Assessing Human Risks

A Workshop for the Community

June 10, 2006
Vieques, Puerto Rico

Agenda

8:00 – 8:15	Registration
8:15 – 8:30	Introductions and Goals of the Workshop
8:30 – 8:45	Risk Assessment Laws and Regulations
	Role of the Risk Assessment in the Clean Up Process
8:45 – 9:45	The Human Risk Assessment Process
	Roles and Responsibilities
	What is Environmental Risk
	EPA’s Method for Conducting Human Health Risk Assessment
9:45 – 10:00	Break
10:00 – 11:30	Site-Specific Application of Risk Assessment Process - Review of Example Sites
	SWMU 14
	AOC K
11:30 – 12:00	Wrap-up

Introductions

Presenters:

Katarina Rutkowski - Risk Assessor - TRC Environmental (Consultants to EQB)

Glenn Markwith - Risk Communicator – NEHC - Navy

Vijaya Mylavarapu – Risk Assessor – CH2M HILL – Navy

Brett Doerr - Environmental Project Manager – CH2M HILL – Navy

In collaboration with:

Yarissa Martinez/ Wilmarie Rivera – Project Managers - EQB

Susana Struve – Facilitator – CH2M HILL – Navy

“What the community wants to know …”

- What is a risk assessment?
- What are risks assessments used for?
- How are risks assessments done?
- What do risk assessments tell us?
- Risk Assessments at Vieques sites?
- The agencies’ decision making process?
- Why should the public trust risk assessments?
- How to include and address the community concerns?

Workshop Goals

Help Citizens…

- Understand Risk Assessments
  - -Why are they done?
  - -How are they done?
  - -How are they used?
- Understand and comment on results
- Understand the Agencies' decision-making process

Understanding Risk Assessments

Risk Assessments:

- Determine potential for chemical concentrations in site media to pose a health risk, based on various scenarios of human exposure to the chemical concentrations
- Indicate which chemicals contribute to the health risk
- Evaluate various scenarios of how people could come into contact with hazardous chemicals

Risk Assessments do not:

- Determine whether any detectable health effects have occurred or will occur because of chemical concentrations at a site
- Identify individuals who are likely to have health problems because of a site
- Identify technologies for addressing contamination problems

Risk Assessment – Laws and Regulations for CERCLA Sites

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What We'll Discuss

- Laws
- Regulations & Policy
- Role of Risk Assessment

CERCLA

In 1980, CERCLA was enacted to:

- Address dangers of abandoned or uncontrolled hazardous waste sites
- Develop a nationwide program for emergency response
- Address liability for responsible parties
- Create a trust fund
- Conduct site assessment and cleanup

SARA

In 1986, SARA was enacted to:

- Encourage permanent remedies and innovative treatment
- Provide new enforcement authority
- Increase state and citizen involvement
- Provide additional funding
- Increase focus of cleanup process on <u>human health and the environment</u>.

NCP

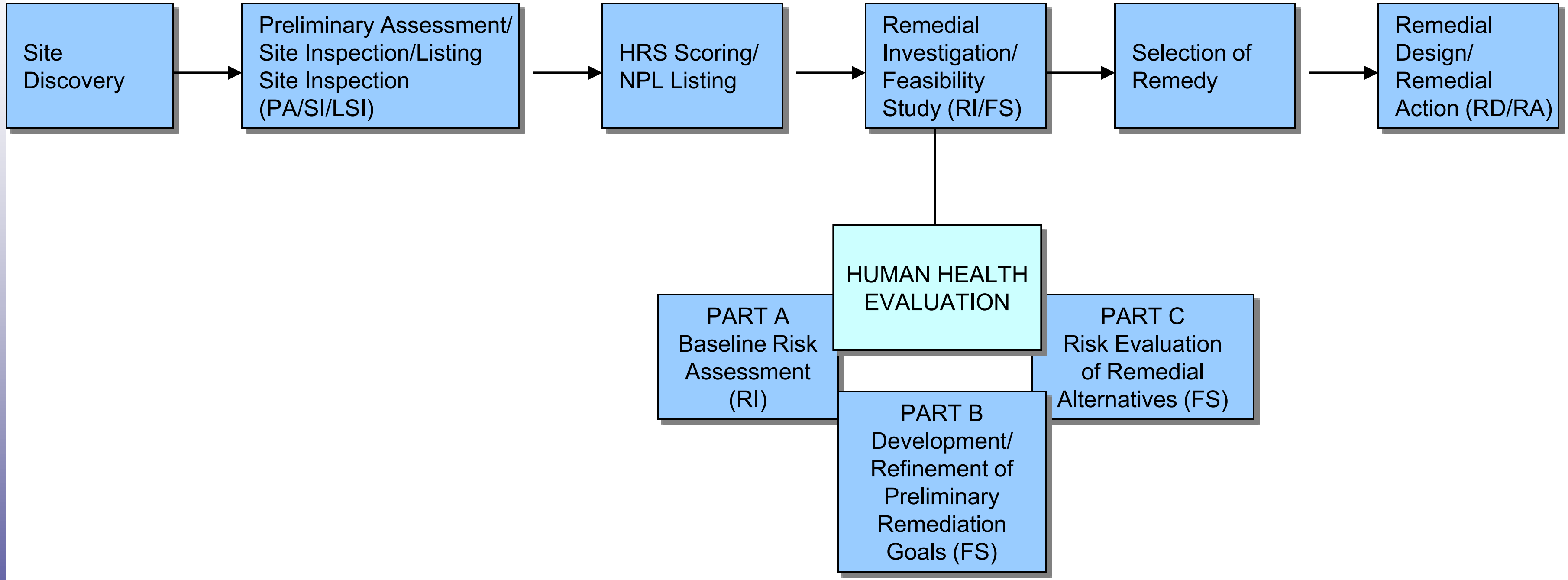
1982 - National Oil & Hazardous Substances Pollution Contingency Plan (NCP)

- Implements the requirements of CERCLA
- Outlines the role of risk assessment in the overall cleanup process
- Establishes 9 evaluation criteria for remedy selection – two related to risk assessment
  - Remedy must be protective of human health & the environment
  - Meet state & federal Applicable or Relevant & Appropriate Requirements
    - Regardless of outcome of risk assessment
      - e.g., MCLs

PREQB Regulations

- Water Quality Standards Regulation
  - Establish definition of potable groundwater
  - Exposure to groundwater used as a drinking water source must be evaluated for groundwater considered potable
  - Establishes standards for groundwater and surface water that are ARARs, regardless of the outcome of the risk assessment
- Underground Storage Tank Control Regulation
  - Provides cleanup levels for petroleum releases from USTs
    - ARAR for UST sites
  - Allows for risk assessment for petroleum related releases from USTs
  - Not applicable or relevant to non-UST sites
- PREQB follows EPA risk assessment guidance

Role of Human Health Risk Assessment in the Cleanup Process



Select Guidance and Policy

- Risk Assessment Guidance for Superfund
  - National guidance on specific methods and requirements for performing risk assessments at Superfund Sites
  - Addresses human health and ecological risk assessments
- Role of the Baseline Risk Assessment in the Superfund Remedy Selection
  - Provides further guidance on how to use the baseline risk assessment to make risk management decisions
- Background Guidance
  - Establishes methods and policy for evaluating background concentrations of chemicals
    - Typically applied to metals
- These documents and others can be found at:
  - http://www.epa.gov/oswer/riskassessment/policy.htm

Goals of Risk Assessment

Overall goals of risk assessment process are to:

- Provide a method to assess baseline risk and determine the need for action
  - Looks at current and future land uses
- Provide a basis to determine levels of chemicals that can remain on site and still be protective of human health and the environment
- Establish a consistent process for everyone to use in evaluating risks posed by CERCLA NPL sites

Risk Assessment

- Risk assessment information comes from available scientific studies & site-specific environmental data
- Risk assessment is a conservative, scientific estimate of the risk to people, plants and animals that could be exposed to chemicals at the site
- Risk assessments are required by law and
- Essential to effective risk communication and risk management decisions for each site

In Summary

- CERCLA law established the authority and requirement to clean up Sites listed on the National Priorities List (NPL)
- NCP and related guidance establish procedures and specific requirements to be followed when conducting a cleanup
- Navy must comply with the NCP

QUESTIONS?

Human Health Risk Assessment Process

June 10, 2006

Vieques, Puerto Rico

Objectives

- Explain Roles & Responsibilities
- Present the Risk Assessment Process
  - Human Health
- Provide Background Information for the Site-specific Discussions that Follow

Roles and Responsibilities

Stakeholders

- Environmental Protection Agency (EPA)
- Puerto Rico Environmental Quality Board (PR EQB)
- Navy
- Community
- USFWS, NOAA, and other Agencies

Roles and Responsibilities

EPA in consultation with other stakeholder agencies:

- Develops & Implements Environmental Policy
- Ensures Compliance with Environmental Laws & Regulations
- Oversees Navy Clean-up of CERCLA Sites
  - Risk Assessment/Management
  - Remedial Action

Roles and Responsibilities

Navy

- Ensures Compliance with State & Federal Environmental Laws & Regulations
- Develops Risk Assessments for Navy National Priority List (NPL) Sites
- Provides Remedial Action and Risk Management Recommendations to Regulators
- Works Together with EPA and PREQB to Conduct Site Clean-up and Community Involvement Activities

Roles and Responsibilities

Community

- Identify Special Issues or Concerns
- Provide Local, Site-specific Knowledge
  - Site History
  - Human Activities
  - Chemical Usage
  - Past, Present, & Future Land Use
- Involved in the Decision-Making Process

What is Environmental Risk?

The likelihood of adverse health effect resulting from exposure to a potential environmental hazard

For a Risk to Occur

- A hazard must exist
- Exposure must take place

Without Exposure, a Hazard Cannot Pose a Risk

- Different degrees of exposure produce different levels of risk
- Different levels of toxicity of specific chemicals produce different levels of risk
- A risk assessment evaluates whether hazards are posing an unacceptable risk to receptors who may come in contact with chemicals at a site

Types of Risk Assessment

What are the Types of Risk Assessment?

