P. O. Box 52025
Phoenix, AZ 85072-2025
(602) 236-5900
www.srpnet.com

Mail Station: PAB352
Phone: (602) 236-2811
Fax: (602) 236-6690
Email: Dan.Casiraro@srpnet.com

Via Electronic and First Class Mail
(bhg@azdeq.gov)

August 18, 2010

Benjamin H. Grumbles
Director
Arizona Department of Environmental Quality
1110 West Washington Street
Phoenix, Arizona 85007

Dear Director Grumbles:

Attached you will find a summary analysis of the Roosevelt Irrigation District ("RID") Public Health Exposure Assessment and Mitigation Work Plan and Evaluation of Human Health Risks Associated with Volatile Organic Compounds in the Roosevelt Irrigation District Canal System, dated August 18, 2010 and prepared by AMEC on behalf of Salt River Project Agricultural Improvement and Power District.

Sincerely,

Daniel J. Casiraro

Enclosures

cc: Henry Darwin (via electronic mail – hrd@azdeq.gov)
Amanda Stone (via electronic mail – as3@adeq.gov)
Julie Riemenschneider (via electronic mail – jjr@azdeq.gov)
Jennifer Thies (via electronic mail – jce@azdeq.gov)

EC 14125.0810

18 August 2010

Project SD10160030

Dan Casiraro
Manager, Environmental Compliance
Environmental Services
Salt River Project
Mail Station PAB352
P.O. Box 52025
Phoenix, AZ 85072-2020

RE: Technical Review
Public Health Exposure Assessment and Mitigation Work Plan
Roosevelt Irrigation District, Early Response Action

Dear Mr. Casiraro;

As requested, we have conducted a technical review of the Public Health Exposure Assessment and Mitigation Work Plan prepared by Synergy Environmental, LLC for the Roosevelt Irrigation District (RID). More specifically, we evaluated the work plan within the context of the requirements of the Arizona Department of Environmental Quality (ADEQ) as presented in its letter to RID dated June 24, 2010[1]. In that letter, ADEQ required RID, as a condition for approval of the proposed RID Early Response Action (ERA), to submit a "risk analysis work plan to ADEQ documenting the risks and demonstrating to ADEQ how and when the ERA will mitigate the risks". This condition was identified as the "Public Health Threat" and ADEQ set the condition in order to define the reason for RID's concern:

> "The RID work plan states there is a current risk to the public health from exposure to VOCs (from both air and water) within the West Van Buren Area (WVBA), however, specific documentation about the risks and how the risks will be mitigated during the ERA implementation has not yet been provided"

Our technical evaluation focused on the specific tasks identified in the work plan and the extent to which the work plan will meet the ADEQ requirements.

Our comments are detailed below. It is clear, however, that the RID work plan does not meet the requirements of the ADEQ condition for defining the public health threat. To illustrate this point, we have completed a screening risk assessment that quantifies the potential public health risks from the RID water conveyance system (i.e., the canal) using typical techniques and assumptions, as required by public health agencies (e.g., U.S. EPA). We completed this analysis as a means of demonstrating the type of assessment that should have been described

[1] Letter to Stanley H. Ashby, RID from Benjamin H. Grumbles, Director, ADEQ, Re: Conditional Approval of a Water Quality Assurance Revolving Fund (WQARF) Early Response Action (ERA) Work Plan for the West Van Buren Registry Site. June 24, 2010.

AMEC Geomatrix, Inc.
510 Superior Avenue, Suite 200
Newport Beach, CA
USA 92663-3627
Tel (949) 642-0245
Fax (949) 642-4474
www.amecgeomatrixinc.com

AMEC Geomatrix

in the RID work plan. Additionally, using a series of reasonably worst-case assumptions, the results of our assessment allows for an initial determination of the upper-bound of current potential risks from volatile organic chemicals (VOCs) in the water in the RID system. Using estimates of exposure through incidental ingestion, dermal contact, inhalation of volatilized chemicals and fish consumption, our findings are that the public health impacts, if any, are substantially below the typical regulatory levels of concern (i.e., theoretical lifetime cancer risks substantially less than one in one million (1×10^{-6}) and a Hazard Quotient that is orders of magnitude less than 1). Based on this screening, reasonably worst-case analysis, we conclude it is likely that there is currently no potential risk to the general public in the vicinity of the RID canal that is of a magnitude to require mitigation. The apparent lack of a public health threat is an important factor for ADEQ to incorporate into its analysis of the proposed ERA and the RID work plan should be focused on completing a more refined risk analysis of the system. We suspect that the calculated risks from a more refined assessment would be even lower than those calculated using reasonable worst-case methods and assumptions.

