/2003	GB6 10' 9/17/2003	GB6 4' 9/17/2003	GB6 8' 9/17/2003	GB7 0' 9/17/2003	GB7 10' 9/17/2003	GB7 4' 9/17/2003	GB7 8' 9/17/2003	*DWPC*	*State Background*
Aluminum	15,000	14,000	17,000	15,000	14,000	15,000	14,000	14,000	16,000	15,000	14,000	15,000	16,000	13,000	14,000	14,000	14,000	16,000	14,000	18,000	13,000	14,000	14,000	14,000	13,000	14,000	14,000	13,000	14,000	13,000	14,000	14,000	*1*	*6,900*
Arsenic	1.8	2.4	2.8	2.9	3.9	2.4	2.7	2.5	2.6	2.8	5.2	2.4	1.9	2.7	2	2.9	2.5	3.1	2.9	2.5	2.5	2.5	2.4	2.1	1.9	3.1	1.8	2.7	2	2.7	1.8	2.4	*4.6*	*5.8*
Beryllium	0.57	0.51	0.56	0.56	0.47	0.52	0.41	0.39	0.63	0.62	0.54	0.48	1.6	0.41	0.41	0.59	0.55	0.54	0.43	0.65	0.5	0.62	0.54	0.57	0.53	0.53	0.55	0.55	0.43	0.51	0.53	0.55	*51*	*NA*
Chromium	36	32	43	42	33	36	23	25	41	41	35	31	28	26	24	28	31	32	26	38	27	31	31	32	29	32	32	30	27	27	31	30	*30*	*NA*
Cobalt	27	24	28	30	24	26	19	19	27	27	23	23	22	20	20	22	24	24	22	30	22	25	24	24	23	24	24	23	23	22	24	23	*0.8*	*6.8*
Copper	2,400	2,800	2,600	2,300	3,200	1,900	2,700	2,200	2,500	2,900	6,700	3,000	1,600	3,700	1,800	4,300	3,400	4,400	3,900	2,700	3,800	4,000	3,600	3,500	2,900	3,900	2,600	3,600	2,900	3,200	2,500	3,700	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	6	4.9	7.3	6.8	7.4	5.8	3.8	3.7	7.2	7.1	6.5	4.4	4.5	4.1	4	5	6.2	6.3	4.1	7	4.9	5	5.4	5.2	4.7	6.5	5.3	5	4.5	4.5	5.3	5	*3.4*	*9.8*
Manganese	490	420	640	600	600	480	300	290	620	560	530	350	350	340	300	430	470	520	340	620	390	420	430	410	410	450	410	390	380	390	400	420	*1*	*440*
Mercury	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	*1.7*	*0.13*
Nickel	32	28	37	37	33	31	24	23	34	36	30	28	27	26	25	27	29	33	36	39	28	30	30	30	28	31	31	29	28	26	31	30	*100*	*20*
Silver	2.6	2.2	2.1	3.7	2.7	1.7	0.9	1.6	2.3	2.2	3.4	0.9	0.6	0.9	0.7	7.7	2.9	3.4	1	2	1.4	2.6	1.7	2.1	1.6	2.7	1.3	2.5	0.9	2.2	1.3	2.3	*4.5*	*1*
Strontium	18	20	23	22	21	20	19	16	21	21	19	17	18	13	17	17	18	19	17	30	15	19	17	18	13	19	17	18	16	18	17	19	*92*	*NA*
Zinc	81	77	89	86	75	74	55	49	81	76	74	66	64	64	60	70	71	74	68	88	73	73	71	71	76	71	78	70	73	74	77	69	*2,400*	*47*

Analytes (mg/kg)	GF6 4	GF6 8	GF7 0	GF7 12	GF7 15	GF7 4	GF7 8	GF8 0	GF8 12	GF8 4	GF8 8	GF9 0	GF9 12	GF9 4	GF9 8	GG1 0	GG1 12	GG1 16	GG1 4	GG1 8	GG2 0	GG2 12	GG2 16	GG2 4	GG2 8	GG3 0	GG3 12	GG3 16	GG3 4	GG3 8	GA-1 0'-4' 9/16/2003	GA-1 12'-16' 9/16/2003	*DWPC*	*State Background*
Aluminum	16,000	17,000	19,000	16,000	16,000	18,000	18,000	19,000	15,000	18,000	16,000	18,000	16,000	17,000	16,000	16,000	17,000	16,000	22,000	17,000	18,000	19,000	18,000	20,000	21,000	19,000	19,000	20,000	19,000	19,000	14,000	14,000	*1*	*6,900*
Arsenic	2.1	1.6	2.3	2.4	2.3	2.7	2	2.8	2.6	2.6	2.1	1.9	2.2	2.1	2.1	2.1	4.4	3.2	2	2.1	1.7	3.1	2.7	2.5	1.8	2.1	2.3	1.9	2.1	2.1	2.5	2.3	*4.6*	*5.8*
Beryllium	0.36	0.38	0.39	0.5	0.6	0.35	0.52	0.37	0.41	0.44	0.45	0.36	0.62	0.42	0.42	0.53	0.56	0.59	0.54	0.45	0.57	0.48	0.46	0.6	0.48	0.52	0.55	0.51	0.6	0.52	0.41	0.42	*51*	*NA*
Chromium	21	32	23	22	29	19	32	22	23	21	24	20	23	20	23	27	33	28	37	33	33	36	33	35	38	31	35	41	33	35	31	33	*30*	*NA*
Cobalt	19	25	18	19	22	16	24	19	20	18	21	19	20	17	19	23	23	23	31	24	25	28	24	27	31	27	27	29	26	28	26	26	*0.8*	*6.8*
Copper	1,500	2,000	1,900	2,700	3,600	3,500	2,700	2,200	3,000	2,300	2,500	1,800	3,200	2,600	3,800	2,000	3,500	3,300	1,700	2,100	1,800	2,700	2,100	3,200	1,800	2,400	3,000	2,400	2,600	2,400	2,800	3,000	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	4.5	7.8	4.3	5	6.7	3.9	8.2	5	5	4.1	5	3.8	4.7	3.8	4.6	6.4	7.8	6.8	9.4	8.6	8.4	8.7	7.2	9.4	10	7	8.5	9.6	7.9	8	8.2	8.7	*3.4*	*9.8*
Manganese	400	730	460	560	630	410	730	480	530	430	570	430	540	440	530	610	730	670	930	730	740	820	740	820	870	760	820	820	780	810	470	520	*1*	*440*
Mercury	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	0.06	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	0.07	<.05	0.06	<.05	*1.7*	*0.13*
Nickel	25	37	24	26	30	21	36	24	26	24	28	24	26	23	26	29	36	31	44	36	35	42	35	41	46	36	40	43	37	40	34	34	*100*	*20*
Silver	0.6	3.6	0.7	1.2	2.8	1	1.4	0.9	1.3	0.9	0.9	0.5	1.4	0.7	1.8	1.6	1.8	2.5	1.7	1.5	1.8	1.6	1.6	1.6	2.7	2	2	1.7	2.1	2	2.7	2.2	*4.5*	*1*
Strontium	15	19	14	12	15	15	17	13	13	15	14	12	14	13	14	11	20	20	25	18	13	21	19	21	27	15	24	26	19	20	14	16	*92*	*NA*
Zinc	56	73	64	65	69	48	72	60	68	55	72	57	68	53	66	69	70	69	91	80	73	82	74	80	88	77	76	86	74	79	87	83	*2,400*	*47*