- Human Health
  - EPA
  - ATSDR
- Ecological (Plants and Animals)

Human Health

EPA and ATSDR conduct human health risk assessments

ATSDR risk assessments follow a different method and have a different purpose

HOW and WHY:

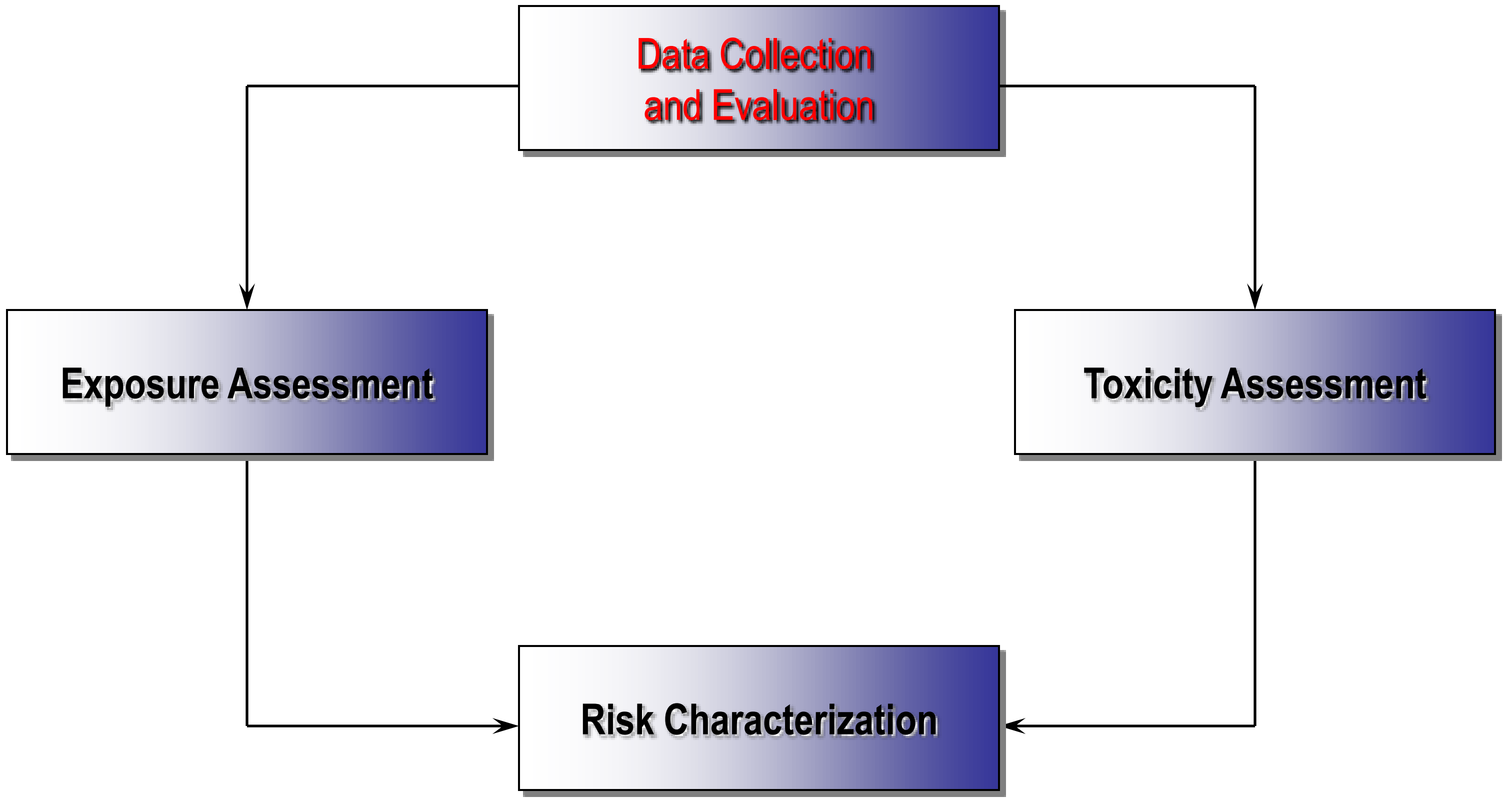
- Unlike EPA risk assessments, risks and hazards are not calculated site-specifically
  - Provides minimal risk level (MRL)
- Designed to assess the impacts to the surrounding communities
- Provide advise on preventing exposures, if identified as excessive
- Public Health Assessment (PHA) documents summarize the evaluation and findings

EPA's Method for Conducting Human Health Risk Assessment

Four Steps in the Baseline Human Health Risk Assessment Process

- Four steps in the HHRA Process
  - Data Collection and Evaluation
  - Exposure Assessment
  - Toxicity Assessment
  - Risk Characterization

Four Steps in the Process



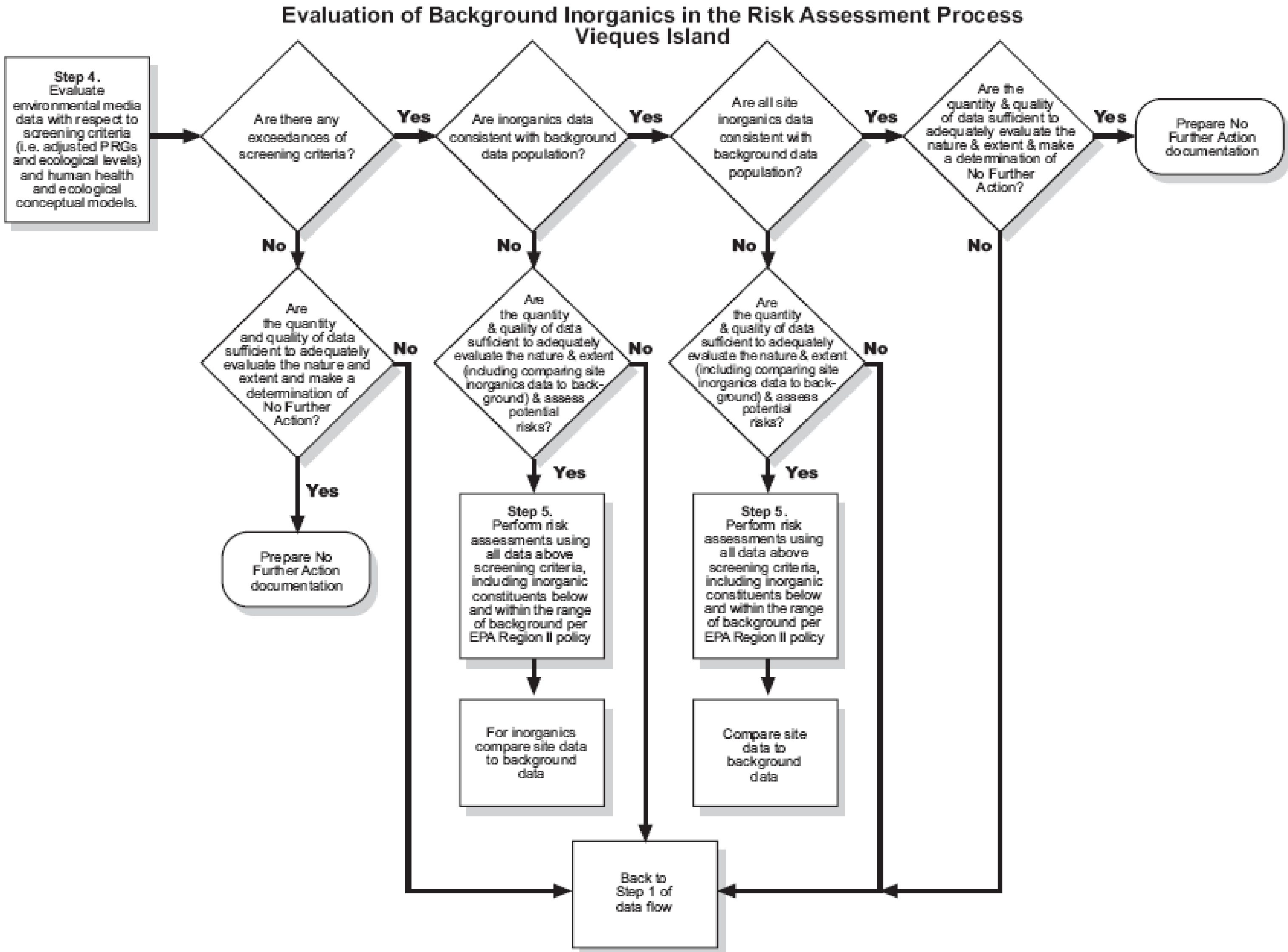
Data Collection and Evaluation

- Uses sampling data collected during site characterization
  - Each sample typically analyzed for a long list of EPA-recommended chemicals
- Sampling data summarized in uniform table format established by EPA
  - RAGS Part D Tables

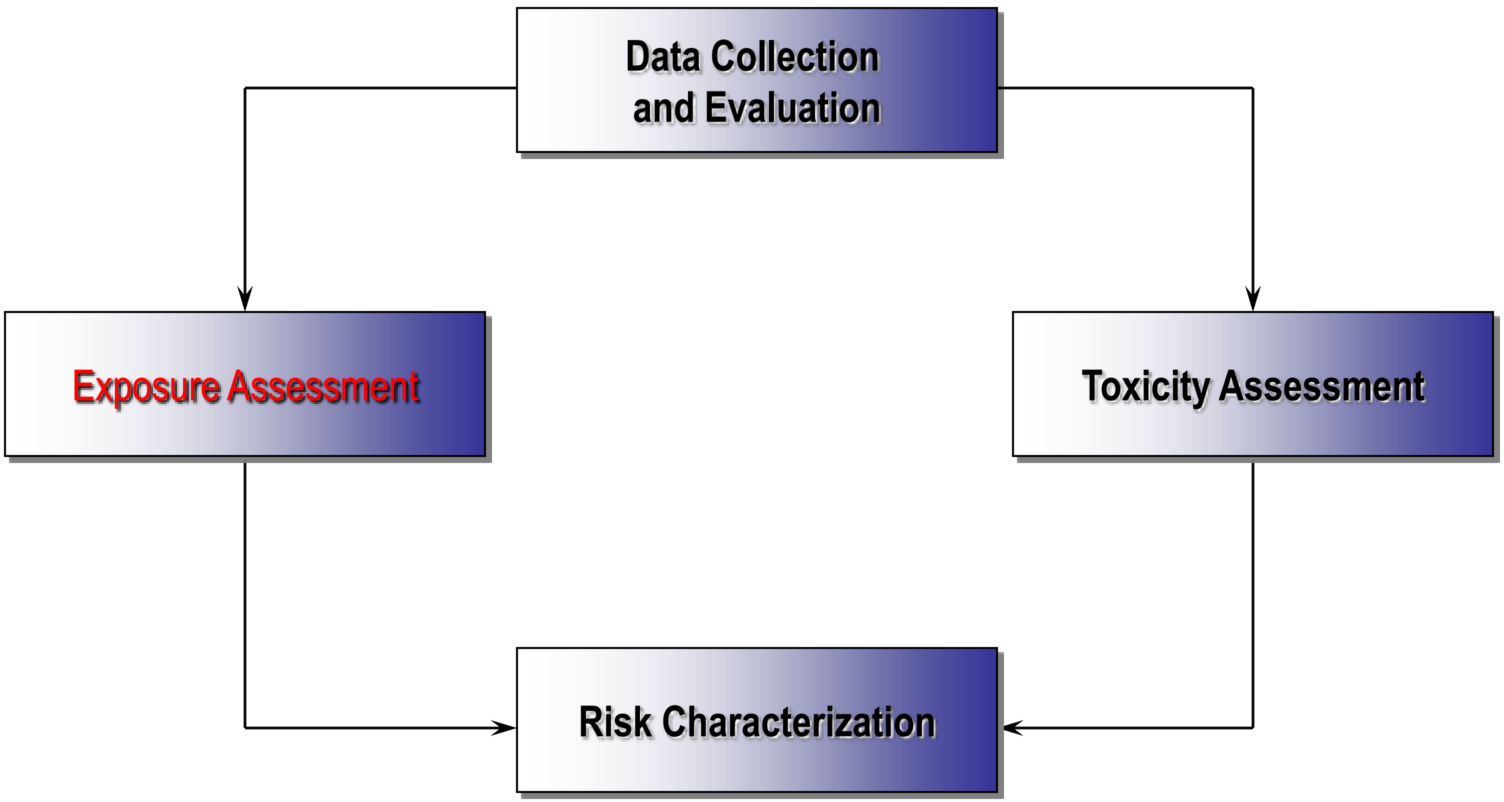
Data Collection and Evaluation

- Compares Maximum Concentration of Each Chemical Detected with conservative risk-based concentrations
  - Examples are PRGs
  - Chemicals not eliminated based on background concentrations if they exceed screening levels
- Used to Determine if a Site Warrants Additional Study or to determine which chemicals require further evaluation in a risk assessment
  - Chemicals of Potential Concern