INTRODUCTION

A human health risk assessment (HHRA) is a regulatory tool designed to provide the risk manager, in this case the ADEQ, with the information necessary to select the best course of action among competing priorities. In support of this, public health agencies such as ADEQ and the USEPA have developed HHRA methods to quantitatively evaluate potential risks from chemicals in the environment in a standardized manner. The ADEQ “Public Health Impact” condition placed on the RID proposal is a requirement to provide the agency with this type of information, so that the agency can evaluate the health impact claim and judge the necessity for mitigation and, to the extent justified, the extent of the required mitigation.

An HHRA consists of two parts: an exposure assessment that determines the rate that a defined segment of the human population (the receptor) is exposed to a given environmental chemical, and risk characterization where exposure rate is evaluated in terms of the probability of producing an adverse effect in those receptors. The quantitative tools available for developing estimates of exposure to chemicals in the environment are extensive and include air dispersion modeling techniques that can estimate a receptor’s exposure due to airborne releases, surface flux modeling techniques that provide estimates of the quantity of chemicals transferred from one environmental matrix (e.g., from water) to another (e.g. air), and standardized exposure parameters that describe the mode and method by which a receptor can come into contact with chemicals in the environment. These pathways of exposure include, but are not limited to, inhalation of gases and/or aerosols, dermal contact with water through occupational or recreational activities, and food consumption from the ingestion of fish exposed to chemicals in water. All of these pathways or scenarios of exposure can be quantified into an estimate of the receptor’s dose rate (amount of exposure per unit time) for the defined environmental chemicals of concern.

In the risk characterization, HHRAs evaluate the significance of the exposure estimates through comparison to public health values developed by regulatory agencies to define the potential for adverse impact. Most such guidance values have been developed by the U.S. EPA and it is our understanding that ADEQ, in the absence of values they have developed, have a preference for the use of U.S. EPA-developed values first, followed by values developed by California’s Office of Environmental Health Hazard Assessment. These health values represent thresholds below which toxic impacts (e.g. organ damage, irreversible neurological effects, reproductive impairment, etc.) are not expected to occur and which are developed with a substantial margin of safety (i.e., are highly public health conservative). Alternately, for a chemical identified as a potential carcinogen, a quantification of the theoretical potential for cancer within the receptor population is determined. Many chemicals, including two of the major VOCs found in the RID Canal, have the potential for both cancer-based and non-cancer based impacts.

The method for comparing the public health values to the exposure rates differs depending on whether the toxic endpoint is carcinogenic or non-carcinogenic. For non-carcinogenic health risk the receptor's average exposure is compared to the public health criteria as the ratio of the estimated exposure divided by the health criteria. This ratio is called the Hazard Quotient. If the exposure exceeds the criteria (i.e., Hazard Quotient greater than 1) then a health risk warranting mitigation may exist. A Hazard Quotient less than one, indicates no adverse health effects would be expected. For potential carcinogenic health risks, the carcinogenic potency of the chemical as defined by the public health value is coupled with the exposure estimate to generate a theoretical cancer risk: the probability that an individual will develop cancer due to the exposure[2] after a lifetime of exposure at the level in question. In general, public health agencies consider risk estimates greater than 100 in one million (1×10^{-4}) to mandate mitigation and risks less than one in one million (1×10^{-6}) to be de minimis and not warrant mitigation. Risks between the two require further evaluation and consideration of other factors (e.g., the level of health conservatism in the analysis, the availability or cost of mitigation measures) by the agency to determine if mitigation is appropriate.

RID WORK PLAN

The RID work plan includes a scope of work that defines the specific activities to be completed including:

- Background information including a description of the site, a summary of sampling data and identification of contaminants of concern
- Loading assessments based on existing conditions including an overview of RID water operations, an estimate of the VOC mass that is discharged from wells into the RID system and identification of routes of exposure from well operations, water conveyance and groundwater use
- Loading reduction plans including an overview of the proposed mitigation, a description of VOC removal through mitigation and engineering controls to limit loading, and
- Summary and conclusions

The work plan further notes that:

> "Furthermore, the assessment proposed in this Work Plan does not constitute a quantitative risk assessment", and

[2] It is important to note that this estimate of risk is a theoretical upper-bound estimate that is most useful for comparing risks from different sources within a regulatory setting. The true risk may be substantially less, if not zero.