Analytes (mg/kg)	GE6 8	GE7 0	GE7 12	GE7 14	GE7 4	GE7 8	GE8 0	GE8 12	GE8 4	GE8 8	GE9 0	GE9 12	GE9 15	GE9 4	GE9 8	GF1 0	GF1 12	GF1 16	GF1 4	GF1 8	GF10 0	GF10 12	GF10 15	GF10 4	GF10 8	GF2 0	GF2 12	GF2 16	GF2 4	GF2 8	GF3 0	GF3 12	*DWPC*	*State Background*
Aluminum	17,000	19,000	17,000	17,000	19,000	17,000	17,000	17,000	17,000	17,000	19,000	16,000	17,000	18,000	16,000	19,000	19,000	18,000	21,000	20,000	19,000	16,000	16,000	20,000	16,000	18,000	20,000	18,000	20,000	19,000	17,000	19,000	*1*	*6,900*
Arsenic	2.2	2	2.8	2.6	2	2.4	1.8	2.4	2.3	2	2.3	2.1	2.3	2.1	3	2.1	3.6	2.9	1.7	1.9	2.6	2.2	2.5	2	2.2	2.5	2.3	2.5	2.4	2.3	2	3.2	*4.6*	*5.8*
Beryllium	0.37	0.31	0.39	0.41	0.35	0.4	0.36	0.43	0.32	0.43	0.35	0.53	0.45	0.37	0.39	0.43	0.44	0.46	0.42	0.48	0.43	0.48	0.45	0.38	0.33	0.5	0.48	0.48	0.56	0.5	0.39	0.51	*51*	*NA*
Chromium	24	18	21	23	19	22	19	23	20	24	20	25	25	19	20	26	30	28	23	38	19	22	29	22	20	29	52	34	42	40	24	38	*30*	*NA*
Cobalt	21	16	19	20	18	20	17	20	20	21	19	20	20	18	19	23	22	24	22	26	17	20	23	20	19	23	29	24	31	29	20	26	*0.8*	*6.8*
Copper	2,800	2,200	4,300	3,100	2,200	2,900	2,300	3,600	3,200	2,500	2,300	3,100	4,300	2,800	5,700	2,600	3,400	3,200	2,500	2,400	3,200	2,900	2,400	2,100	3,500	2,700	2,100	2,700	2,800	2,600	2,700	2,800	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	5.8	4.2	5.1	5.5	4	4.5	4.1	4.3	3	3.9	4	5.3	5.2	3.2	4	6	8	7.1	5.8	9.2	4.4	4.9	6.5	5.2	4.3	5.6	9.2	7.9	9.2	9.1	4.3	8	*3.4*	*9.8*
Manganese	680	460	620	620	500	590	440	650	540	600	510	590	550	470	570	690	820	750	630	870	500	520	650	550	500	550	800	770	850	800	470	760	*1*	*440*
Mercury	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	0.09	<.05	0.07	<.05	*1.7*	*0.13*
Nickel	31	23	27	29	26	28	24	29	28	29	26	28	27	24	26	30	36	34	27	39	20	26	31	25	25	29	43	33	45	39	24	36	*100*	*20*
Silver	1.4	0.6	1.9	1.4	0.8	1	1.1	1.8	1.1	1.5	0.6	1.3	2.6	0.8	1.7	2.1	1.6	1.9	0.9	1.5	1	1.4	1.7	0.6	0.9	1.5	2.9	2.1	1.9	1.6	1	1.7	*4.5*	*1*
Strontium	13	14	12	13	13	13	11	13	14	13	14	14	14	14	13	11	18	17	15	21	10	14	17	17	14	13	24	19	24	23	12	21	*92*	*NA*
Zinc	73	51	67	69	59	72	56	72	72	76	61	68	66	58	70	77	70	78	78	89	57	68	73	64	63	79	87	78	90	84	62	78	*2,400*	*47*

exceeds Residential/Commercial I Drinking Water Protection Criteria (DWPC)
For some samples, DWPC was exceeded, but the State Background criteria was not exceeded. Therefore, these samples are not shaded
mg/kg = milligrams per kilogram
Note: Data summary was completed by MDEQ and updated by WESTON

Table 7b
Soil Sample Results Above Residential Drinking Water Protection Criteria
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

Analytes (mg/kg)	GC1 0' 9/17/2003	GC1 12' 9/17/2003	GC1 16' 9/17/2003	GC1 4' 9/17/2003	GC1 8' 9/17/2003	GC2 0' 9/17/2003	GC2 12' 9/17/2003	GC2 16' 9/18/2003	GC2 4' 9/17/2003	GC2 8' 9/17/2003	GC3 0'	GC3 12'	GC3 16'	GC3 4'	GC3 8'	GC4 0'	GC4 12'	GC4 16'	GC4 4'	GC4 8'	GC5 0'	GC5 10'	GC5 4'	GC5 8'	GC6 0'	GC6 4'	GC6 7'	GC7 0'	GC7 4'	GC7 6'	GE1 0'	GE1 12'	DWPC	State Background
Aluminum	13,000	16,000	15,000	14,000	14,000	13,000	15,000	17,000	15,000	14,000	14,000	16,000	17,000	14,000	15,000	14,000	16,000	14,000	15,000	13,000	14,000	13,000	14,000	14,000	14,000	14,000	13,000	13,000	13,000	13,000	12,000	14,000	*1*	*6,900*
Arsenic	2.1	5	2.5	2	2.2	2	1.5	2.2	2	2	1.8	1.6	1.5	1.8	4.7	1.7	1.5	2.6	2.1	2.4	1	1.9	2	2.6	2.2	2.3	2.4	1.3	2.2	1.7	1.7	3.1	*4.6*	*5.8*
Beryllium	0.54	0.49	0.56	0.55	0.4	0.42	0.47	0.54	0.54	0.54	0.45	0.49	0.48	0.4	0.47	0.38	0.47	0.5	0.44	0.47	0.38	0.51	0.48	0.44	0.51	0.54	0.49	0.57	0.5	0.52	0.5	0.54	*51*	*NA*
Chromium	32	33	36	31	23	24	34	40	33	32	28	37	36	24	33	22	32	31	24	24	22	30	29	32	29	29	25	28	29	26	27	36	*30*	*NA*
Cobalt	25	24	27	26	20	20	25	32	27	24	23	29	28	21	25	20	26	25	21	19	20	22	23	18	23	23	21	23	23	22	23	26	*0.8*	*6.8*
Copper	2,200	5,100	2,700	2,200	2,600	2,800	2,500	2,300	2,500	2,300	2,300	1,800	1,700	1,700	3,900	1,500	1,800	3,100	1,800	4,700	2,300	2,900	2,200	2,900	2,600	3,200	3,200	2,400	3,200	3,300	2,100	2,600	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	5.3	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5.1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	5.6	7.3	7.6	5.9	4.5	4.1	7.5	7.9	7	6.3	5	7.8	7.3	4.1	6.9	3.9	6.7	6.3	4.5	4.2	4.3	6.1	5.6	6.1	5.5	5.4	4.6	4.4	5.7	4.9	4.9	7	*3.4*	*9.8*
Manganese	440	560	620	460	340	340	600	680	500	470	410	650	630	320	590	320	590	520	320	370	310	480	430	500	420	420	390	390	410	430	390	570	*1*	*440*
Mercury	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	0.06	<.05	<.05	<.05	0.06	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	*1.7*	*0.13*
Nickel	30	35	38	31	23	25	36	44	33	30	27	39	40	25	37	25	38	32	27	24	26	31	32	24	32	31	27	30	32	29	27	37	*100*	*20*
Silver	2.6	3.1	2	1.9	0.7	1.4	2.5	1.5	2.3	2.4	1.6	2	1.6	1	2.5	0.5	1.9	2.8	0.6	1.7	0.6	2.6	1.7	2	1.5	1.7	2.5	1.5	1.9	2.4	2.3	1.8	*4.5*	*1*
Strontium	14	18	21	17	15	13	19	23	17	18	14	23	24	18	21	16	22	19	16	17	13	19	15	20	12	16	17	14	17	19	16	21	*92*	*NA*
Zinc	81	73	90	86	66	85	77	97	91	79	75	90	87	66	77	63	79	76	64	68	63	73	75	81	79	74	76	78	77	71	73	77	*2,400*	*47*

Analytes (mg/kg)	GA-1 15'-19' 9/16/2003	GA-1 19' 9/16/2003	GA-1 23' 9/16/2003	GA-1 4'-8' 9/16/2003	GA-1 8'-12' 9/16/2003	G-A10 - 0 9/17/2003	G-A10 - 4 9/17/2003	G-A10 - 8 9/17/2003	GA-2 12' 9/17/2003	GA-2 13' 9/17/2003	GA-2 18' 9/17/2003	GA-2 2' 9/17/2003	GA-2 21' 9/17/2003	GA-2 8' 9/17/2003	GA-3 0' 9/17/2003	GA-3 12' 9/17/2003	GA-3 13' 9/17/2003	GA-3 16' 9/17/2003	GA-3 20' 9/17/2003	GA-3 22' 9/17/2003	GA-3 4' 9/17/2003	GA-3 6' 9/17/2003	GA-4 0' 9/17/2003	GA-4 11' 9/17/2003	GA-4 4' 9/17/2003	GA-4 5' 9/17/2003	GA-5 0' 9/17/2003	GA-5 12' 9/17/2003	GA-5 4' 9/17/2003	GA-5 8' 9/17/2003	GA-6 0' 9/17/2003	GA-6 10' 9/17/2003	DWPC	State Background
Aluminum	13,000	15,000	15,000	14,000	17,000	13,000	13,000	13,000	14,000	14,000	14,000	16,000	15,000	14,000	13,000	17,000	13,000	15,000	14,000	14,000	14,000	13,000	13,000	17,000	12,000	13,000	13,000	13,000	13,000	13,000	14,000	14,000	*1*	*6,900*
Arsenic	2.6	3.1	3.4	1.3	2.5	1.9	2	2.3	6	5.2	3.5	2.2	3.7	2.9	2.3	2.2	3.4	4.6	2.7	3.2	2.5	1.9	2.3	2.2	2.4	2.4	2.8	2.7	2.3	2.8	2.3	3.2	*4.6*	*5.8*
Beryllium	0.39	0.39	0.38	0.3	0.34	0.48	0.48	0.48	0.44	0.39	0.35	0.26	0.38	0.47	0.26	0.45	0.31	0.38	0.35	0.37	0.29	0.24	0.39	0.49	0.41	0.41	0.43	0.54	0.48	0.51	0.42	0.56	*51*	*NA*
Chromium	33	27	30	21	27	25	29	29	35	42	29	21	36	32	19	33	25	32	32	25	19	19	20	29	21	21	21	26	28	26	26	27	*30*	*NA*
Cobalt	24	22	23	20	25	22	23	22	26	25	23	20	25	25	19	29	21	25	23	22	18	20	18	26	18	18	17	21	22	20	22	21	*0.8*	*6.8*
Copper	2,600	3,500	2,900	1,800	2,400	2,500	2,200	2,300	4,800	4,400	3,400	2,200	3,400	2,300	2,100	2,500	4,400	3,300	2,900	4,600	1,900	1,700	1,900	2,600	2,100	1,600	2,400	3,000	2,900	3,800	2,400	4,000	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	6.1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	8.7	5.2	6.4	6.1	7.8	4.9	5.6	5	7.4	7.3	8.2	5.8	7.3	6.9	4.7	8.2	5.4	7.3	7.7	6.7	4.6	5.1	3.5	6	3.9	4.3	3.7	5.7	5.8	5.1	5.5	6.5	*3.4*	*9.8*
Manganese	470	430	450	380	440	380	410	380	560	520	570	390	510	540	290	610	370	520	460	460	320	310	300	490	290	300	300	410	420	420	410	450	*1*	*440*
Mercury	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	*1.7*	*0.13*
Nickel	35	29	30	24	29	28	31	29	34	36	34	24	34	34	25	40	28	34	33	32	24	28	21	33	24	24	22	27	31	26	30	28	*100*	*20*
Silver	2.4	1.7	2.1	0.6	0.7	1.9	1.4	1.4	4.1	2.6	2.3	0.8	2.1	2.1	0.5	1.7	1.4	2.3	2.2	2.9	0.5	0.6	0.5	0.9	0.4	0.6	0.6	2.4	1.3	3.2	1	3	*4.5*	*1*
Strontium	16	11	12	11	14	9.6	16	16	19	17	16	12	16	16	7.5	20	13	16	16	14	12	13	12	18	15	14	12	15	15	15	15	15	*92*	*NA*
Zinc	77	100	99	69	84	77	80	75	82	79	78	70	86	77	56	93	86	92	81	72	53	63	56	97	110	60	55	74	72	67	79	77	*2,400*	*47*