Data Evaluation Flow Chart



Next in the Four Step Process



Exposure Assessment

Exposure evaluates potentially complete exposure pathways

- Identify Concentrations of Chemicals to which People Might be Exposed
  - Exposure point concentrations (EPCs)
- Identify Who Might be Exposed
  - Receptors
- Identify How Long People Might be Exposed
  - Exposure frequency and Duration
- Identify How People Might be Exposed
  - Exposure route
- Evaluate a Reasonable Maximum Exposure (RME)
  - Highest exposure reasonably anticipated to occur at a site
  - May also evaluate a central tendency exposure (CTE)
  - Estimate Risk/Hazards under More Typical, or Average, Exposures

Exposure Assessment - EPCs

- Identifies Concentrations of Chemicals to which People Might be Exposed
  - Exposure point concentrations (EPCs)
- EPCs are conservative estimates of a concentration that a receptor would be exposed to over the time they are exposed
  - A conservative estimate of an average concentration is used
    - Consistent with exposure by a receptor that does not stay in one spot for years and years

Exposure Assessment - Receptors

- Receptors
  - Residents
  - Recreational Users
  - Maintenance Workers
  - Commercial/Industrial Workers
  - Construction Workers

Exposure Assessment – Exposure Frequency and Duration

- Residents
  - Assumes daily exposure to chemicals for 350 days per year for 30 years
    - Very conservative
    - If residential exposure is acceptable, site poses no unacceptable risks for all uses

Exposure Assessment – Exposure Frequency and Duration

- Recreational Users
  - For Vieques, assumes weekly exposure by the same recreational user for 30 years

Exposure Assessment – Exposure Frequency and Duration

- Maintenance Worker
  - Assumes weekly contact with a chemical for 25 years
    - Higher contact rates assumed associated with outdoor landscaping activities

Exposure Assessment – Exposure Frequency and Duration

- Commercial/Industrial Receptors
  - Assumes daily contact with a chemical over a typical work day for 250 days per year for 25 years

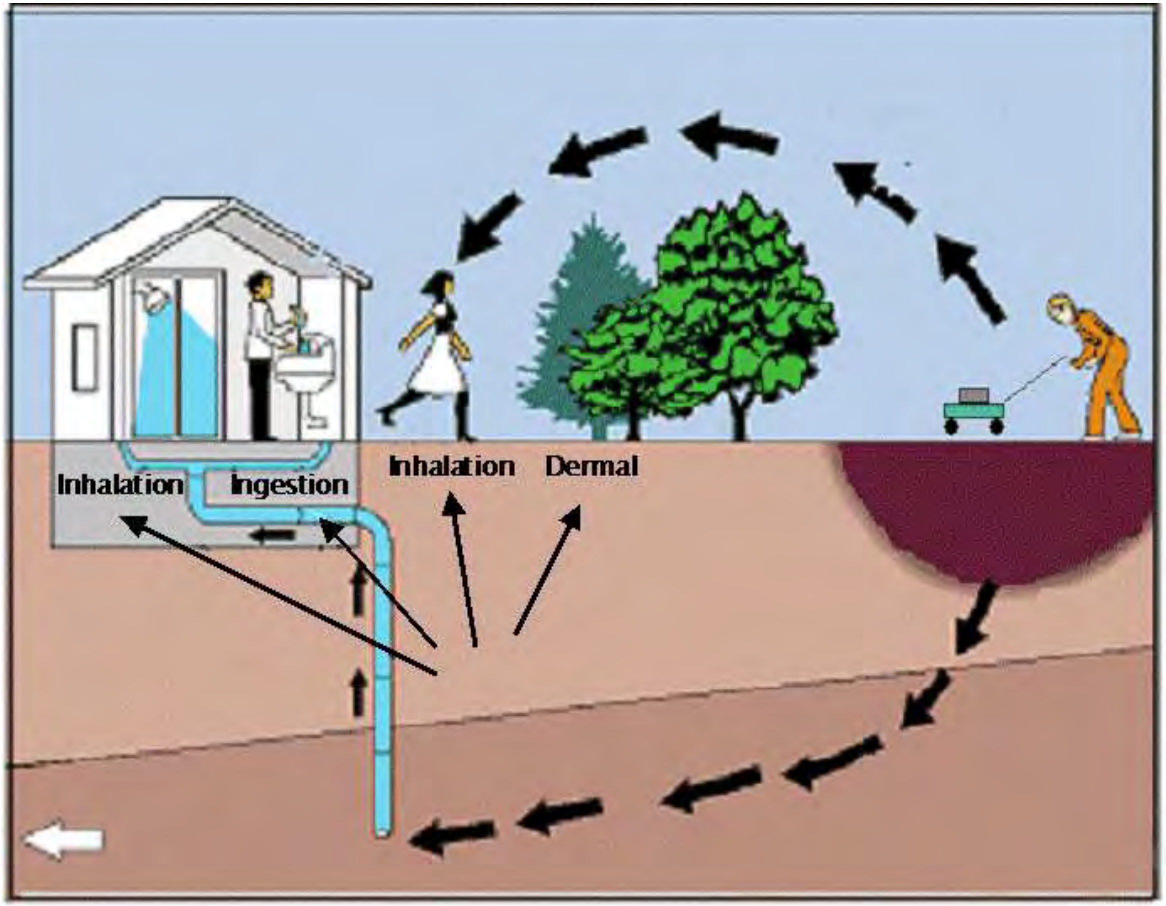
Exposure Assessment – Exposure Frequency and Duration

- Construction Worker
  - Assumes daily contact with a chemical over the work day for 250 days per year for 1 year
    - Higher exposure to environmental media assumed than other exposure scenarios

Exposure Assessment – Exposure Routes

- Dermal contact
- Incidental Ingestion
- Inhalation of dust
- Inhalation of volatiles
  - If present

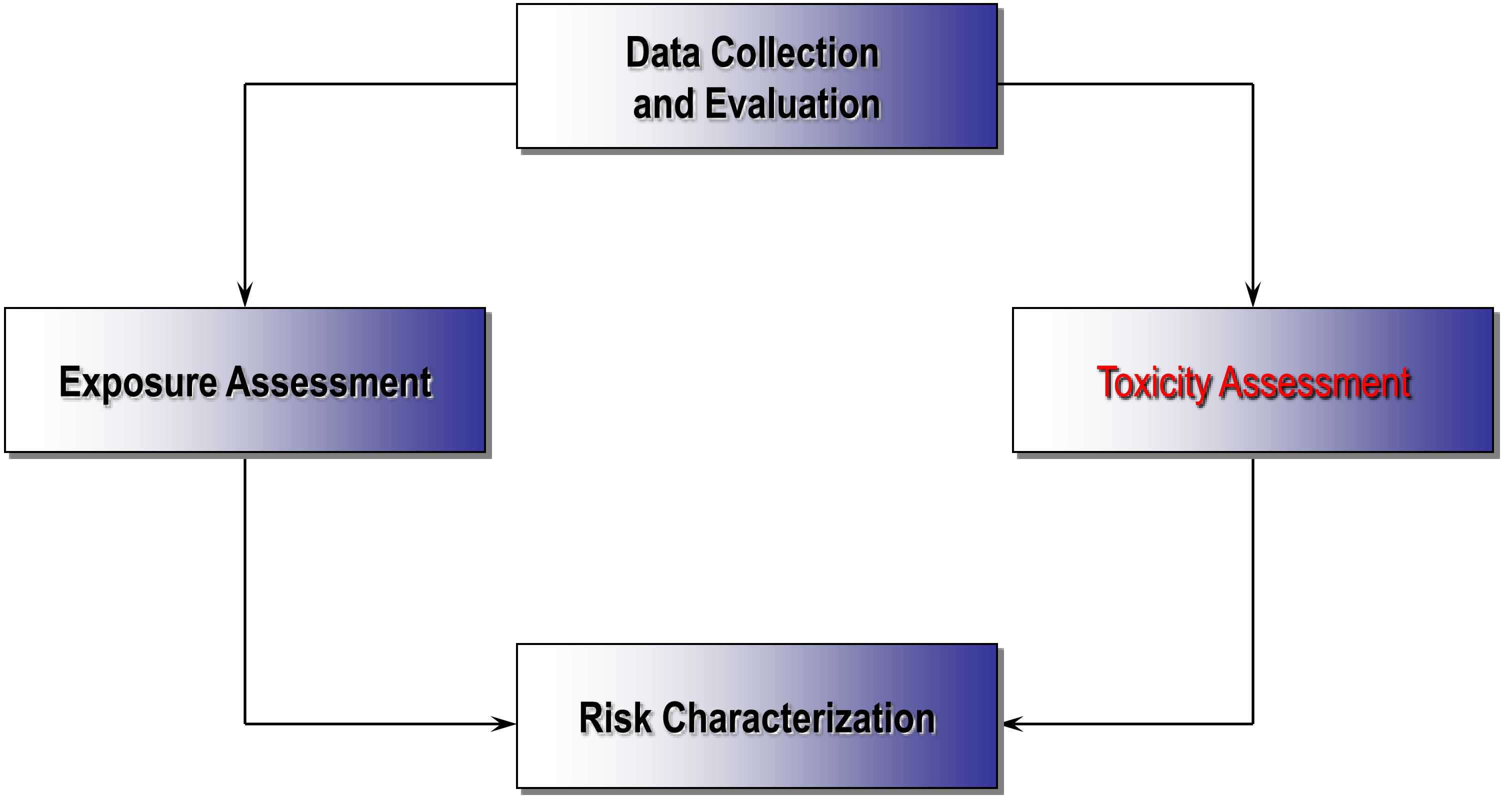
Exposure Assessment – Types of Exposure Pathways