> "A groundwater baseline risk assessment may be conducted prior to the WVBA Site Feasibility Study, if required by ADEQ, to quantify potential health and ecological risk and other routes of exposure associated with the impacted groundwater."

Not only does the work plan provide that no risk assessment is to be done, it also indicates that the scope will not include any calculation of exposure, rather:

> "This section will identify pathways that may lead to public exposure to contaminants of concern by ingestion, skin contact and inhalation associated with current RID well operations, water conveyance, and groundwater use in the WVBA Site".

In other words, the work plan will identify possible pathways of exposure, but will not attempt to quantify the exposure associated with the pathways.

COMMENTS ON THE RID WORK PLAN

The RID work plan does not provide the elements required by the ADEQ. The ADEQ for the "Public Health Threat" condition is specifically and directly asking RID to determine and document the risks and how the risks will be mitigated. Instead, the work plan proposes the provision of summaries for already existing data, the calculation of the amount of VOCs that will be removed by the mitigation plan, and a plan to limit VOCs loading to the RID canal via engineering controls.

This type of information, while of interest, places the cart before the horse in that it details mitigation for a public risk that has not been identified or quantified. In order to judge if any mitigation is necessary, a baseline estimate of risk under current conditions is essential. Otherwise, there is no way for the risk manager, ADEQ, to determine if the potential risk associated with a specific discharge even warrants mitigation or if some potential discharges are of greater importance than others and therefore need be prioritized.

If the work plan is to be responsive to the requirements set forth in ADEQ's conditional approval of the RID proposed Early Response Action (ERA), it must address the classical elements of an HHRA. Specifically, it must include the development of estimates of exposure for various classes of receptors as well as the associated public health risks. For example, rather than just identifying potential pathways of concern (which is a trivial task), the work plan should minimally address determining:

- The quantity of chemicals of concern released to the air through volatilization at the point of well discharge to the canals,
- The quantity of chemicals of concern released to air due to volatilization of VOCs from the surface of the canal,
- The potential exposure to each of these chemicals to nearby residents (adult and child) from each of these sources,
- The potential exposure to each of these chemicals to nearby industrial workers from each of these sources,
- The potential exposure to each of these chemicals due to swimming in the canals, as appropriate,
- The potential exposure to an individual that ingests fish caught in the canal, and
- The potential health risks associated with each of the pathways described above.

Without this critical information, it is not possible for ADEQ to make informed decisions regarding the importance, impact, or significance of the mitigation effort, if any.

SCREENING HEALTH RISK ASSESSMENT

As noted, there are a number of tools readily available for quantifying exposure and associated health risks for exposure scenarios comparable to those mentioned above and relevant to the RID system. We have used these tools to quantify public health risks associated with the RID system using a worst-case screening process. For this effort we selected two specific physical locations along the canal and conducted a separate analysis of each. The first is the residential development downstream of the 83rd Avenue confluence of the Salt Canal with the RID Main Canal. These receptors are thought to be the ones whose potential health risk would be most greatly benefited by the proposed mitigation design. Second, we selected the RID Main Canal at the lateral outfall for Well 92 at 43rd Avenue. This location possesses the highest concentration of VOCs as a worst-case location of a point discharge (i.e., the location with the highest theoretical volatilization from a single point) to which the public may be exposed.

Our findings are summarized below. The highest Hazard Quotient as the sum of all chemicals is 1.6×10^{-3} (0.0016) for the hypothesized adolescent trespasser at the 43rd Avenue Lateral. The highest cancer risk is 1.0×10^{-7} (0.1 in one million), also for the adolescent trespasser at the 43rd Avenue Lateral. Therefore, based on conservative exposure assumptions, there is no significant human health risk associated with the VOCs in the RID Main Canal either downstream of the 83rd Avenue crossing, or at the 43rd Avenue lateral. The actual risk for these exposure scenarios is expected to be substantially lower. The documentation supporting this risk assessment is attached to this letter.

Summary of HHRA Results for the RID Main Canal Downstream of the 83rd Avenue Crossing and at the 43rd Avenue Lateral.