Analytes (mg/kg)	GF3 16	GF3 4	GF3 8	GF4 0	GF4 12	GF4 16	GF4 4	GF4 8	GF5 12	GF5 4	GF5 8	GF6 0	GF6 12	GF6 16	G-B9 - 8 9/17/2003	G-C10 - 0 9/17/2003	G-C10 - 4 9/17/2003	G-C8 - 0 9/17/2003	G-C8 - 4 9/17/2003	G-C8 - 8 9/17/2003	G-C9 - 0 9/17/2003	G-C9 - 4 9/17/2003	G-C9 - 8 9/17/2003	GD-1 0' 9/18/2003	GD-1 10_5 9/18/2003	GD-1 16' 9/18/2003	GD-1 4' 9/18/2003	GD-1 6' 9/18/2003	G-D10 - 0 9/17/2003	G-D10 - 4 9/17/2003	G-D10 - 8 9/17/2003	GD-2 0' 9/18/2003	DWPC	State Background
Aluminum	22,000	20,000	23,000	19,000	21,000	20,000	20,000	19,000	22,000	20,000	20,000	15,000	16,000	16,000	12,000	12,000	13,000	12,000	13,000	13,000	12,000	14,000	13,000	14,000	14,000	14,000	14,000	14,000	14,000	20,000	13,000	15,000	*1*	*6,900*
Arsenic	2.2	2.2	4	2.1	1.9	2.6	2.1	2	1.8	2.2	1.8	2.4	2.2	2.9	3.2	2.5	2	1.6	2.4	2.6	1.7	2.8	2.9	2.3	6.7	5.3	1.9	2	1.9	4.2	2.3	4.5	*4.6*	*5.8*
Beryllium	0.48	0.54	0.48	0.39	0.55	0.49	0.48	0.48	0.52	0.36	0.46	0.48	0.52	0.48	0.37	0.54	0.52	0.35	0.55	0.53	0.33	0.36	0.37	0.53	0.53	0.56	0.62	0.43	0.5	1	0.42	0.54	*51*	*NA*
Chromium	41	40	44	24	40	39	39	38	34	24	26	31	31	24	24	27	27	25	30	29	20	28	25	27	30	31	29	24	29	27	26	33	*30*	*NA*
Cobalt	29	28	36	21	29	28	27	28	30	20	23	24	24	21	21	21	20	21	23	23	20	24	22	22	21	23	23	20	24	24	24	24	*0.8*	*6.8*
Copper	2,100	2,900	2,700	3,300	2,900	2,400	2,600	2,500	3,000	1,800	2,800	2,400	2,000	3,500	4,100	3,800	2,400	2,700	2,600	3,500	2,900	2,700	3,500	2,200	7,800	4,600	2,200	2,100	2,900	5,400	2,100	4,800	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	9.1	8.2	10	5.2	9	8.4	7.8	7.7	8.6	4.8	5.6	6.2	7.4	5.4	5.9	5.6	5.6	4.9	5.9	5.8	5.2	6.8	6.4	5.6	6.5	7.1	7.1	5.2	5.6	8.8	6	7.3	*3.4*	*9.8*
Manganese	870	860	920	540	900	850	1700	780	950	490	630	630	730	580	390	390	360	380	400	440	350	400	410	430	530	600	500	410	410	680	470	600	*1*	*440*
Mercury	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	0.07	<.05	<.05	0.06	<.05	<.05	<.05	<.05	0.06	*1.7*	*0.13*
Nickel	43	41	45	24	41	40	38	39	42	26	28	30	34	28	30	28	30	27	30	30	28	35	32	26	30	31	28	23	30	32	34	31	*100*	*20*
Silver	1.6	1.5	1.8	0.8	2.3	1.7	1.4	1.5	1.5	0.6	1.6	1.8	2	2.1	3.7	1.8	1.4	0.9	1.4	2.2	1.4	1.5	1.9	3.9	3.7	3.3	2.3	1.4	1	2.5	1.6	2.6	*4.5*	*1*
Strontium	27	22	26	12	24	21	21	20	24	17	13	15	17	14	14	18	18	12	17	17	11	16	14	14	17	17	11	14	16	18	17	17	*92*	*NA*
Zinc	87	85	120	69	90	86	82	85	91	59	75	76	73	66	74	72	75	74	76	76	73	80	74	73	64	74	80	67	82	76	75	77	*2,400*	*47*

exceeds Residential/Commercial I Drinking Water Protection Criteria (DWPC)
For some samples, DWPC was exceeded, but the State Background criteria was not exceeded. Therefore, these samples are not shaded
mg/kg = milligrams per kilogram
Note: Data summary was completed by MDEQ and updated by WESTON

Table 7b
Soil Sample Results Above Residential Drinking Water Protection Criteria
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

Analytes (mg/kg)	GE1 16'	GE1 4'	GE1 8'	GE2 0	GE2 12	GE2 16	GE2 4	GE2 8	GE3 0	GE3 12	GE3 4	GE3 8	GE4 0	GE4 4	GE4 8	GE4 9	GE5 0	GE5 11	GE5 4	GE5 8	GE6 0	GE6 12	GE6 16	GE6 4	*DWPC*	***State Background***
Aluminum	13,000	14,000	15,000	18,000	18,000	20,000	18,000	19,000	20,000	17,000	19,000	18,000	19,000	21,000	24,000	20,000	17,000	16,000	20,000	20,000	18,000	16,000	19,000	19,000	*1*	*6,900*
Arsenic	3.2	1.7	2.4	1.9	2.6	2	2.3	2.5	1.6	1.6	2.5	3.5	2.7	2	2.7	2.9	2.2	3.3	1.9	4.2	1.9	3.2	2.2	2.9	*4.6*	*5.8*
Beryllium	0.54	0.56	0.5	0.45	0.43	0.47	0.45	0.44	0.41	0.44	0.5	0.43	0.42	0.46	0.44	0.51	0.3	0.37	0.48	0.46	0.34	0.41	0.48	0.35	*51*	*NA*
Chromium	30	33	35	28	33	38	31	35	31	31	38	30	24	37	39	30	18	20	32	31	18	22	26	20	*30*	*NA*
Cobalt	24	27	25	25	26	28	25	25	25	24	26	24	21	27	30	25	17	19	24	24	17	19	22	18	*0.8*	*6.8*
Copper	2,800	2,200	2,100	2,100	2,700	2,700	2,100	1,900	1,800	1,800	2,200	3,600	3,100	2,000	2,600	2,500	1,500	3,600	3,100	2,700	1,900	4,600	2,700	1,900	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	5.4	5.8	7	6.1	8.3	8.2	7.5	8.6	7.4	5.1	9.1	7.1	7	7.9	10	7.5	4	4.8	9.2	9.3	3.2	5.4	6	4.5	*3.4*	*9.8*
Manganese	490	480	570	670	820	830	790	790	730	760	800	740	600	820	1000	810	450	530	850	830	430	580	630	450	*1*	*440*
Mercury	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	*1.7*	*0.13*
Nickel	31	31	37	31	39	40	39	38	37	40	40	40	27	40	48	36	24	26	36	39	23	27	31	26	*100*	*20*
Silver	2.4	2.3	1.6	2.3	1.7	1.4	1.5	1.5	1.1	2	1.6	2.7	1.4	1.9	1.2	1.9	0.4	1.8	1.7	1.8	1	2.1	1.6	0.6	*4.5*	*1*
Strontium	20	20	18	22	20	22	19	21	17	18	19	20	12	15	25	16	13	13	20	20	11	13	15	15	*92*	*NA*
Zinc	76	87	78	85	81	94	79	79	84	72	81	73	73	85	92	80	54	65	75	84	55	67	76	59	*2,400*	*47*