Exposure Assessment

- End result is an estimate of how much of a chemical a receptor could be exposed to on a daily basis
- Called an Average Daily Dose (ADD)
  - for chemicals that are shown to produce health effects other than cancer (noncarcinogens)
- Lifetime Average Daily Dose (LADD)
  - for cancer-causing chemicals (carcinogens)

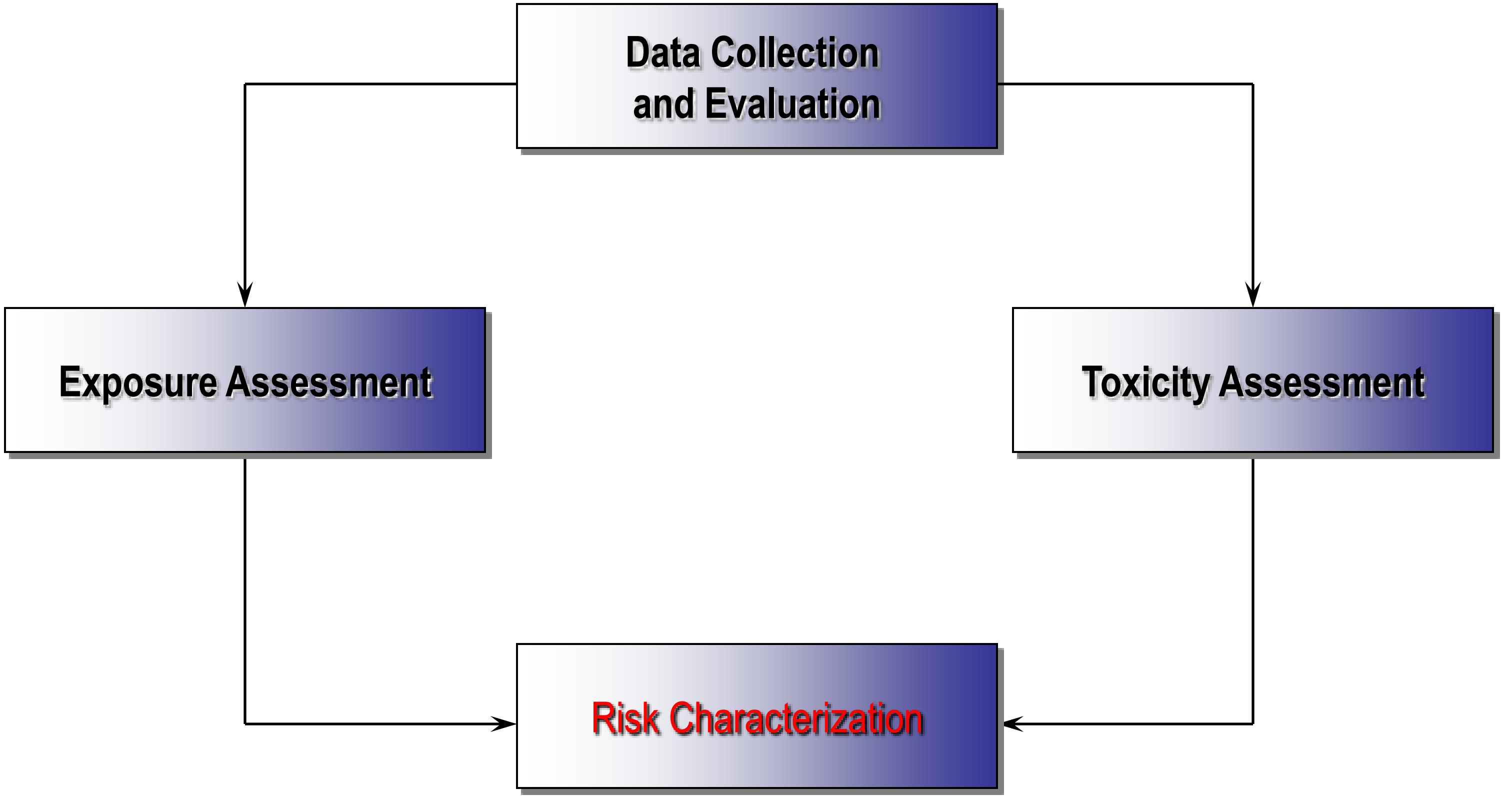
Next Step in the Process



Toxicity Assessment

- Identifies Toxicity Values for Each Chemical of Potential Concern
  - Carcinogenic Effects
  - Non-carcinogenic Effects
- Noncarcinogens
  - Reference Dose
    - Estimated dose that is **not** likely to cause an adverse effect during a lifetime of exposure
    - Includes protective uncertainty factors
- Carcinogens
  - Cancer Slope Factor (CSF)
    - Estimates the chance of developing cancer associated with a particular dose
      - Applies to chemicals shown to be a known, probable or possible human carcinogens

Final Step in the Process



Risk Characterization

Risk Characterization:

- Integrates the results of all previous steps to summarize:
  - Cancer Risks and Non-Cancer hazards
  - Uncertainty Analysis

Risk Characterization

Cancer Risks

- Additional risk of developing cancer, above the background incidence, caused by exposure to substances at the site;
  - Calculated as the LADD x CSF
- Cancer risks are summed across chemicals and pathways regardless of type of cancer
- US EPA acceptable cancer risk levels for excess cancer attributable to a site under the assumed exposure scenario are values in the range of 1 in 10,000 to 1 in 1,000,000

Risk Characterization

Non-Cancer Hazards for Noncarcinogens

- Expressed as a Ratio of Estimated Dose to an Allowable Dose
  - ADD/RfD
- Hazard Quotients (HQ) are Summed for All Chemicals and Pathways at a Site (Hazard Index [HI])
  - May group chemicals based on what target organ or system they are shown to effect
- The US EPA Hazard Index of Concern is Any Value Greater Than 1
  - HI greater than 1 indicates the potential for adverse health effects, with the potential increasing as the HI or HQ value increases

Risk Characterization

- Risk Characterization takes into account the contribution from background for those chemicals carried through the risk assessment process after screening

Background Statute and Select Guidances

- *CERCLA, Section 9604(a)(3) – Response Authority*
- *Risk Assessment Guidance for Superfund (RAGS), Volume 1 Human Health Evaluation Manual (Part A)*
- *Role of Background in the CERCLA Cleanup Program (OSWER 9285.6-07P, April 2002)*
  - *Included as appendix in the guidance below*
- *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (EPA 540-R-01-003/OSWER 9285.7-41, September 2002)*

Background Statute

- *CERCLA, Section 9604(a)(3) addresses naturally occurring background chemicals:*
  - *(3) Limitations on Response.— The President shall not provide for a removal or remedial action under this section in response to a release or threat of release— (A) of a naturally occurring substance in its unaltered form, or altered solely through naturally occurring processes or phenomena, from a location where it is naturally found*
    - *Excludes CERCLA site activities that result in the release of naturally occurring substances into other environmental media or result in chemical transformation*

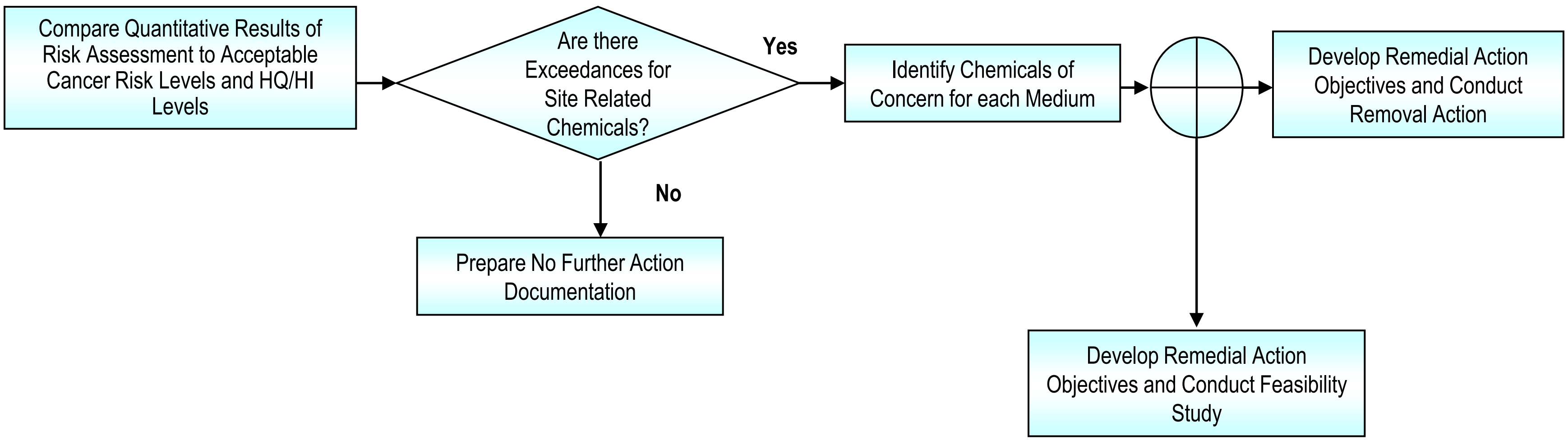
Background Chemicals

- Types of background
  - Naturally occurring
    - Chemical concentrations present in the environment that have not been influenced by humans
  - Anthropogenic
    - "Natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question)"
      - Agriculture
      - Industry
      - Automobiles

Role of Background

- Policy Recommendations
  - Evaluate COPCs that exceed risk-based screening criteria quantitatively in risk assessment
    - Regardless of whether there is a background contribution
  - Allows for distinguishing site-related risks from background risks
  - Process followed on Vieques
    - See flow chart

Decision-Making Process at End of Risk Assessment



No Further Action

- No Further Action is recommended when the results of the Remedial Investigation and Risk Assessment demonstrate no unacceptable risk to human health or the environment:
  - No hazardous substances, as defined under CERCLA, have been released at a site or
  - Hazardous substances associated with a CERCLA site are below acceptable cancer risk levels and target HQ/HI

Remedial Objectives and Actions

- Remedial Action Objectives (RAOs) aimed at protecting human health and the environment. They should specify:
  - The contaminant(s) of concern
  - Exposure route(s) and receptor(s)
  - An acceptable contaminant level or range of levels for each exposure route (i.e., a remediation goal)
- RAOs are met through Remedial Actions

Human Health Risk Assessment - Summary of Key Points

- Risk Assessment Process Developed by EPA
- Process is Standardized & Accepted Nationwide
- Process is Based Upon Best Available Science
- Process provides information that is used in making cleanup decisions for a site
  - No Further Action
  - Removal Action
  - Remedial Design/Remedial Action
- Process Results in conservative cancer risk and noncancer hazard estimates used to make cleanup decisions that are protective of human health and the environment
  - Evaluates background concentrations for those chemicals that did not screen out

In summary …

We evaluate whether the chemical concentrations at a site pose a risk or hazard to people by using federally developed and/or approved procedures and guidance in accordance with the law as follows . . .