VOCs	Resident[1]		Industrial Worker		Adolescent Trespasser	
	Hazard Quotient[2]	Cancer Risk Ratio of Incidents[3]	Hazard Quotient[2]	Cancer Risk Ratio of Incidents[3]	Hazard Quotient[2]	Cancer Risk Ratio of Incidents[3]
Downstream of 83rd Ave. Crossing						
1,1-DCE	6.5×10^{-8}	N/A			2.8×10^{-7}	N/A
PCE	8.3×10^{-6}	2.0×10^{-8}			6.6×10^{-4}	2.1×10^{-8}
TCE	1.3×10^{-4}	2.6×10^{-10}			7.1×10^{-4}	2.6×10^{-10}
Total	1.3×10^{-4}	2.0×10^{-8}			1.4×10^{-3}	2.1×10^{-8}
RID Main Canal at 43rd Ave. Lateral						
1,1-DCE			5.1×10^{-11}	N/A	1.4×10^{-6}	N/A
PCE			6.2×10^{-10}	4.6×10^{-14}	1.1×10^{-4}	1.0×10^{-7}
TCE			7.4×10^{-11}	3.1×10^{-14}	1.5×10^{-3}	4.5×10^{-10}
Total			7.5×10^{-10}	7.7×10^{-14}	1.6×10^{-3}	1.0×10^{-7}

[1] Non-cancer risk (hazard quotient) is representative of the child receptor. Cancer risk is representative of total lifetime risk.
[2] Values less than 1.0 indicate no significant risk of a non-cancer adverse effect.
[3] Values less than 1×10^{-6} indicate no significant increase in cancer risk.
N/A: No available slope factor currently recognized by ADEQ.

SUMMARY

Our review of the RID Public Health Exposure Assessment and Mitigation Work Plan found that the plan does not respond to the requirements set forth by ADEQ in the conditional approval of the proposed ERA. While the ADEQ requirement reasonably requested that the basis for the RID's belief that there is an ongoing public health impact be documented and that the means to provide this documentation be provided in the work plan, RID instead has proposed to provide an evaluation of mitigation measures based on VOC mass reduction. This approach bypasses the initial step in the risk assessment process which would define if an unacceptable public health impact actually exists and, if so, the extent to which specific factors might be appropriately mitigated. Without this step there is no basis for ADEQ to provide an informed judgment as to the extent and/or type of mitigation required.

The risk analysis requested by ADEQ relies on a highly standardized approach to evaluating public health risks. In order to demonstrate the type of analysis that would be required by ADEQ, we completed a screening, reasonably worst-case analysis of what we believe to be the theoretical points of highest risk (i.e., public health impact) associated with the RID system. This screening assessment not only provided an example of the type of study that should be conducted by RID and which is readily performed, it clearly showed that, in fact, the theoretical health risks associated with VOCs in the RID system are substantially less than levels considered to be unacceptable based on human health risk. In other words, our analysis indicated that there is no public health impact associated with the current operation of the RID system with a substantial margin of safety.

We are available at your convenience to discuss these results.

Sincerely,
AMEC Geomatrix, Inc.

James W. Embree, Ph.D., DABT
Principal Toxicologist

EVALUATION OF HUMAN HEALTH RISKS ASSOCIATED WITH VOLATILE ORGANIC COMPOUNDS IN THE ROOSEVELT IRRIGATION DISTRICT CANAL SYSTEM

Prepared for:

Salt River Project
Phoenix, Arizona

Prepared by:

AMEC Geomatrix, Inc.
510 Superior Avenue, Suite 200
Newport Beach, California 92663
(949) 642-0245

August 18, 2010

Evaluation of Human Health Risks Associated with Volatile Organic Compounds in the Roosevelt Irrigation District Canal System

INTRODUCTION

The following is a human health risk assessment (HHRA) performed on the Roosevelt Irrigation District (RID) canal system based on sampling results attained in June 2010. The purpose was to determine whether residents adjacent to, or visitors who frequent, the RID Main Canal downstream of the 83rd Avenue crossing would be exposed to a significant health risk as the result of volatile organic compounds (VOCs) being present in the water. As a contrast, the potential risk associated with the 43rd Avenue lateral was also assessed. This lateral represents one of the highest VOC concentrations entering into the open canal system. In this case, the most likely human receptors exposed are employees of adjacent industries as well as transient trespassers. The method of assessment and results are presented in the following sections.

SITE CHARACTERIZATION

The RID Main Canal begins at 19th Avenue and runs west beyond 83rd Avenue. Its principal water source is a series of thirty-three groundwater wells east of 83rd Avenue as well as the 23rd Avenue wastewater treatment facility. Some wells discharge directly into the canal. However, the majority discharge via lateral pipelines or ditches as well as from the Salt Canal pipeline that parallels W. Van Buren Street. Water within the canal is utilized for non-potable agricultural purposes. Most of the wells appear to pump during the growing season and are shut down in winter. At that time the major source of water to the canal is the wastewater facility as well as a few pumps operated to maintain flow.