Analytes (mg/kg)	GA-6 4' 9/17/2003	GA-6 8' 9/17/2003	GA-7 0' 9/17/2003	GA-7 4 9/17/2003	GA-7 8' 9/17/2003	G-A8 - 0 9/17/2003	G-A8 - 4 9/17/2003	G-A8 - 8 9/17/2003	G-A9 - 0 9/17/2003	G-A9 - 4 9/17/2003	GB-1 0'-4' 9/16/2003	GB-1 12'-16' 9/16/2003	GB-1 16'-20' 9/16/2003	GB-1 20'-24' 9/16/2003	GB-1 4'-8' 9/16/2003	GB-1 8'-12' 9/16/2003	G-B10 - 0 9/17/2003	G-B10 - 4 9/17/2003	G-B10 - 8 9/17/2003	G-B8 - 0 9/17/2003	G-B8 - 4 9/17/2003	G-B8 - 8 9/17/2003	G-B9 - 0 9/17/2003	G-B9 - 4 9/17/2003	*DWPC*	***State Background***
Aluminum	14,000	12,000	14,000	14,000	13,000	14,000	12,000	12,000	13,000	12,000	15,000	16,000	14,000	15,000	15,000	16,000	13,000	13,000	13,000	13,000	14,000	13,000	13,000	13,000	*1*	*6,900*
Arsenic	1.8	2.8	2.2	2.4	1.7	2.5	2.3	2.3	2	3	2.2	3.6	3.1	3	15.5	2.7	2.3	2.8	2.7	2.4	1.7	2	2	2.4	*4.6*	*5.8*
Beryllium	0.49	0.43	0.45	0.55	0.75	0.53	0.56	0.47	0.33	0.41	0.3	0.39	0.32	0.34	0.52	0.42	0.52	0.55	0.54	0.52	0.57	0.54	0.34	0.39	*51*	*NA*
Chromium	27	23	24	26	22	30	26	19	23	23	22	31	30	41	32	38	27	31	32	26	29	24	18	25	*30*	*NA*
Cobalt	23	19	20	22	19	24	20	16	22	20	21	23	24	23	25	27	22	22	24	23	23	19	19	22	*0.8*	*6.8*
Copper	2,700	4,100	2,400	3,800	3,400	3,100	3,100	3,100	2,100	3,700	2,400	3,000	2,700	3,600	13,000	2,800	2,500	2,700	2,700	2,700	2,300	2,600	2,400	3,400	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	5.2	4.3	4.8	5	4.3	5.4	5	5	5.6	5.7	5.5	7.6	8	6.4	7.3	7.8	5	5.4	5	5.3	5.4	5.1	5.6	6.1	*3.4*	*9.8*
Manganese	420	370	370	410	370	410	340	370	370	370	390	580	590	490	530	600	390	420	410	390	410	370	400	410	*1*	*440*
Mercury	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	*1.7*	*0.13*
Nickel	30	24	25	28	24	27	26	25	32	28	25	32	35	31	34	38	30	29	30	29	29	27	26	30	*100*	*20*
Silver	2.2	2	1.2	1.9	1.8	1.6	1.8	2.2	1.2	3.7	0.7	2.3	2.2	1.9	6	2	1.1	2	1.7	1.2	2.7	1.8	1.1	2.5	*4.5*	*1*
Strontium	14	15	13	15	14	16	17	17	9.6	14	10	14	16	13	17	19	16	19	17	14	16	17	9.9	14	*92*	*NA*
Zinc	100	67	70	86	65	85	68	69	77	67	71	74	81	100	76	86	79	76	79	80	79	71	75	74	*2,400*	*47*

Analytes (mg/kg)	GD-2 12' 9/18/2003	GD-2 16' 9/18/2003	GD-2 4' 9/18/2003	GD-2 8' 9/18/2003	GD-3 0' 9/18/2003	GD-3 12' 9/18/2003	GD-3 14' 9/18/2003	GD-3 4' 9/18/2003	GD-3 8' 9/18/2003	GD-4 0' 9/18/2003	GD-4 10' 9/18/2003	GD-4 4' 9/18/2003	GD-4 8' 9/18/2003	GD-5 0' 9/18/2003	GD-5 4' 9/18/2003	GD-5 6' 9/18/2003	GD-6 0' 9/18/2003	GD-6 12' 9/18/2003	GD-6 4' 9/18/2003	GD-6 6' 9/18/2003	GD-6 9' 9/18/2003	GD-7 0' 9/18/2003	GD-7 4' 9/18/2003	GD-7 7' 9/18/2003	GD-8 - 0 9/17/2003	GD-8 - 4 9/17/2003	G-D9 - 0 9/17/2003	G-D9 - 4 9/17/2003	G-E10 - 0 9/17/2003	G-E10 - 4 9/17/2003	G-E10 - 8 9/17/2003	*DWPC*	***State Background***
Aluminum	15,000	16,000	17,000	16,000	14,000	16,000	19,000	13,000	16,000	13,000	15,000	18,000	18,000	15,000	17,000	13,000	13,000	13,000	12,000	14,000	14,000	14,000	13,000	14,000	13,000	13,000	14,000	12,000	11,000	13,000	12,000	*1*	*6,900*
Arsenic	1.9	2.1	2.2	4.7	2.5	2.4	2.9	2.4	3.5	2.3	2.4	2.1	3.9	2.2	2.7	3	2.3	2.5	2.8	1.6	2.7	2.1	2	2.7	2.4	2.7	2.5	1.8	2.3	1.8	2.6	*4.6*	*5.8*
Beryllium	0.55	0.52	0.58	0.39	0.53	0.54	0.6	0.55	0.48	0.43	0.53	0.5	0.58	0.51	0.52	0.5	0.44	0.51	0.47	0.49	0.52	0.45	0.55	0.69	0.5	0.49	0.33	0.34	0.34	0.41	0.36	*51*	*NA*
Chromium	34	32	34	31	33	35	40	31	34	23	35	28	39	30	36	24	22	31	25	28	32	26	25	31	22	25	23	25	21	23	24	*30*	*NA*
Cobalt	24	25	29	24	24	26	30	23	24	19	26	24	29	23	26	20	18	23	20	24	24	21	21	23	19	20	22	22	21	21	21	*0.8*	*6.8*
Copper	2,100	2,200	1,900	5,100	2,200	2,400	2,400	1,700	3,700	1,800	2,100	2,100	4,200	2,400	2,300	3,000	1,800	3,000	4,600	2,300	3,700	2,200	2,500	3,700	2,200	3,200	2,600	2,500	2,800	2,200	2,900	*5,800*	*32*
Lead	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5.5	<5	5.3	<5	<5	<5	<5	<5	<5	*700*	*21*
Lithium	7.5	7.4	6.8	7.2	6.2	7.3	8.5	6.7	7.8	4.1	6.8	5.9	8.8	6.9	7.6	4.6	4	4.9	4.3	5.3	4.6	4.2	4.4	5.2	4.2	5.8	5.6	6.6	4.3	5.5	5.9	*3.4*	*9.8*
Manganese	620	650	570	620	490	650	730	510	630	310	560	440	720	610	630	390	300	400	380	440	380	320	350	440	320	410	360	380	330	360	400	*1*	*440*
Mercury	<.05	<.05	0.07	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	0.11	<.05	0.06	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	*1.7*	*0.13*
Nickel	35	36	34	33	30	37	42	32	36	23	35	29	39	32	36	27	23	30	26	30	31	26	26	29	25	30	30	31	28	29	29	*100*	*20*
Silver	1.4	2	2	4.6	2	1.9	1.4	2.2	2.1	0.6	1.8	0.9	2	1.6	1.6	1.2	0.7	1.5	1.4	1.2	1.3	0.6	0.9	2.1	0.6	1.4	0.8	1.8	1.2	1.4	1.9	*4.5*	*1*
Strontium	17	22	22	20	15	24	26	17	21	14	20	21	24	19	22	14	14	17	14	18	19	16	17	16	14	15	12	13	8.1	15	13	*92*	*NA*
Zinc	70	77	94	70	77	79	92	66	72	58	82	73	87	70	78	68	55	71	67	80	74	62	65	74	65	73	73	70	74	75	72	*2,400*	*47*

exceeds Residential/Commercial I Drinking Water Protection Criteria (DWPC)
For some samples, DWPC was exceeded, but the State Background criteria was not exceeded. Therefore, these samples are not shaded
mg/kg = milligrams per kilogram
Note: Data summary was completed by MDEQ and updated by WESTON

Table 8
Dissolved Groundwater Sample Results Above Residential Drinking Water Criteria
Gay 2003 Stamp Sand Soil Quality Evaluation