First, the site is characterized

- Identify which media could be affected by an historic release
  - Soil
  - Groundwater
  - Surface water
  - Sediment
- Collect samples of those media for various chemicals
  - VOCs, SVOCs, explosives, inorganics, etc.

Next, COPCs are identified

- Compare data to risk-based screening levels published by EPA
  - PRGs

- COPCs are identified as those chemicals whose maximum concentrations in site media exceed risk-based screening levels

Then, risks to people are estimated for the COPCs

- First, an estimate is made of the amount of each COPC people that could use the site may be exposed to, based on the concentrations detected at the site
  - Residents living at the site could work and play in the dirt (soil) and streams, drink and bathe in the groundwater
  - Visitors could use the site for an outing where they play in the streams and sit or walk across the site
  - Workers at the site could come in contact with soil or groundwater during construction or stir up dust during grass mowing, vegetation clearance, or other maintenance activities

And…

- Next, the toxicity of each COPC is identified
  - Provided by EPA
    - Non-carcinogen
    - Carcinogen
- Then, the risks to people are estimated by combining the estimates of the amount of exposure to the COPCs with the toxicity of the COPCs

Finally, the risks are discussed and recommendations made

- Once the risks estimates are quantified, the uncertainties and other qualifications are discussed
  - Inorganics are compared to background
  - Realistic land use is discussed
- Based on the risk estimates, considering other factors such as background inorganics and site land use, recommendations are made
  - No further action if concentrations of chemicals do not pose unacceptable risk
  - Further action if concentrations of chemicals do pose an unacceptable risk