In this analysis, two potential exposure locations were considered. The first is located downstream of the confluence where the Salt Canal meets the RID Main Canal at 83rd Avenue. The human receptors in closest long-term proximity to this location are the residents along W. Lilian Lane, W. Christina Way, and N. Alzoa Way. This development is approximately 1 mile downstream of the point where the RID Main Canal crosses under 83rd Avenue and approximately 0.5 miles downstream of the proposed VOC treatment plant. We also considered including exposure to the Salt Canal immediately to the east of 83rd Avenue as the location of a receptor; the concentrations of VOCs as measured in June 2010 are higher than the concentrations in the RID Main Canal. However, the length of exposed canal is limited and the water is difficult to access. Additionally, the open section is distant from the location of any fixed receptor and much less likely to be attractive to the trespasser. We also judged that potential fishing of the canal would be extremely limited, if any. Therefore, we selected the residential area farther downstream as the worst-case receptor.

The second location is the confluence of the RID Main Canal with the 43rd Avenue lateral. This location represents the highest measured concentrations of VOCs entering the RID canal system based on the June 2010 sampling event. Receptors in this case are workers from the adjacent industrial facilities as well as transient trespassers who may intentionally contact the RID canal system.

MEASURED VOC CONCENTRATIONS IN THE CANAL WATER

VOC exposure concentrations in the RID Main Canal at the two exposure evaluation areas were determined based on the measured results from samples taken in June of 2010. Three specific VOCs were considered in the assessment: tetrachloroethylene (CAS# 127-18-4; PCE), trichloroethylene (CAS# 79-01-6, TCE), and 1,1-dichloroethylene (CAS # 75-35-4; 1,1-DCE). These are the predominant contaminants originating from the West Van Buren Area groundwater plume. Measured concentrations were reported on the ADEQ website (http://www.azdeq.gov/environ/waste/sps/wvb.html) as follows[1]:

Sample location	PCE	TCE µg/l	1,1-DCE
RID Main Canal East of 83rd Avenue	1.5	2.5	< 0.5
43rd Avenue lateral from Well # 92	12	70	2.2
Estimated RID Main Canal at 43rd Avenue[1]	2.6	5.3	1.2

[1] Concentrations were determined based on comparative flow and VOC loading at this point in the RID Canal.

Since there are no impacted water inputs downstream from 83rd Ave, the VOC exposure concentration for the residential receptors was assumed to be the same as that measured.

[1] We did no independent review of these data. For our analysis we assumed that the data were accurate and reflective of the average concentration of VOCs at the various sampling locations and that sampling locations were appropriately selected and monitored.

The exposure concentration for the RID Main Canal at 43rd Avenue was determined based on the water inputs from well #92 relative to all other inputs upstream of its lateral. In this case, it was determined that Well #92 contributed about 5 percent of the water and 32, 14, and 7 percent of the TCE, PCE, and 1,1-DCE, respectively.

DERIVATION OF VOC EMISSION RATES FROM THE CANAL

The U.S. EPA's Air Emission Model for Quiescent Surface Impoundments was used to calculate the air concentrations resulting from volatilization from surface water (U.S. EPA, 1995)[2]. The vapor emission rate of organics from the surface water is assumed to be proportional to the water concentration of the chemical dissolved in the water and the mass transfer coefficient. The U.S. EPA has proposed a two-film theory of volatilization from quiescent surface impoundments. The chemical is assumed to move upward from the bulk aqueous solution through a thin "liquid film." A concentration gradient develops because the transfer rate is limited by diffusion. The chemical is then volatilized and passes through a thin "gas film," where transfer is again limited before reaching the bulk vapor phase or free atmosphere. Values and assumptions used in the derivation of the VOC vapor concentrations were as follows:

VOCs	[VOC] Surface Water (mg/L)	Henry's Law Constant (atm-m^3/mol)	Aqueous Mass Transfer Coefficient (cm^3/cm^2-sec)	Vapor Mass Transfer Coefficient (cm^3/cm^2-sec)	Solute Mass Transfer Coefficient (cm^3/cm^2-sec)	Emission Rate (mg/sec-m^2)
Downstream of 83rd Ave. Crossing						
1,1-DCE	0.00025	$2.6x10^{-2}$	$1.2x10^{-3}$	$4.8x10^{-1}$	$1.2x10^{-3}$	$2.9x10^{-14}$
PCE	0.0015	$1.8x10^{-2}$	$8.8x10^{-4}$	$4.0x10^{-1}$	$8.8x10^{-4}$	$1.3x10^{-13}$
TCE	0.0025	$1.0x10^{-2}$	$9.9x10^{-4}$	$4.3x10^{-1}$	$9.9x10^{-4}$	$2.5x10^{-13}$
RID Main Canal at 43rd Ave. Lateral						
1,1-DCE	0.0012	$2.6x10^{-2}$	$1.2x10^{-3}$	$4.8x10^{-1}$	$1.2x10^{-3}$	$1.4x10^{-13}$
PCE	0.0026	$1.8x10^{-2}$	$8.8x10^{-4}$	$4.0x10^{-1}$	$8.8x10^{-4}$	$2.3x10^{-13}$
TCE	0.0053	$1.0x10^{-2}$	$9.9x10^{-4}$	$4.3x10^{-1}$	$9.9x10^{-4}$	$5.2x10^{-13}$

[2] USEPA. 1995. Air/superfund national technical guidance study series: guidelines for predictive baseline emissions estimation for superfund sites. Interim Final. Office of Air Quality Planning and Standards. November.

ESTIMATION OF AIR CONCENTRATIONS

Outdoor air concentrations were predicted from the forecasted emission rates using the U.S. EPA's SCREEN3 air dispersion model. SCREEN3 is a screening-level single source dispersion model which provides maximum one-hour ground-level concentrations for point, area, flare, and volume sources. The most recent version of SCREEN3 (version dated 96043) was used to estimate worst-case concentrations of VOCs near the RID Main Canal in order to estimate exposure to VOCs for potential receptors near the 43rd Avenue discharge and downstream from the 83rd Avenue crossing.

The chemical emission rates presented above were input into the model as the area emission source on the canal near both exposure areas. The 43rd Avenue lateral source area was taken to be 2400 square meters (m^2) with dimensions corresponding to the length of the industrial property bordering the canal and the width of the canals (dimensions of 560 m by 4.3 m). For the area downstream of the 83rd Avenue crossing, the source was modeled as a 130 m^2 area with dimensions corresponding to the length of the closest residential property bordering the canal and the width of the canal (dimensions of 30 m by 4.3 m). Although the nearest measured canal concentration of VOCs is approximately 1 mile upstream from the zone of assessed exposure, the concentrations of VOCs in air were modeled assuming the VOC water concentrations were identical to that measured at the 83rd Avenue crossing.

Using worst-case meteorological conditions, Screen3 predicted the maximum VOC air concentrations 8 meters from the canal as $1.3\text{x}10^{-8}$ µg/m^3 downstream of the 83rd Avenue crossing (i.e., at the nearest residence), and $1.1\text{x}10^{-7}$ ug/m^3 31 meters from the canal at the 43rd Avenue lateral (i.e., at the nearest industrial facility).

DERIVATION OF VOC CONCENTRATIONS IN FISH

Estimates of VOC concentrations in fish tissue were based on measured bioconcentration factors presented in U.S. EPA guidance (U.S. EPA, 2005)[3]. Bioconcentration factors are a numerical expression of the equilibrium concentration of a chemical within fish tissue (expressed as milligrams per kg of whole fish mass) relative to the concentration of the

[3] USEPA. 2005. Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities, Final. EPA520-R-05-006. Office of Solid Waste and Emergency Response, Washington DC.

chemical dissolved in the water (expressed as milligrams per liter volume). Bioconcentration factors applied in this risk assessment were as follows:

VOC	BCF	VOC Concentration in Fish	
		83rd Avenue	43rd Avenue
	l/kg WW	mg/kg WW	
PCE	82.8	0.12	0.21
TCE	14.1	0.035	0.074
1,1-DCE	8.26	0.0021	0.010

Note that the bioconcentration factors apply to the whole fish, and not just the edible portions. In the case of VOCs, one can expect that the predicted concentrations will be higher than that actually eaten by a potential human receptor.

RECEPTORS OF CONCERN

In this assessment, four types of receptors were considered. At the site downstream from the 83rd Avenue crossing, the potential receptors of concern were 1) the adult resident, 2) the child resident, and 3) the adolescent trespasser. At the confluence of the 43rd Avenue lateral, the two receptors considered were the industrial worker and the adolescent trespasser. Consideration of exposure factors for each of these receptor types are discussed in the following subsections.