Analytes (ug/L)	Part 201 Residential/Commercial I Drinking Water Criteria		GD-1 25-27 9/20/03	GB-2 28-30 9/20/03	GF-4 22.24 9/20/03	GC-4 22.24 9/20/03	GE-5 19-21 9/20/03	GA-6 13-15 9/20/03	GD-7 10-12 9/20/03	GB-8 7-9 9/20/03	GF-9 16-18 9/20/03	GC-10 7-9 9/20/03
Mercury - Dissolved	2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Aluminum - Dissolved	50*	300	<50	<50	<50	<50	<50	<50	<50	**120**	**92**	**56**
Arsenic - Dissolved	10		1.3	6.9	4.8	2.0	5.6	3.1	2.3	4.5	4.2	6.5
Barium - Dissolved	2,000		73	60	14	18	7.2	6.6	5.0	5.0	5.0	5.0
Beryllium - Dissolved	4		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cadmium - Dissolved	5		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium - Dissolved	100		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cobalt - Dissolved	40		<15	<15	<15	<15	<15	<15	<15	<15	<15	<15
Copper - Dissolved	1,000*	1,400	7.1	3.1	10	4.2	18	8.2	9.9	16	13	23
Lead - Dissolved	4		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Manganese - Dissolved	50*	860	**240**	**430**	**78**	**320**	**150**	47	**56**	15	20	11
Nickel - Dissolved	100		2.9	3.1	2.5	2.7	2.1	2.0	2.0	2.0	2.0	2.0
Selenium - Dissolved	50		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Silver -Dissolved	34		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium - Dissolved	4,600		250	310	260	300	230	180	130	95	110	120
Zinc - Dissolved	2,400		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Lithium - Dissolved	170		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Shading indicates the analyte was detected.
Bold font indicates Residential/Commercial I Drinking Water Criteria was exceeded.
ug/L = micrograms per liter
* Note, the Part 201 Residential Drinking Water Criteria for aluminum, copper, and manganese are the aesthetic drinking water criteria.
The second value for these analytes is the State Of Michigan Health-Based Drinking Water Standard.

Data summary was completed by MDEQ and updated by WESTON.

Table 9a
Calculation of Mean PEC Quotients
Gay Southern Area 2003 Stamp Sand Soil Quality Evaluation
(All concentrations in mg/kg)

	Soil Concentration		Sediment Quality Guidelines		PEC Quotient	
Analyte	**Maximum**	**95 UCL**	**TEC**	**PEC**	**Maximum**	**95 UCL**
Aluminum	16,000	11,791	--	--	--	--
Arsenic	2.7	1.6	9.79	33	0.08	0.05
Beryllium	0.61	0.46	--	--	--	--
Chromium	42	29.4	43.4	111	0.38	0.27
Cobalt	28	19.71	--	--	--	--
Copper	5,300	1,713	31.6	149	35.6	11.5
Lead	--	--	35.8	128	--	--
Lithium	8	5.8	--	--	--	--
Manganese	560	407	--	--	--	--
Mercury	--	--	0.18	1.06	--	--
Nickel	44	27.5	22.7	48.6	0.91	0.57
Silver	2.6	1.27	--	--	--	--
Strontium	35	13	--	--	--	--
Zinc	92	66	121	459	0.20	0.14
				SUM of PEC quotients	37	13
				Mean PEC quotient	7.4	2.5

PEC = Probable effect concentration.
TEC = Threshold effect concentration.
95UCL = 95% upper confidence limit on the mean.
PEC Quotient = Soil Concentration / PEC
-- = Not available.

Table 9b
Calculation of Mean PEC Quotients
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation
(All concentrations in mg/kg)

	Soil Concentration		Sediment Quality Guidelines		PEC Quotient	
Analyte	**Maximum**	**95 UCL**	**TEC**	**PEC**	**Maximum**	**95 UCL**
Aluminum	24,000	15,872	--	--	--	--
Arsenic	15.5	2.65	9.79	33	0.47	0.08
Beryllium	1.6	0.48	--	--	--	--
Chromium	52	29.5	43.4	111	0.47	0.27
Cobalt	36	23.3	--	--	--	--
Copper	13,000	2,972	31.6	149	87.25	19.95
Lead	6.1	2.6	35.8	128	0.048	0.020
Lithium	10	6.2	--	--	--	--
Manganese	1,700	549	--	--	--	--
Mercury	0.11	0.028	0.18	1.06	0.10	0.03
Nickel	48	31.6	22.7	48.6	0.99	0.65
Silver	7.7	1.84	--	--	--	--
Strontium	30	17.05	--	--	--	--
Zinc	120	75.8	121	459	0.26	0.17
				SUM of PEC quotients	90	21
				Mean PEC quotient	12.8	3.0

PEC = Probable effect concentration.
TEC = Threshold effect concentration.
95UCL = 95% upper confidence limit on the mean.
PEC Quotient = Soil Concentration / PEC
-- = Not available.

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Table 10a

Comparison to Alternative Sediment Screening Benchmarks[1]
Gay Southern Area 2003 Stamp Sand Soil Quality Evaluation
(All concentrations in mg/kg)

Analyte	Soil Concentration		ARCS			Ontario		NOAA		R5 ESL	FDEP	
	Maximum	95 UCL	NEC	PEC	TEC	Low	Severe	ER-L	ER-M		PEL	TEL
Aluminum	16,000	11,791	73,200	58,000	--	--	--	--	--	--	--	--
Beryllium	0.61	0.46	--	--	--	--	--	--	--	--	--	--
Cobalt	28	19.71	--	--	--	--	--	--	--	50	--	--
Lithium	8	5.8	--	--	--	--	--	--	--	--	--	--
Manganese	560	407	819	1,080	1,670	**460**	1,100	--	--	--	--	--
Silver	2.6	1.27	--	--	--	--	--	**1**	3.7	**0.5**	**1.77**	**0.73**
Strontium	35	13	--	--	--	--	--	--	--	--	--	--

Shading indicates 95UCL concentration exceeds screening benchmark.
Bold indicates maximum concentration exceeds screening benchmark.

[1]Source: ORNL Risk Assessment Information System (RAIS) database.
URL: http://risk.lsd.ornl.gov/cgi-bin/eco/bench_select

NEC = No effect concentration
PEC = Probable effects concentration.
TEC = Threshold effects concentration.
ER-L = Effects Range-low
ER-M = Effects Range-median
ESL = Ecological Screening Level
PEL = Probable effects level
TEL = Threshold effects level
R5 = U.S. EPA Region 5
FDEP = Florida Department of Environmental Protection
NOAA = National Oceanic and Atmospheric Administration
ARCS = U.S. EPA Assessment and Remediation of Contaminated Sediments Program.

Table 10b
Comparison to Alternative Sediment Screening Benchmarks[1]
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation
(All concentrations in mg/kg)

	Soil Concentration		ARCS			Ontario		NOAA		R5 ESL	FDEP	
Analyte	**Maximum**	**95 UCL**	**NEC**	**PEC**	**TEC**	**Low**	**Severe**	**ER-L**	**ER-M**		**PEL**	**TEL**
Aluminum	24,000	15,872	73,200	58,000	--	--	--	--	--	--	--	--
Beryllium	1.6	0.48	--	--	--	--	--	--	--	--	--	--
Cobalt	36	23.3	--	--	--	--	--	--	--	50	--	--
Lithium	10	6.2	--	--	--	--	--	--	--	--	--	--
Manganese	1,700	549	**819**	**1,080**	**1,670**	**460**	**1,100**	--	--	--	--	--
Silver	7.7	1.84	--	--	--	--	--	**1**	**3.7**	**0.5**	**1.77**	**0.73**
Strontium	30	17.05	--	--	--	--	--	--	--	--	--	--

Shading indicates 95UCL concentration exceeds screening benchmark.
Bold indicates maximum concentration exceeds screening benchmark.