Site-Specific Application of Risk Assessment Process - Review of Example Sites

Vieques, PR

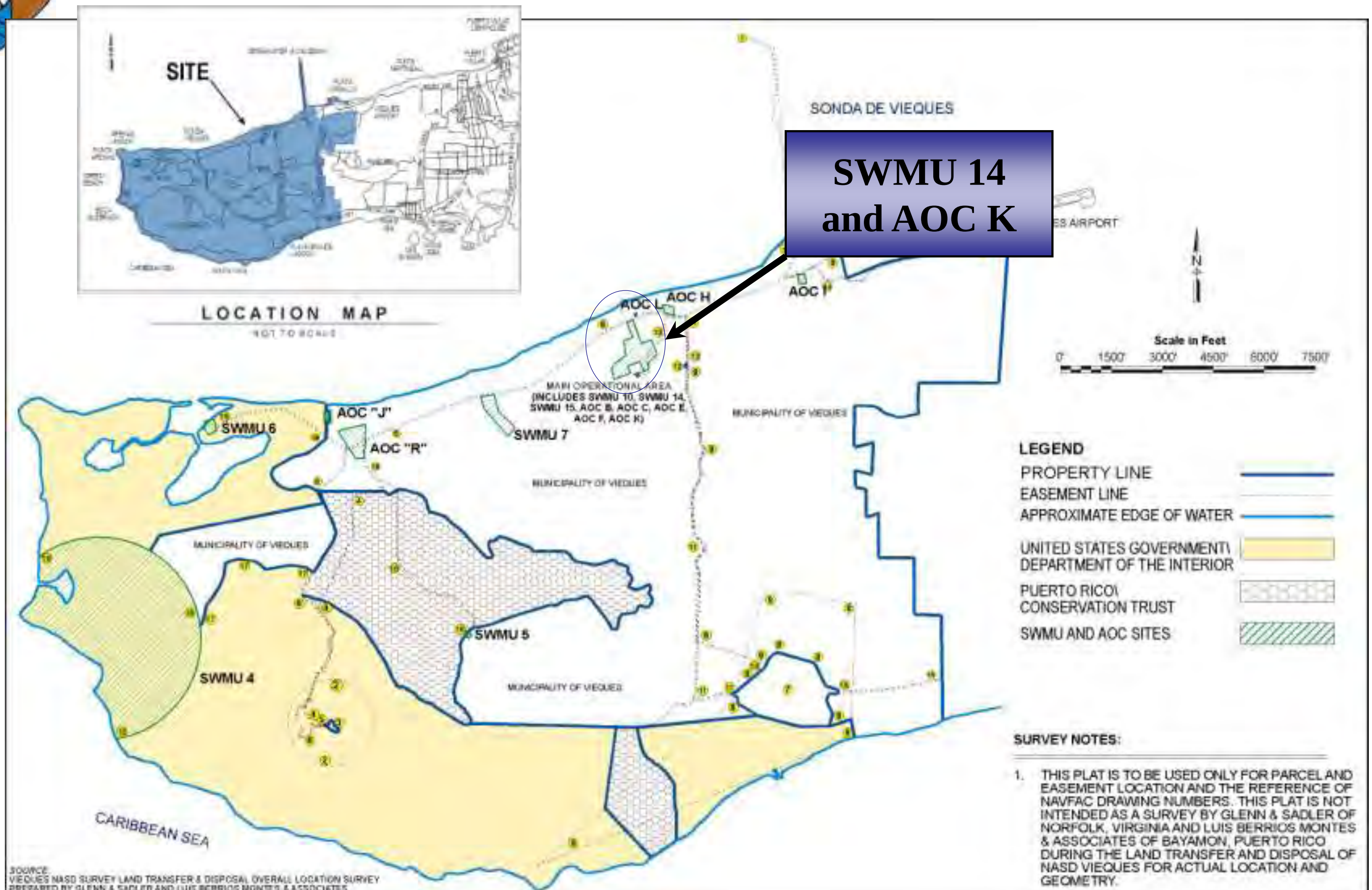
June 10, 2006

Example Sites for Detailed Risk Assessment Presentation

Selected two sites from NFA report as examples

- SWMU 14 – Wash Rack
- AOC K – Former Water Well

Location of Example Sites



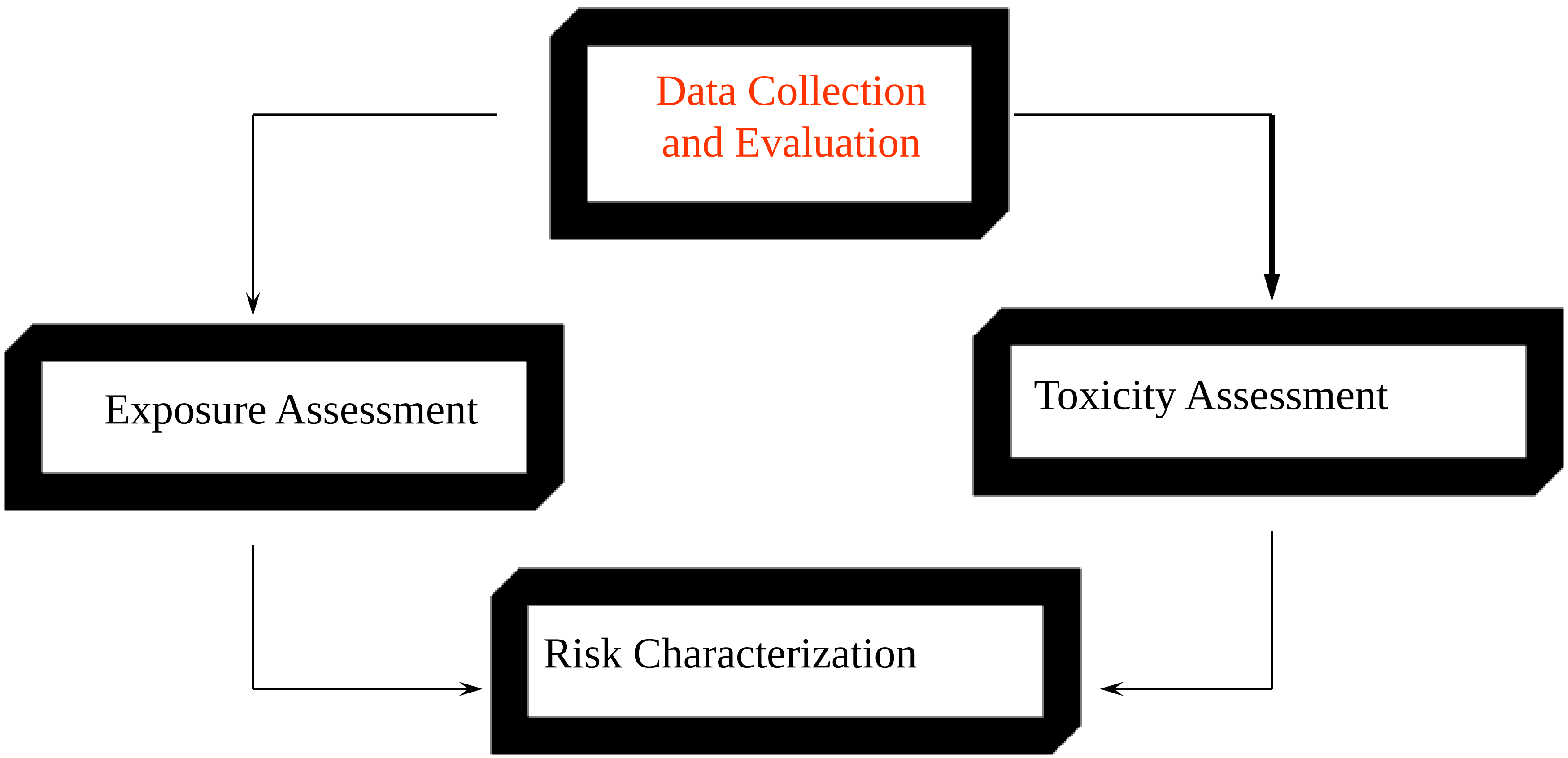
SWMU 14 - Wash Rack Description

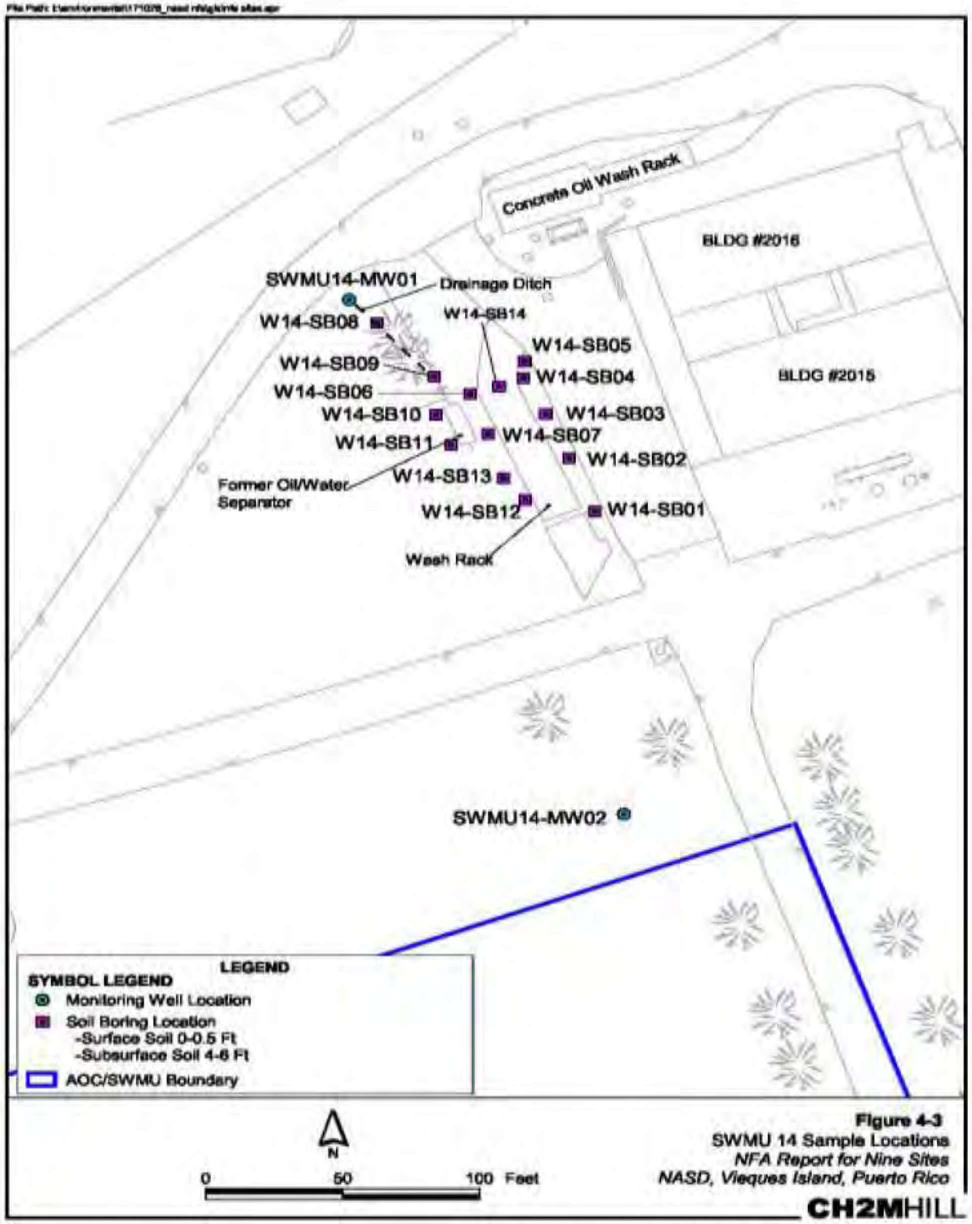
- Site is located inside the Main Operational Area - within fenced boundaries
  - The SWMU 14 concrete pad is 20 ft by 10 ft
- Its is near two other Sites: AOC E to the north and SWMU 15 to the west
- It was used to wash vehicles from 1970s to 2000.
- The concrete structures and old oil-water separator are no longer in place

Figure 1

SWMU 14 Former Wash Rack (2002), Facing South

First in the Four Step Process




Concrete Oil Wash Rack
BLDG #2016
BLDG #2015
SWMU14-MW01
Drainage Ditch
W14-SB14
W14-SB08
W14-SB05
W14-SB09
W14-SB04
W14-SB06
W14-SB10
W14-SB03
W14-SB11
W14-SB07
W14-SB02
Former Oil/Water Separator
W14-SB13
W14-SB12
W14-SB01
Wash Rack
SWMU14-MW02
LEGEND
SYMBOL LEGEND
Monitoring Well Location
Soil Boring Location
-Surface Soil 0-0.5 Ft
-Subsurface Soil 4-6 Ft
AOC/SWMU Boundary
N
0
50
100 Feet
Figure 4-3
SWMU 14 Sample Locations
NFA Report for Nine Sites
NASD, Vieques Island, Puerto Rico
CH2MHILL

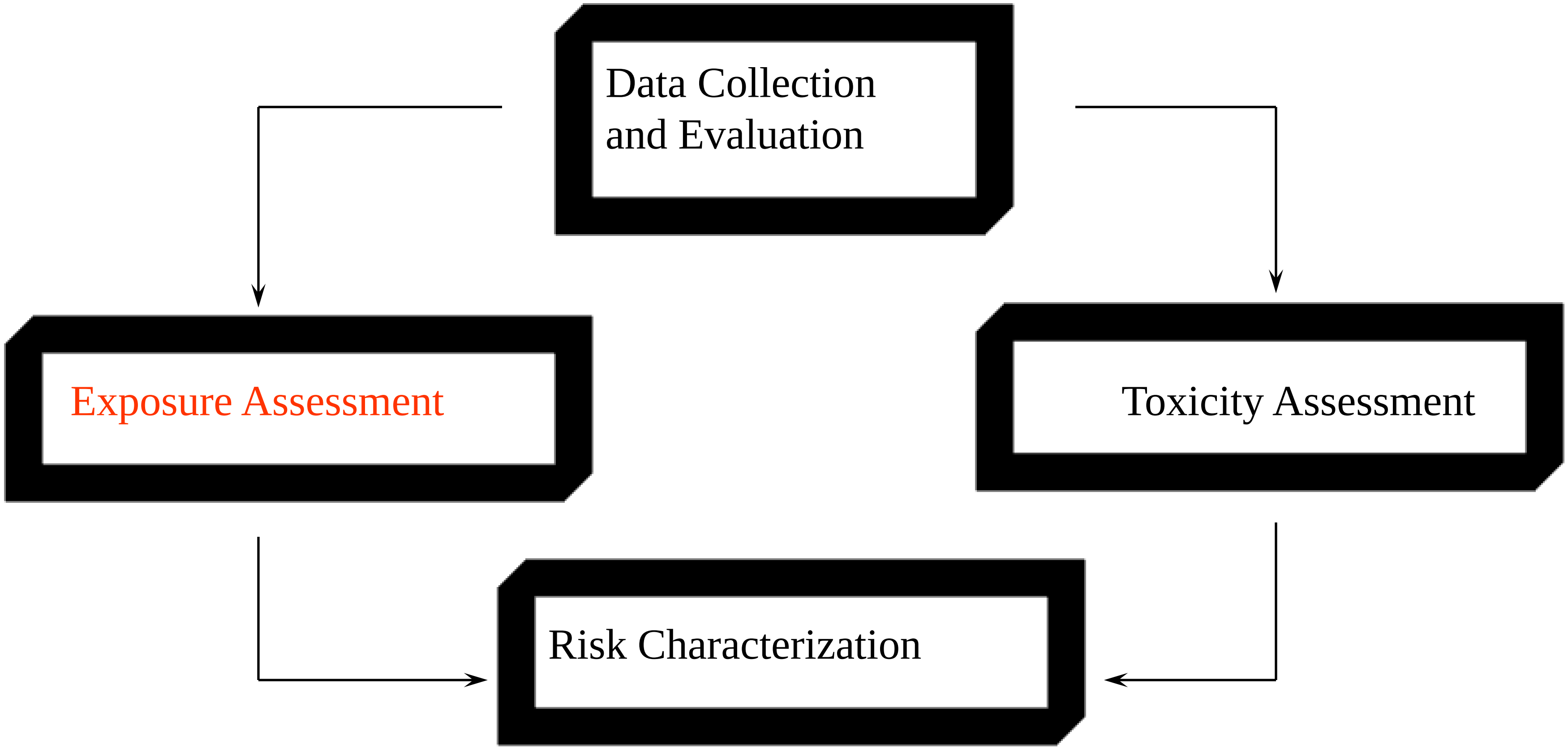
Data Collection and Analysis Details – SWMU 14

- A total of 14 surface and 14 subsurface soil samples are collected from SWMU 14
- Groundwater water samples were collected from two monitoring wells – one upgradient and one down-gradient
- All samples were compared against screening criteria to identify exceedences
- Chemicals exceeding criteria are identified as Chemicals of Potential Concern (COPCs) and these are included for risk assessment.

SWMU 14 - Hazard Identification/COPC Selection

- The soil had following COPCs
  - Aluminum (Al)
  - Arsenic (As)
  - Chromium (Cr)
  - Iron (Fe)
  - Manganese (Mn)
  - Thallium (Tl)
  - Vanadium (V)
- Groundwater had following COPCs
  - Dieldrin and Mn

Next in the Four Step Process



SWMU 14 – Conceptual Site Model

Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Exposure Media	Exposure Route	Mainten ance Worker	Industrial Worker	Contruction Worker	Residential Adult/Child
Wash Rack	Dishcharge to Surface Soils	Soil		Soil	Ingestion	X	X	X	X
					Dermal Contact	X	X	X	X
					Dust Inhalation	X	X	X	X
			Leaching	Groundwater	Ingestion		X		X
					Dermal Contact		X		X
					Inhalation				

X - Quantitatively evaluated exposure pathway

FIGURE

Conceptual Site Model - SWMU 14

Exposure Assessment

SWMU 14 Potentially Complete Exposure Pathways and Receptors

Future Receptor	Media	Exposure Route and Point of Exposure	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Maintenance Worker	Surface Soil	Ingestion, dermal contact and inhalation exposure to COPCs in site surface soils	Yes	Scenario is protective of any occasional maintenance work such as lawn moving.
Industrial Worker	Surface Soil and groundwater	Ingestion, dermal contact and inhalation exposure to COPCs in site surface soils and groundwater	Yes	Area could be developed in the future for industrial use. Both site soil and groundwater exposure is assumed. Inhalation exposure to groundwater is not significant as no volatile COPCs are identified.
Construction Worker	Subsurface Soil	Ingestion, dermal contact and inhalation exposure to COPCs in site subsurface soils	Yes	Scenario is protective of any occasional construction activities at the site.
Recreational Users	Surface Soil	Ingestion, dermal contact and inhalation exposure to COPCs in site surface soils	Yes	Area could be developed in the future for recreational use and would be protective of any occasional trespasser.
Residents	Surface Soil and groundwater	Ingestion, dermal contact and inhalation exposure to COPCs in site surface soils and groundwater	Yes	Although the site is unlikely to be considered for residential development, this is a conservative scenario for comparison purposes. Inhalation exposure to groundwater is not significant as no volatile COPCs are identified.