ADULT AND CHILD RESIDENTS

The adult and child residents are individuals who reside in close proximity to the RID Main Canal downstream from the 83rd Avenue crossing. Exposure is considered to be principally through inhalation of VOCs volatilizing from the canal. There is also an assumed exposure from direct contact with the canal water. These direct contact events involve both dermal exposure as well as incidental ingestion. No fish consumption was assumed for this scenario; rather individuals taking fish from the canal for food are evaluated in the trespassing scenario. It is our understanding that Arizona Fish and Game regulations, while allowing fishing in canals, prohibits fishing in canals marked as No Trespassing. From our inspection, it appeared that the majority of the RID Main Canal is marked as No Trespassing. Specific exposure parameters are as follows:

Parameter	Adult Resident	Child Resident	Units
Body Weight	70	15	kg
Inhalation Exposure Frequency and Time	350 (24)	350 (24)	d/yr (hr/d)
Inhalation Rate	0.83	0.42	m^3/hr
Ingestion Exposure Frequency and Time	39 (0.25)	39 (0.25)	d/yr (hr/d)
Ingestion Rate	0.05	0.05	L/hr
Exposure Frequency and Duration	39 (0.25)	39 (0.25)	d/yr (hr/day)
Dermal Surface Area	8,900	5,700	cm^2
Averaging Time-Non-cancer	8,760	2,190	days
Averaging Time-Cancer	25,550	25,550	days

ADOLESCENT TRESPASSER

The adolescent trespasser represents a young individual who may come into contact with the RID Main Canal as the result of intentionally trespassing upon the canal. He is assumed to potentially contact the RID Main Canal both at the 43rd Avenue lateral as well as downstream of the 83rd Avenue crossing. The trespasser is considered not to be less than 12-years of age, but may include adults as well. The trespasser's intentions are uncertain, so it is assumed that they will be exposed through inhalation, direct contact (dermal and incidental water ingestion) as well as through the ingestion of fish caught from the canal. Specific exposure parameters are as follows:

Parameter	Adolescent Trespasser	Units
Body Weight	70[4]	kg
Inhalation Exposure Frequency and Time	24 (3)	d/yr (hr/d)
Inhalation Rate	1.2	m^3/hr
Ingestion Exposure Frequency and Time	24 (0.25)	d/yr (hr/d)
Ingestion Rate	0.05	L/hr
Exposure Frequency and Duration	24 (0.25)	d/yr (hr/day)
Dermal Surface Area	6,600	cm^2
Fish Ingestion Frequency	24	d/yr
Fish Ingestion Rate	14	g/d
Averaging Time-Non-cancer	4,380	Days
Averaging Time-Cancer	25,550	Days

INDUSTRIAL WORKER

The industrial worker is an individual whose place of employment is in close proximity to the RID Main Canal. This receptor was exclusively considered in the vicinity of the 43rd Avenue lateral where there were no residents in the general area. The industrial worker is assumed to be exposed via inhalation throughout the work day, but is also assumed to have no direct contact with the canal waters nor ingest any fish from the canal. Specific exposure parameters are as follows:

Parameter	Industrial Worker	Units
Body Weight	70	Kg
Inhalation Exposure Frequency and Time	250 (8)	d/yr (hr/d)
Inhalation Rate	2.5	m^3/hr
Averaging Time-Non-cancer	9,125	Days

[4] The U.S. EPA default for this situation is to assume the adult (i.e., 70 kg) body weight.

TOXICITY ASSESSMENT

TETRACHLOROETHYLENE

The reference dose rates used to evaluate non-cancer based toxicity as well as the cancer slope factors used to evaluate lifetime cancer risk were as follows:

Exposure Route	Non Cancer Reference Dose	Cancer Slope Factor
	mg/kg-day	kg-day/mg
Inhalation	0.01[1]	0.021[1]
Ingestion	0.01[2]	0.54[1]
Dermal	0.01[2]	0.54[1]

Source: [1] Office of Environmental Health Hazard Assessment, 2010, Toxicity Criteria Database. California Environmental Protection Agency, Sacramento, CA.
[2] U.S. EPA, 2010, Integrated Risk Information System (IRIS) Data Base. National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

TRICHLOROETHYLENE

The reference dose rates used to evaluate non-cancer based toxicity as well as the cancer slope factors used to evaluate lifetime cancer risk were as follows:

Exposure Route	Non Cancer Reference Dose	Cancer Slope Factor
	mg/kg-day	kg-day/mg
Inhalation	0.17[1]	0.007[1]
Ingestion	0.0003[1]	0.0059[1]
Dermal	0.0003[1]	0.0059[1]

Source: [1] Office of Environmental Health Hazard Assessment, 2010, Toxicity Criteria Database. California Environmental Protection Agency, Sacramento, CA.