[1]Source: ORNL Risk Assessment Information System (RAIS) database.
URL: http://risk.lsd.ornl.gov/cgi-bin/eco/bench_select

NEC = No effect concentration
PEC = Probable effects concentration.
TEC = Threshold effects concentration.
ER-L = Effects Range-low
ER-M = Effects Range-median
ESL = Ecological Screening Level
PEL = Probable effects level
TEL = Threshold effects level
R5 = U.S. EPA Region 5
FDEP = Florida Department of Environmental Protection
NOAA = National Oceanic and Atmospheric Administration
ARCS = U.S. EPA Assessment and Remediation of Contaminated Sediments Program.
UCL = upper confidence limit
mg/kg = milligrams per kilogram

Table 11a
Comparison to Groundwater Surface Water Interface Protection Criteria Based on Surface Water Quality Criteria
Gay Southern Area 2003 Stamp Sand Soil Quality Evaluation

	Rule 57 Water Quality Criteria (ug/L)			Soil-Water Distribution Coefficients (Kd)	GSWIP (mg/kg)			Soil Concentration (mg/kg)	
Analyte	**FCV**	**AMV**	**FAV**	**L/Kg**	**FCV**	**AMV**	**FAV**	**Maximum**	**95 UCL**
Aluminum	NA	NA	NA	NA	NA	NA	NA	16,000	11,791
Arsenic	150	340	680	29	70	158	316	2.7	1.6
Beryllium	0.34	3.0	6.0	790	4.2	38	76	0.61	0.46
Chromium [D]	39	302	603	1.8E+6	1,130,042	8,687,319	17,374,637	42	29.4
Cobalt	100	370	740	NA	NA	NA	NA	28	19.71
Copper [D]	4.6	6.5	13	360	27	37	74	**5,300**	**1,713.7**
Lead [D]	4.4	39	78	11,000	771	6,862	13,725	--	--
Lithium	96	870	1,700	NA	NA	NA	NA	8	5.8
Manganese	976	2,105	4,209	NA	NA	NA	NA	560	407
Mercury	0.77	1.4	2.8	52	0.6	1.2	2.3	--	--
Nickel [D]	27	243	485	65	28	252	505	**44**	27.5
Silver	0.06	0.54	1.1	8.3	0.008	0.07	0.15	**2.6**	**1.27**
Strontium	8,300	75,000	150,000	NA	NA	NA	NA	35	13
Zinc [D]	61	61	121	62	61	60	120	**92**	**66**

Bold indicated GWSIP criteria was exceeded.
All Rule 57 water quality criteria are expressed as total unless indicated D for dissolved.
FCV = Final chronic value, based on hardness of 46 milligrams/liter (mg/L) where applicable.
FAV = Final acute value, based on hardness of 46 mg/L where applicable.
AMV = Aquatic maximum value, based on hardness of 46 mg/L where applicable.
GWSIP = Groundwater surface water interface protection criteria.
Kd values from MDEQ Part 201 tables.
NA = Not available.
ln(H) = 3.828641396

Total to dissolved conversion factor for lead = 0.904158662
UCL = upper confidence limit
L/kg = liters per kilogram
mg/kg = milligrams per kilogram
ug/L = milligrams per liter
Note: source for 46 mg/L hardness value is 2003 MDEQ investigation.

Table 11b
Comparison to Groundwater Surface Water Interface Protection Criteria Based on Surface Water Quality Criteria
Gay Northern Area 2003 Stamp Sand Soil Quality Evaluation

	Rule 57 Water Quality Criteria (ug/L)			Soil-Water Distribution Coefficients (Kd)	GSWIP (mg/kg)			Soil Concentration (mg/kg)	
Analyte	**FCV**	**AMV**	**FAV**	**L/Kg**	**FCV**	**AMV**	**FAV**	**Maximum**	**95 UCL**
Aluminum	NA	NA	NA	NA	NA	NA	NA	24,000	15,872
Arsenic	150	340	680	29	70	158	316	15.5	2.65
Beryllium	0.34	3.0	6.0	790	4.2	38	76	1.6	0.48
Chromium [D]	39	302	603	1.8E+6	1,130,042	8,687,319	17,374,637	52	29.5
Cobalt	100	370	740	NA	NA	NA	NA	36	23.3
Copper [D]	4.6	6.5	13	360	27	37	74	**13,000**	**2,972**
Lead [D]	4.4	39	78	11,000	771	6,862	13,725	6.1	2.6
Lithium	96	870	1,700	NA	NA	NA	NA	10	6.2
Manganese	976	2,105	4,209	NA	NA	NA	NA	1,700	549
Mercury	0.77	1.4	2.8	52	0.6	1.2	2.3	0.11	0.028
Nickel [D]	27	243	485	65	28	252	505	**48**	**31.6**
Silver	0.06	0.54	1.1	8.3	0.008	0.07	0.15	**7.7**	**1.84**
Strontium	8,300	75,000	150,000	NA	NA	NA	NA	30	17.05
Zinc [D]	61	61	121	62	61	60	120	**120**	**75.8**

Bold indicated GWSIP criteria was exceeded.
All Rule 57 water quality criteria are expressed as total unless indicated D for dissolved.
FCV = Final chronic value, based on hardness of 46 milligrams per liter (mg/L) where applicable.
FAV = Final acute value, based on hardness of 46 mg/L where applicable.
AMV = Aquatic maximum value, based on hardness of 46 mg/L where applicable.
GWSIP = Groundwater surface water interface protection criteria.
Kd values from MDEQ Part 201 tables.
NA = Not available.
ln(H) = 3.828641396

Total to dissolved conversion factor for lead = 0.904158662
UCL = upper confidence limit
L/kg = liters per kilogram
mg/kg = milligrams per kilogram
ug/L = milligrams per liter
Note: source for 46 mg/L hardness value is 2003 MDEQ investigation.

Table 12a
Comparison of Total Groundwater Data to Surface Water Quality Criteria
Gay 2003 Stamp Sand Soil Quality Evaluation

Chemical	Rule 57 Water Quality Criteria (ug/L)			GD-1	GB-2	GF-4	GC-4	GE-5	GA-6	GD-7	GB-8	GF-9	GC-10
	FCV	**AMV**	**FAV**	(ug/L)									
Aluminum	NA	NA	NA	1,000	2,700	30,000	19,000	35,000	14,000	72,000	21,000	36,000	13,000
Arsenic	150	340	680	1.8	7.4	7.4	5.1	12	4.4	19	6.5	15	8.9
Beryllium	0.34	3.02	6.05	<1	<1	<1	<1	<1	<1	**2.5**	<1	**1.2**	<1
Chromium	45.6	955	955	2.1	6.6	**58**	**52**	**65**	29	**120**	36	**75**	31
Cobalt	100	370	740	<15	<15	63	36	60	31	89	45	56	25
Copper	4.8	6.7	6.7	**280**	**250**	**1,700**	**2,000**	**4,500**	**770**	**22,000**	**1,800**	**13,000**	**2,200**
Lead	4.8	43.1	43.1	<1	<1	2.7	2.7	**5.1**	1.4	**13**	2	**6.6**	2.1
Lithium	96	870	1,700	<10	<10	17	15	18	<10	30	13	15	<10
Manganese	976	2,105	4,209	260	500	**1,100**	**1,000**	**1,500**	550	**2,600**	760	**1,200**	420
Mercury	0.77	1.4	2.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2
Nickel	27.0	243	243	5.2	9.6	**75**	**47**	**74**	**40**	**110**	**56**	**66**	**30**
Selenium	5	62	120	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Silver	0.06	0.54	1.1	<0.5	<0.5	**1.6**	**1.9**	**4.7**	**1.1**	**16**	**5.2**	**6.9**	**4**
Strontium	8,300	75,000	150,000	240	300	290	240	290	180	290	93	180	130
Zinc	62.1	62.1	62.1	<10	18	**190**	**120**	**200**	**100**	**320**	**150**	**200**	**81**

Shading indicates detected concentration.
Bold indicates FCV is exceeded.
FCV = Final chronic value, based on hardness of 46 milligrams per liter (mg/L) where applicable.
FAV = Final acute value, based on hardness of 46 mg/L where applicable.
AMV = Aquatic maximum value, based on hardness of 46 mg/L where applicable.
NA = Not available.
ln(H) = 3.8
ug/L = micrograms per liter
<1 = analyte was not detected above respective detection limit.
Note: source of 46 mg/L hardness value is 2003 MDEQ investigation.

Table 12b
Comparison of Dissolved Groundwater Data to Surface Water Quality Criteria
Gay 2003 Stamp Sand Soil Quality Evaluation

Chemical	Rule 57 Water Quality Criteria (ug/L)			GD-1	GB-2	GF-4	GC-4	GE-5	GA-6	GD-7	GB-8	GF-9	GC-10
	FCV	**AMV**	**FAV**	(ug/L)									
Aluminum	NA	NA	NA	<50	<50	<50	<50	<50	<50	<50	120	92	56
Arsenic	150	340	680	1.3	6.9	4.8	2	5.6	3.1	2.3	4.5	4.2	6.5
Beryllium	0.34	3.02	6.05	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	39.2	302	603	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cobalt	100	370	740	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15
Copper	4.6	6.5	12.9	**7.1**	3.1	**10**	4.2	**18**	**8.2**	**9.9**	**16**	**13**	**23**
Lead	4.4	39.0	78.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Lithium	96	870	1,700	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Manganese	976	2,105	4,209	240	430	78	320	150	47	56	15	20	11
Mercury	0.77	1.4	2.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel	27.0	243	485	2.9	3.1	2.5	2.7	2.1	2	2	2	2	2
Selenium	5	62	120	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Silver	0.06	0.54	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium	8,300	75,000	150,000	250	310	260	300	230	180	130	95	110	120
Zinc	61.2	60.7	121.4	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Shading indicates detected concentration.
Bold indicates FCV is exceeded.
FCV = Final chronic value, based on hardness of 46 mg/L where applicable.
FAV = Final acute value, based on hardness of 46 mg/L where applicable.
AMV = Aquatic maximum value, based on hardness of 46 mg/L where applicable.
NA = Not available.
ln(H) = 3.8
dissolved conversion factor for lead 0.90
ug/L = micrograms per liter
<1 = analyte was not detected above respective detection limit.
Note: source of 46 mg/L hardness value is 2003 MDEQ investigation.