Exposure Media and Routes

- Soil is evaluated for direct exposure
  - Ingestion
  - Dermal contact
  - Dust inhalation
- Groundwater - unfiltered samples only
  - Ingestion
  - Dermal contact
  - No inhalation- as no volatile chemicals

Intake Equations

- Intake is also called ‘dose,’ or average daily dose
- Its is estimated using assumptions about behavior of people on a site under current and future land use
- Each assumption is called a exposure factor

Example Intake Equation

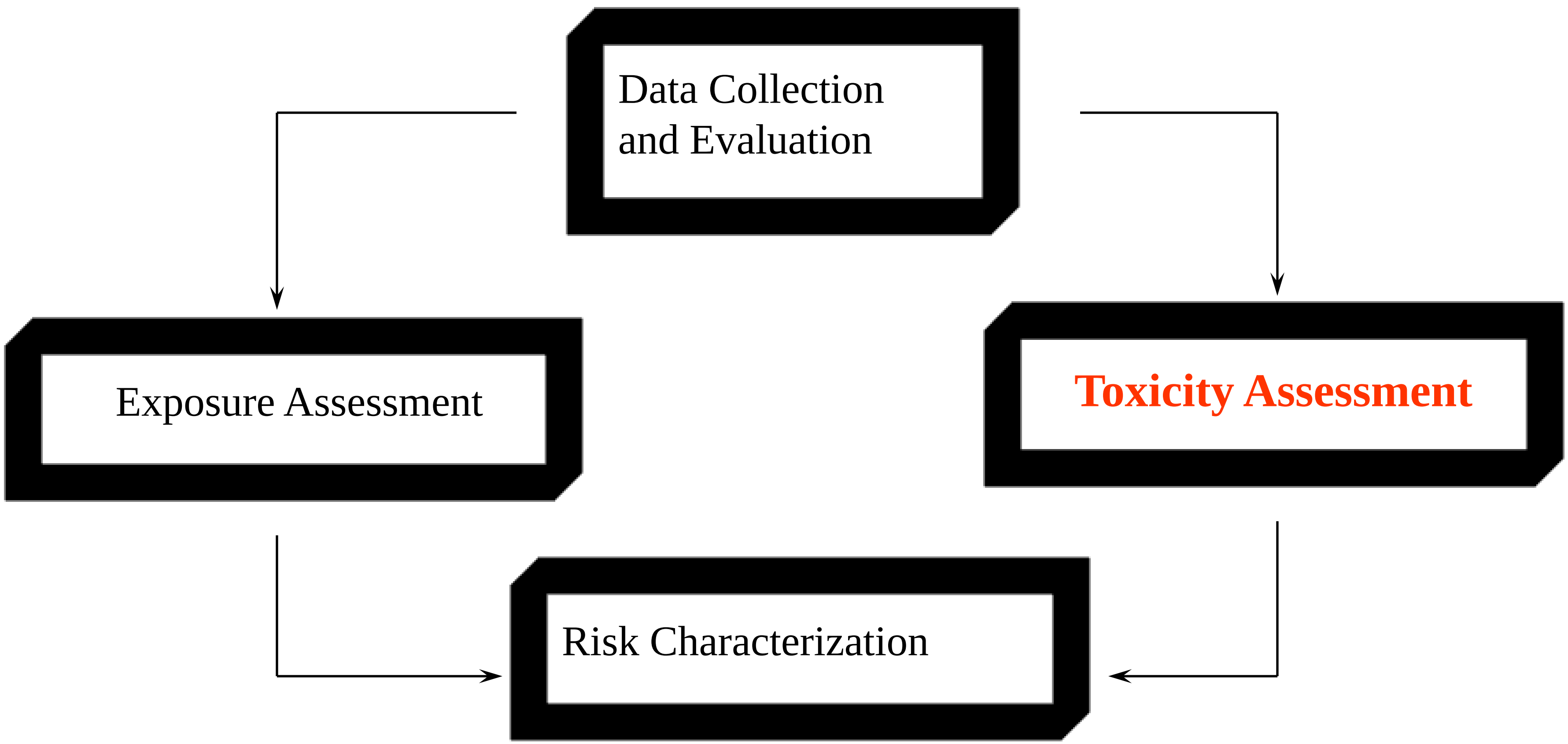
Intake (mg/kg/day)

=Average Daily Dose (ADD) =
(C x IR x FI x EF x ED x CF) / (BW x AT)

Where:

C = concentration in soil or groundwater (mg/kg or mg/L)
IR = ingestion rate (mg/day)
FI = fraction ingested (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
CF = conversion factor (kg/mg)
BW = body weight (kg)
AT = averaging time (days x years)

Next in the Four Step Process



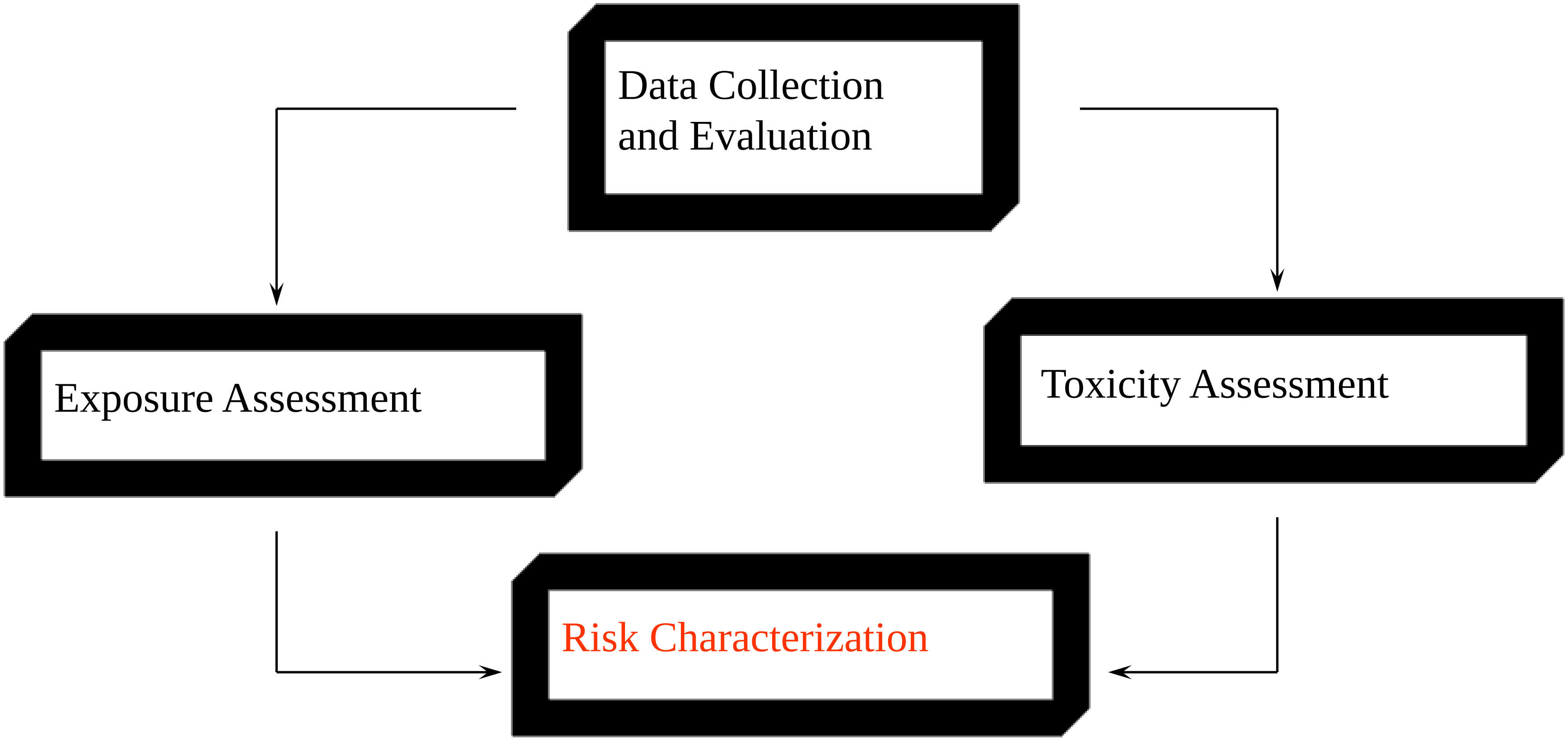
Toxicity Assessment

- Toxicity criteria are provided by EPA in the following sources:
  - Integrated Risk Information System (IRIS)
  - National Center for Environmental Assessment (NCEA), through EPA Region 2
  - Provisional Peer Reviewed Toxicity Values (PPRTV)
  - Health Effects Assessment Summary Tables (HEAST), etc

Example Toxicity Criteria

- Both carcinogenic toxicity criteria and reference doses are identified
- See Handout Tables on Pages 8 through 11

Next in the Four Step Process



Quantitative Risk Characterization

Risk characterization combines the results of the the toxicity assessment and exposure assessment into a quantitative (and qualitative) expression of risk.

Cancer Risk = Average Daily Dose (ADD) (mg/kg/day) X Cancer Slope Factor (CSF) (1/mg/kg/day)

Cumulative Cancer Risk = Sum of Individual Chemical Risks

$$\text{Hazard Quotient (HQ)} = \frac{ADD \frac{mg}{kg-day}}{RfD \frac{mg}{kg-day}}$$

$$\text{Hazard Index (HI)} = \sum \text{Individual Chemical HQs}$$

Note: see Handout Tables on Pages 12 to 15

Comparison of Estimated Cancer Risk and Hazard Index (HI) Values

- Risk Characterization presents Cancer Risk and Hazard Index (HI) for each scenario
- Estimated cumulative risk is compared to 10^{-6} (1 in 1,000,000) to 10^{-4} (1 in 10,000) cancer risk range
- Estimated HI is compared to a value of 1.0
- Inorganic chemicals are compared against background levels

Risk Summary – SWMU 14

Receptor	ELCR Ingestion	ELCR Inhalation	ELCR Dermal	ELCR Total	HI Ingestion	HI Inhalation	HI Dermal	HI Total
Maintenance Worker								
Soil	1.8E-07	2.7E-10	3.6E-08	2.2E-07	0.0234	0.0018	0.0020	0.02725
Total	**1.8E-07**	**2.7E-10**	**3.6E-08**	**2.2E-07**	**0.0234**	**0.0018**	**0.0020**	**0.0273**
Industrial Worker								
Soil	8.9E-07	1.3E-09	1.8E-07	1.1E-06	0.107	0.009	0.008	0.12
Groundwater	5.6E-07	0.0E+00	4.6E-10	5.6E-07	0.009	0.000	0.000	0.009
Total	**8.9E-07**	**1.3E-09**	**1.8E-07**	**1.1E-06**	**0.11**	**0.009**	**0.01**	**0.12**
Recreational Adult								
Soil	3.5E-07	5.2E-10	1.2E-07	4.8E-07	0.047	0.004	0.007	0.06
Total	**3.5E-07**	**5.2E-10**	**1.2E-07**	**4.8E-07**	**0.05**	**0.004**	**0.01**	**0.06**
Recreational Youth								
Soil	8.3E-07	6.1E-10	6.9E-08	9.0E-07	0.437	0.017	0.016	0.47
Total	**8.3E-07**	**6.1E-10**	**6.9E-08**	**9.0E-07**	**0.44**	**0.017**	**0.02**	**0.47**
Construction Worker								
Soil	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.232	0.001	0.003	0.24
Total	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.23**	**0.001**	**0.00**	**0.24**
Residential Adult								
Soil	1.2E-06	1.8E-09	1.4E-07	1.3E-06	0.158	0.012	0.008	0.18
Groundwater	1.5E-06	0.0E+00	4.6E-10	1.5E-06	0.024	0.000	0.001	0.026
Total	**1.2E-06**	**1.8E-09**	**1.4E-07**	**1.3E-06**	**0.16**	**0.012**	**0.01**	**0.18**
Residential Child								
Soil	2.8E-06	2.0E-09	2.3E-07	3.0E-06	1.472	0.058	0.053	1.58
Groundwater	8.8E-07	0.0E+00	4.6E-10	8.8E-07	0.057	0.000	0.003	0.060
Total	**2.8E-06**	**2.0E-09**	**2.3E-07**	**3.0E-06**	**1.47**	**0.058**	**0.05**	**1.58**