1,1-DICHLOROETHYLENE

The reference dose rate used to evaluate non-cancer based toxicity for 1,1-DCE toxicity is as follows:

Exposure Route	Non Cancer Reference Dose	Cancer Slope Factor
	mg/kg-day	kg-day/mg
Inhalation	0.057[1]	N/A
Ingestion	0.05[1]	N/A
Dermal	0.05[1]	N/A

Source: [1] U.S. EPA, 2010, Integrated Risk Information System (IRIS) Data Base. National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

RISK CHARACTERIZATION

Based on the above exposure factors and public health toxicity values, the potential risk was evaluated for the receptors of concern. The risk values are listed below. For the non-cancer impacts, a Hazard Quotient less than 1.0 indicates that the exposure concentrations was less than the threshold value and therefore there is no significant potential for an adverse effect. For the cancer-based endpoint, a value less than $1x10^{-6}$ indicates that the theoretical cancer risk is de minimis and generally not of concern. Results were as follows.

RISK DOWNSTREAM FROM 83RD AVENUE

The risk values for both the residents and the adolescent trespasser, at or directly downstream from the 83rd Avenue crossing were as follows.

VOC	Resident[1]		Adolescent Trespasser	
	Hazard Quotient	Cancer Risk Ratio of Incidents	Hazard Quotient	Cancer Risk Ratio of Incidents
1,1-DCE	$6.5x10^{-8}$	N/A	$2.8x10^{-7}$	N/A
PCE	$8.3x10^{-6}$	$2.0x10^{-8}$	$6.6x10^{-4}$	$2.1x10^{-8}$
TCE	$1.3x10^{-4}$	$2.6x10^{-10}$	$7.1x10^{-4}$	$2.6x10^{-10}$
Total	$1.3x10^{-4}$	$2.0x10^{-8}$	$1.4x10^{-3}$	$2.1x10^{-8}$

[1] Non-cancer risk (hazard quotient) is representative of the child receptor.
Cancer risk is representative of total lifetime risk.

No potential risk of adverse impact or significant increase in cancer risk was detected for the local resident (adult of child) or for the adolescent trespasser

By way of further analysis and as discussed above, the residential receptor in this location was selected for analysis rather than a location on the Salt Canal east of 83rd Avenue. At that location, which is a significant distance from any fixed receptor, the trespasser would be the only likely exposure scenario. For comparison, we calculated the risk for this individual using Salt Canal water data from June 2010. The presumed exposure for a trespasser at this location does not include fish ingestion. The calculated total cancer risk was $3.2x10^{-9}$, while the total Hazard Quotient was 1.4×10^{-4}. As predicted, these risk estimates are even lower than the low risk estimated for the residential receptor.

RISK AT THE 43RD AVENUE LATERAL

The risk values for both the industrial worker and the adolescent trespasser from the RID Main Canal at the 43rd Avenue lateral were as follows.

VOC	Industrial Worker		Adolescent Trespasser	
	Hazard Quotient	Cancer Risk Ratio of incidents	Hazard Quotient	Cancer Risk Ratio of incidents
1,1-DCE	$5.1x10^{-11}$	N/A	$1.4x10^{-6}$	N/A
PCE	$6.2x10^{-10}$	$4.6x10^{-14}$	$1.1x10^{-4}$	$1.0x10^{-7}$
TCE	$7.4x10^{-11}$	$3.1x10^{-14}$	$1.5x10^{-3}$	$4.5x10^{-10}$
Total	$7.5x10^{-10}$	$7.7x10^{-14}$	$1.6x10^{-3}$	$1.0x10^{-7}$

No potential risk of adverse impact or significant increase in cancer risk was detected for the industrial worker or for the adolescent trespasser.

CONCLUSION

Based on the results of this risk assessment, it can be concluded that exposure rates from VOCs present in the RID canal system are insufficient to represent a public health threat to individuals most directly associated with the structure. Risk from inhalation represented the lowest risk concern; the highest potential risk, while still negligible, came from the ingestion of fish present in the canal.