Table 13
Phase I Bioassessment Chemical and Physical Analyses Results
The Gay Site
Gay, Michigan

Sample I.D. Sample Location: Sample Date: Metals (mg/kg)	KCRC-1 Keweenaw 1/21/2005	KCRC-2 Keweenaw 1/21/2005	KCRC-3 Keweenaw 1/21/2005	KCRC-4 Keweenaw 1/21/2005	KCRC-5 Keweenaw 1/21/2005	KCRC-6 Keweenaw 1/21/2005	KCRC-7 Keweenaw 1/21/2005	KCRC-8 Keweenaw 1/21/2005	KCRC-9 Keweenaw 1/21/2005	KCRC-10 Keweenaw 1/21/2005
Aluminium	17,000	16,000	16,000	16,000	17,000	16,000	17,000	16,000	17,000	17,000
Arsenic	1.7	1.6	1.1	1.5	1.2	1.5	1.5	1.3	1.3	1.4
Beryllium	0.45	0.4	0.4	0.39	0.38	0.35	0.48	0.48	0.5	0.42
Chromium	27	27	26	26	27	25	26	25	25	24
Cobalt	24	23	22	21	21	20	25	24	26	24
Copper	2,100	2,400	2,000	1,900	1,900	1,800	1,900	2,700	2,200	2,200
Lead	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Lithium	6.2	6.1	5.5	5.9	5.8	5.5	6.9	7.0	7.1	6.7
Manganese	450	420	400	400	390	370	460	450	470	430
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel	31	29	29	30	30	28	30	27	28	26
Silver	1.3	1.2	1.2	1.1	1.0	1.1	1.9	1.2	1.2	0.9
Strontium	12	12	11	12	12	11	14	14	14	15
Zinc	86	83	81	80	80	77	81	76	79	74

mg/kg = milligrams per kilogram

Analyte	KCRC-6	KCRC-8	Silica Sand	Sandia Creek
% Gravel	34.1	36.4	0	4
% Sand	59.4	56.9	99.2	84.4
% Silt	3.7	3.9	0.4	9.6
% Clay	2.8	2.8	0.4	2
TOC	0.07	0.07	0.03	0.39

% = percent
TOC = total organic carbon

Table 14
Phase I Bioassessment Bioassay Results
The Gay Site
Gay, Michigan

		Standard Unacclimated							Acclimated						
		Elutriate Concentration (%)							Elutriate Concentration (%)						
Sample	Test	Control 0%	10%	50%	100%	LC_{50}	NOEC	TUa [1]	Control 0%	10%	50%	100%	LC50	NOEC	TUa [1]
KCRC - 6	*C. dubia*		92	4	0	23.51	10	10		75	40	0	29.6	<10	>10
KCRC - 8			96	4	0	23.48	10	10	100	80	30	0	23.58	10	10

		Standard Unacclimated		Acclimated	
Sample	Test	Survival %	Growth (mg)	Survival (%)	Growth (mg)
Control 1 (a)	*H. azteca* 10-day	90	0.187	100	0.147
Control 2 (b)		97.5	0.3214	100	0.222
Control 3 (c)		Not tested		Not tested	
KCRC - 6		87.5	0.171 b*	96.7	0.123 b*
KCRC - 8		81.25 b*	0.118 a*, b*	90	0.16
Control 1 (a)	*H. azteca* 28-day	Not tested under standard protocol because too high mortality under this protocol occurred during the 10-day exposure.		84	0.256
Control 2 (b)				94	0.512
Control 3 (c)				Not tested	
KCRC - 6				72	0.251 b*
KCRC - 8				88	0.304 b*
Control 1 (a)	*C. dilutus* 10- day	Not tested		76.3	1.967
Control 2 (b)		90	1.365	82.7	1.849
Control 3 (c)		77.5	1.006	92.6	1.457
KCRC - 6		86.25	0.694 c*, b*	67.5 c*	0.535 a*, b*, c*
KCRC - 8		73.75 b*	0.716 c*, b*	78.8	0.548 a*, b*, c*

[1] TUa = Toxic Units Acute. Calculated by 100/NOEC
*Statistically significant from controls a (silica sand), b (Sandia Creek) or c (peat moss)
LC50 = median lethal concentration
NOEC = no observable effect concentration
% = percent
TUa =acute toxicity units
mg = milligrams

Table 15
Phase II Bioassessment Chemical and Physical Analyses Results
The Gay Site
Gay, Michigan

Sample I.D.	Gay Toxicity A				Rule 57 Water Quality Values		
Collection Date	Sep-05						
	Solid Phase Total Metals (mg/kg)	SEM (mg/kg)	Elutriate Total Results (mg/L)	Elutriate Dissolved Results (mg/L)	FCV (mg/L)	AMV (mg/L)	FAV (mg/L)
Aluminum	15,000	1,340	6	0.061	Not Available		
Arsenic	3.7	-	0.0015	-	0.15	0.34	0.68
Beryllium	0.48	0.10	-	-	0.00034	0.003	0.006
Cadmium	NT	-	NT	NT	0.0022	0.0011	0.0023
Chromium	29	3.3	0.011	-	0.039	0.302	0.603
Cobalt	24	1.7	-	-	0.1	0.37	0.74
Copper	4,400	2,470	0.81	0.028	0.0046	0.0065	0.013
Lead	-	-	0.0016	-	0.0044	0.039	0.078
Lithium	4.7	-	-	-	0.096	0.87	1.7
Manganese	440	113	0.17	-	0.976	2.105	4.209
Mercury	-	0.03	-	-	0.00077	0.0014	0.0028
Nickel	31	2.0	0.014	-	0.027	0.243	0.485
Silver	1.4	1.6	0.0005	-	0.00006	0.00054	0.0011
Strontium	10	4.1	0.057	0.059	8.3	75	150
Zinc	81	8.2	0.034	-	0.061	0.061	0.121
AVS (mg/kg)		-			Not Applicable		

Sample I.D.	Gay Toxicity B				Rule 57 Water Quality Values		
Collection Date	Sep-05						
	Solid Phase Total Metals (mg/kg)	SEM (mg/kg)	Elutriate Total Results (mg/L)	Elutriate Dissolved Results (mg/L)	FCV (mg/L)	AMV (mg/L)	FAV (mg/L)
Aluminum	12,000	976	6.5	0.076	Not Available		
Arsenic	2.9	-	-	-	0.15	0.34	0.68
Beryllium	0.4	0.08	-	-	0.00034	0.003	0.006
Cadmium	NT	-	NT	NT	0.0022	0.0011	0.0023
Chromium	29	2.0	0.0089	-	0.039	0.302	0.603
Cobalt	23	1.2	-	-	0.1	0.37	0.74
Copper	3,800	1,010	0.62	0.032	0.0046	0.0065	0.013
Lead	-	-	-	-	0.0044	0.039	0.078
Lithium	5.9	NT	-	-	0.096	0.87	1.7
Manganese	370	82	0.15	-	0.976	2.105	4.209
Mercury	-	0.01	-	-	0.00077	0.0014	0.0028
Nickel	32	1.3	0.011	-	0.027	0.243	0.485
Silver	1.3	0.7	0.00042	-	0.00006	0.00054	0.0011
Strontium	7.6	3.3	0.061	0.063	8.3	75	150
Zinc	76	6.4	0.027	-	0.061	0.061	0.121
AVS (mg/kg)		-			Not Applicable		

Notes:
AVS = acid volatile sulfide
ID = insufficient data to derive value
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
NA = not available
NT = not tested
NTU = nephelometric turbidity unit
SEM = simultaneously extracted metals
TSS = total suspended solids
TDS = total dissolved solids
umhos/cm = micro ohms per centimeter
- = not detected

Shaded cells indicate Rule 57 Water Quality Value is exceeded.

Laboratory Notes:
D = Analyte value quantified from a dilution(s); reporting limit raised

Criteria Notes:
AMV = Aquatic maximum value, based on hardness of 46 mg/L where applicable.
FAV = Final acute value, based on hardness of 46 mg/L where applicable.
FCV = Final chronic value, based on hardness of 46 mg/L where applicable.

Table 15
Phase II Bioassessment Chemical and Physical Analyses Results
The Gay Site
Gay, Michigan

Sample I.D.	Gay Toxicity C				Rule 57 Water Quality Criteria		
Collection Date	Sep-05						
	Solid Phase Total Metals (mg/kg)	SEM (mg/kg)	Elutriate Total Results (mg/L)	Elutriate Dissolved Results (mg/L)	FCV (mg/L)	AMV (mg/L)	FAV (mg/L)
Aluminum	13,000	1,070	5	0.084	Not Available		
Arsenic	4.2	<5.0	-	-	0.15	0.34	0.68
Beryllium	0.37	0.11	-	-	0.00034	0.003	0.006
Cadmium	NT	-	NT	NT	0.0022	0.0011	0.0023
Chromium	31	2.7	0.0067	-	0.039	0.302	0.603
Cobalt	23	1.4	-	-	0.1	0.37	0.74
Copper	3,800	1,950	0.44	0.02	0.0046	0.0065	0.013
Lead	-	-	-	-	0.0044	0.039	0.078
Lithium	6.7	NT	-	-	0.096	0.87	1.7
Manganese	410	98	0.11	-	0.976	2.105	4.209
Mercury	-	0.02	-	-	0.00077	0.0014	0.0028
Nickel	34	1.6	0.0079	-	0.027	0.243	0.485
Silver	1.3	0.3	0.00034	-	0.00006	0.00054	0.0011
Strontium	8.5	3.3	0.056	0.06	8.3	75	150
Zinc	75	6.5	0.018	-	0.061	0.061	0.121
AVS (mg/kg)		-			Not Applicable		

Sample I.D.	Gay Toxicity D				Rule 57 Water Quality Criteria		
Collection Date	Sep-05						
	Solid Phase Total Metals (mg/kg)	SEM (mg/kg)	Elutriate Total Results (mg/L)	Elutriate Dissolved Results (mg/L)	FCV (mg/L)	AMV (mg/L)	FAV (mg/L)
Aluminum	12,000	891	8.8	0.075	Not Available		
Arsenic	1.4	3	0.0014	-	0.15	0.34	0.68
Beryllium	0.38	0.28	-	-	0.00034	0.003	0.006
Cadmium	NT	0.2	NT	NT	0.0022	0.0011	0.0023
Chromium	27	2.3	0.015	-	0.039	0.302	0.603
Cobalt	21	1.4	0.015	-	0.1	0.37	0.74
Copper	1,400	777	0.96	0.017	0.0046	0.0065	0.013
Lead	-	1.0	0.0011	-	0.0044	0.039	0.078
Lithium	5.6	NT	-	-	0.096	0.87	1.7
Manganese	380	90	0.24	0.0053	0.976	2.105	4.209
Mercury	-	0.008	-	-	0.00077	0.0014	0.0028
Nickel	27	1.5	0.021	-	0.027	0.243	0.485
Silver	0.9	0.3	0.00071	-	0.00006	0.00054	0.0011
Strontium	8.4	3.2	0.073	0.057	8.3	75	150
Zinc	76	6.3	0.053	-	0.061	0.061	0.121
AVS (mg/kg)		-					
Calcium				29.4			
Chloride				3			
Conductance (umhos/cm)				196			
Potassium				0.5			
Sodium				18.6			
Sulfate				3			
TOC				0.5			
TDS				110			
TSS				5			
Turbidity (NTU)				25			

Not Applicable

Notes:
AVS = acid volatile sulfide
ID = insufficient data to derive value
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
NA = not available
NT = not tested
NTU = nephelometric turbidity unit
SEM = simultaneously extracted metals
TSS = total suspended solids
TDS = total dissolved solids
umhos/cm = micro ohms per centimeter
- = not detected

Shaded cells indicate Rule 57 Water Quality Value is exceeded.

Laboratory Notes:
D = Analyte value quantified from a dilution(s); reporting limit raised

Criteria Notes:
AMV = Aquatic maximum value, based on hardness of 46 mg/L where applicable.
FAV = Final acute value, based on hardness of 46 mg/L where applicable.
FCV = Final chronic value, based on hardness of 46 mg/L where applicable.

Table 15
Phase II Bioassessment Chemical and Physical Analyses Results
The Gay Site
Gay, Michigan

Sample I.D.	Gay Toxicity E				Rule 57 Water Quality Criteria		
Collection Date	Sep-05						
	Solid Phase Total Metals (mg/kg)	SEM (mg/kg)	Elutriate Total Results (mg/L)	Elutriate Dissolved Results (mg/L)	FCV (mg/L)	AMV (mg/L)	FAV (mg/L)
Aluminum	11,000	971	3.6	0.097	Not Available		
Arsenic	1.5	-	-	-	0.15	0.34	0.68
Beryllium	0.37	0.08	-	-	0.00034	0.003	0.006
Cadmium	NT	-	NT	NT	0.0022	0.0011	0.0023
Chromium	30	2.4	0.0047	-	0.039	0.302	0.603
Cobalt	25	1.3	-	-	0.1	0.37	0.74
Copper	1,700	1,060	0.22	0.016	0.0046	0.0065	0.013
Lead	-	-	-	-	0.0044	0.039	0.078
Lithium	6.5	NT	-	-	0.096	0.87	1.7
Manganese	380	87	0.068	-	0.976	2.105	4.209
Mercury	-	0.02	-	-	0.00077	0.0014	0.0028
Nickel	36	1.4	0.0056	-	0.027	0.243	0.485
Silver	0.9	-	-	-	0.00006	0.00054	0.0011
Strontium	5.6	3.0	0.06	0.061	8.3	75	150
Zinc	82	6.6	0.013	-	0.061	0.061	0.121
AVS (mg/kg)		-			Not Applicable		

Notes:
AVS = acid volatile sulfide
ID = insufficient data to derive value
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
NA = not available
NT = not tested
NTU = nephelometric turbidity unit
SEM = simultaneously extracted metals
TSS = total suspended solids
TDS = total dissolved solids
umhos/cm = micro ohms per centimeter
- = not detected

Laboratory Notes:
D = Analyte value quantified from a dilution(s); reporting limit raised

Criteria Notes:
AMV = Aquatic maximum value, based on hardness of 46 mg/L where applicable.
FAV = Final acute value, based on hardness of 46 mg/L where applicable.
FCV = Final chronic value, based on hardness of 46 mg/L where applicable.

Shaded cells indicate Rule 57 Water Quality Value is exceeded.

Analyte	Gay Tox A	Gay Tox B	Gay Tox C	Gay Tox D	Gay Tox E
% Water	7.58	4.95	4.12	6.45	4.26
% Gravel	33.2	73.8	58.8	81.8	79.3
% Sand	65.9	24.8	40.4	16.9	19.8
% Silt	0.8	1.1	0.4	0.8	0.4
% Clay	0.1	0.2	0.4	0.5	0.5
TOC	0.41	0.18	0.17	0.21	0.15

E = Estimated value below the method reporting limit and above the method detection limit.
% = percent
TOC = total organic carbon

Table 16
Pond Water Chemical Results
The Gay Site
Gay, Michigan Site

Metals (ug/L)	Gay Pond 1	Gay Pond 2	Gay Pond 3	Gay Pond 4	Rule 57 Water Quality Values	
					Final Acute Value (FAV) (ug/L)	Final Chronic Value (FCV) (ug/L)
Aluminum	ND	ND	ND	ND	NA	NA
Arsenic	7.5	5	6	9	680	150
Beryllium	ND	ND	ND	ND	6	0.34
Chromium	ND	ND	ND	ND	603	39
Cobalt	ND	ND	ND	ND	740	100
Copper	**230**	**350**	**130**	**83**	13	5
Lead	ND	ND	ND	ND	78	4
Lithium	ND	ND	ND	ND	1,700	96
Manganese	20	62	10	8	4,209	976
Mercury	ND	ND	ND	ND	2.8	0.8
Nickel	2.4	2.8	2.4	ND	485	27
Silver	ND	ND	ND	ND	1.1	0.1
Strontium	61	44	70	88	150,000	8,300
Zinc	ND	ND	ND	ND	121	61

Data summary was completed by MDEQ.
ug/L = micrograms per liter
ND = non detect
Shaded cells indicate the FAV or FCV was exceeded.

Table 17
Phase II Bioassessment Bioassay Results
The Gay Site
Gay, Michigan

Sample	C. dubia	Standard Unacclimated							
		Elutriate Concentration (%)					LC_{50}	NOEC	TUa [1]
		Control 0%	1	10	50	100			
Gay Tox A		100	96	100	0	0	21.99	10	10
Gay Tox B			96	100	0	0	22.00	10	10
Gay Tox C			88	76	0	0	14.75	1	100
Gay Tox D			84	84	0	0	19.18	10	10
Gay Tox E			96	88	16	12	23.76	10	10

Sample	*H. azteca* 10-day	Standard Unacclimated	
		Survival (%)	Growth (mg)
Control 1 (a)		88.75	0.1985
Control 2 (b)		95.00	0.2527
Gay Tox A		$50.00^{a,b}$	$0.1355^{a,b}$
Gay Tox B		$50.00^{a,b}$	$0.1053^{a,b}$
Gay Tox C		$61.25^{a,b}$	$0.1215^{a,b}$
Gay Tox D		$50.00^{a,b}$	$0.1000^{a,b}$
Gay Tox E		$58.75^{a,b}$	$0.1390^{a,b}$

Sample	*C. dilutus* 10- day	Standard Unacclimated	
		Survival (%)	AFDW (mg)
Control 1 (a)		87.50	1.2396
Control 2 (b)		93.75	0.9981
Control 3 (c)		75.63	1.1718
Gay Tox A		78.75	0.8727^{a}
Gay Tox B		$65.00^{a,b}$	0.8733^{a}
Gay Tox C		$53.75^{a,b,c}$	0.8671^{a}
Gay Tox D		$63.75^{a,b}$	$0.7315^{a,c}$
Gay Tox E		$48.75^{a,b,c}$	0.9282^{a}

[1] TUa = Toxic Units Acute. Calculated by 100/NOEC
*Statistically significant from controls a (silica sand), b (Sandia Creek) or c (peat moss)
% = percent
AFDW = ash free dry weight
LC50 = median lethal concentration
NOEC = no observable effect concentration
TUa = acute toxicity units
mg = milligrams