Example Uncertainties in Risk Assessment

Toxicity

- Animal to Man Extrapolation *(uncertainty factor or UF=10*)
- High Dose to Low Dose Extrapolation *(UF = 3 to 100)*
- Dose Uncertainty with uncontrolled human data *(UF=10 to 100)*

Exposure

- Future Land Use
- Future Exposure Scenarios
- Actual Behavior Patterns of Receptors

Selected Chemical Background Soil Inorganic Levels Compared Against SWMU 14

Table 12-3

Site Versus Background Soil Concentrations for the Inorganic COPCs

Chemical	Background Range			SWMU 14		
	Minimum		**Maximum**	**Minimum**		**Maximum**
Aluminum	1600	-	29000	4900	-	16300
Arsenic	0.57	-	2.5	0.39	-	3
Iron	2500	-	39000	7490	-	28300
Manganese	48	-	1200	263	-	907
Thallium	0.45	-	0.67	0.4	-	1.7

Units in mg/kg

AOC K – Former Water Supply Well

AOC K – Former Water Supply Well

- The site is a former water supply well located to the northeast of the former barracks, and it was in use between 1941 and 1969. It has been plugged and abandoned since 1969.
- The well was opened in 1997 as part of a water well investigation conducted by the USGS.
- During the USGS investigations, well was identified to have benzene at concentrations above the MCL level (>5 ug/L).
- PA/SI conducted in 2002 collected sample by re-opening the plugged well:
  - to determine VOC and inorganic chemical levels
  - results showed benzene was not detected in the well
  - five additional wells were installed - 2 upgradient and 3 downgradient

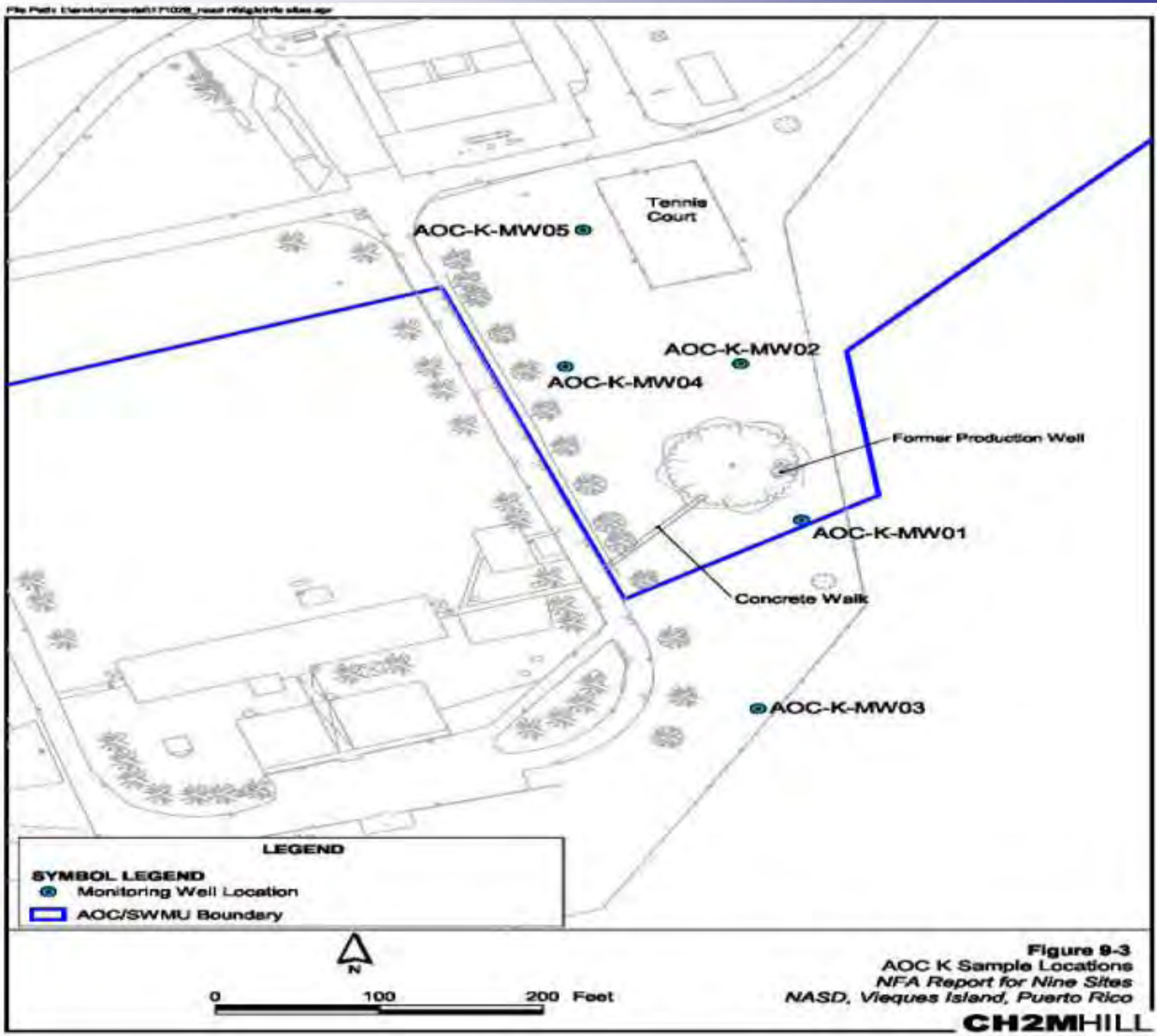
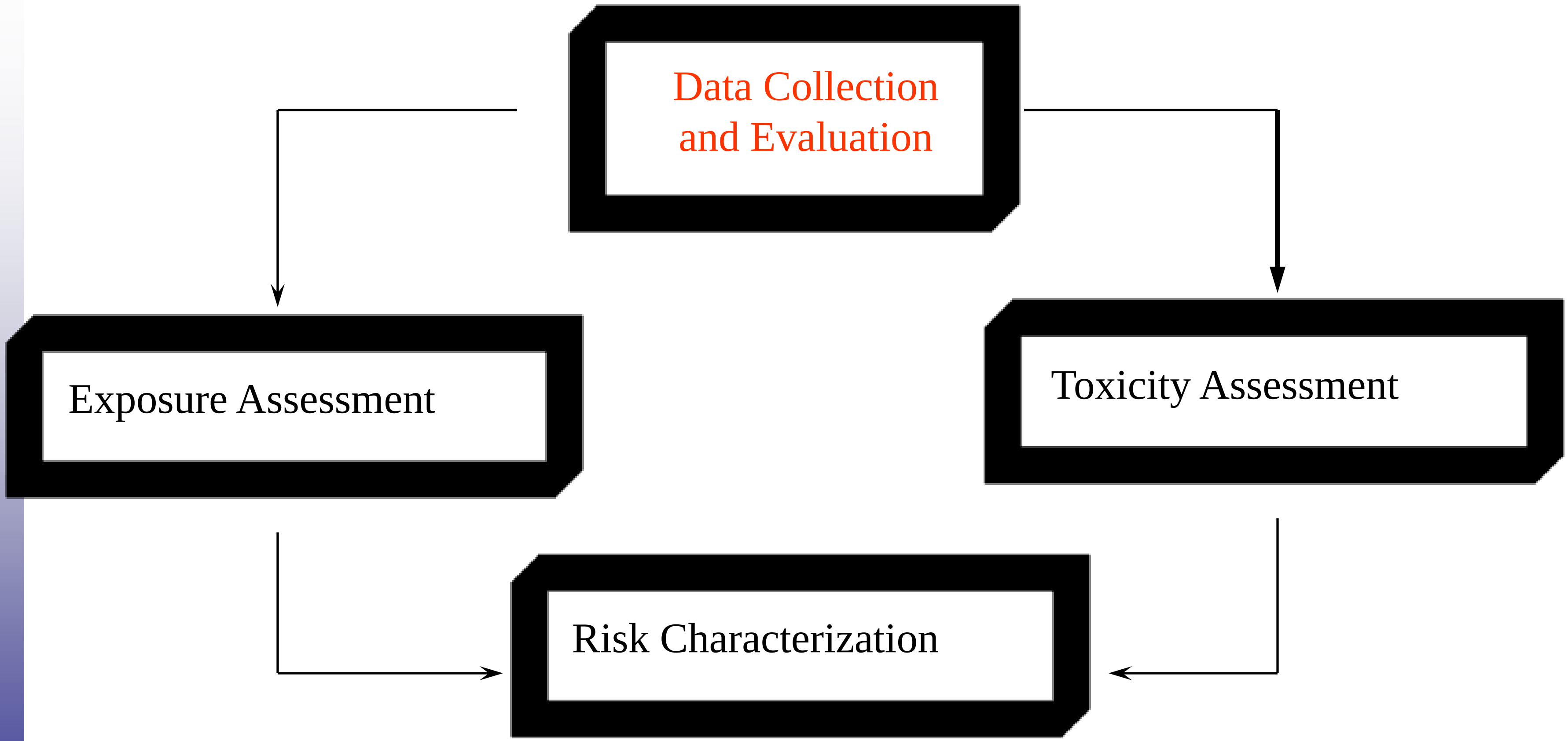

Tennis Court
AOC-K-MW05
AOC-K-MW02
AOC-K-MW04
Former Production Well
AOC-K-MW01
Concrete Walk
AOC-K-MW03
LEGEND
SYMBOL LEGEND
Monitoring Well Location
AOC/SWMU Boundary
N
0 100 200 Feet
Figure 9-3
AOC K Sample Locations
NFA Report for Nine Sites
NASD, Vieques Island, Puerto Rico
CH2MHILL

Figure
AOC K Former Water Well (Closer View of Well Location)

First in the Four Step Process



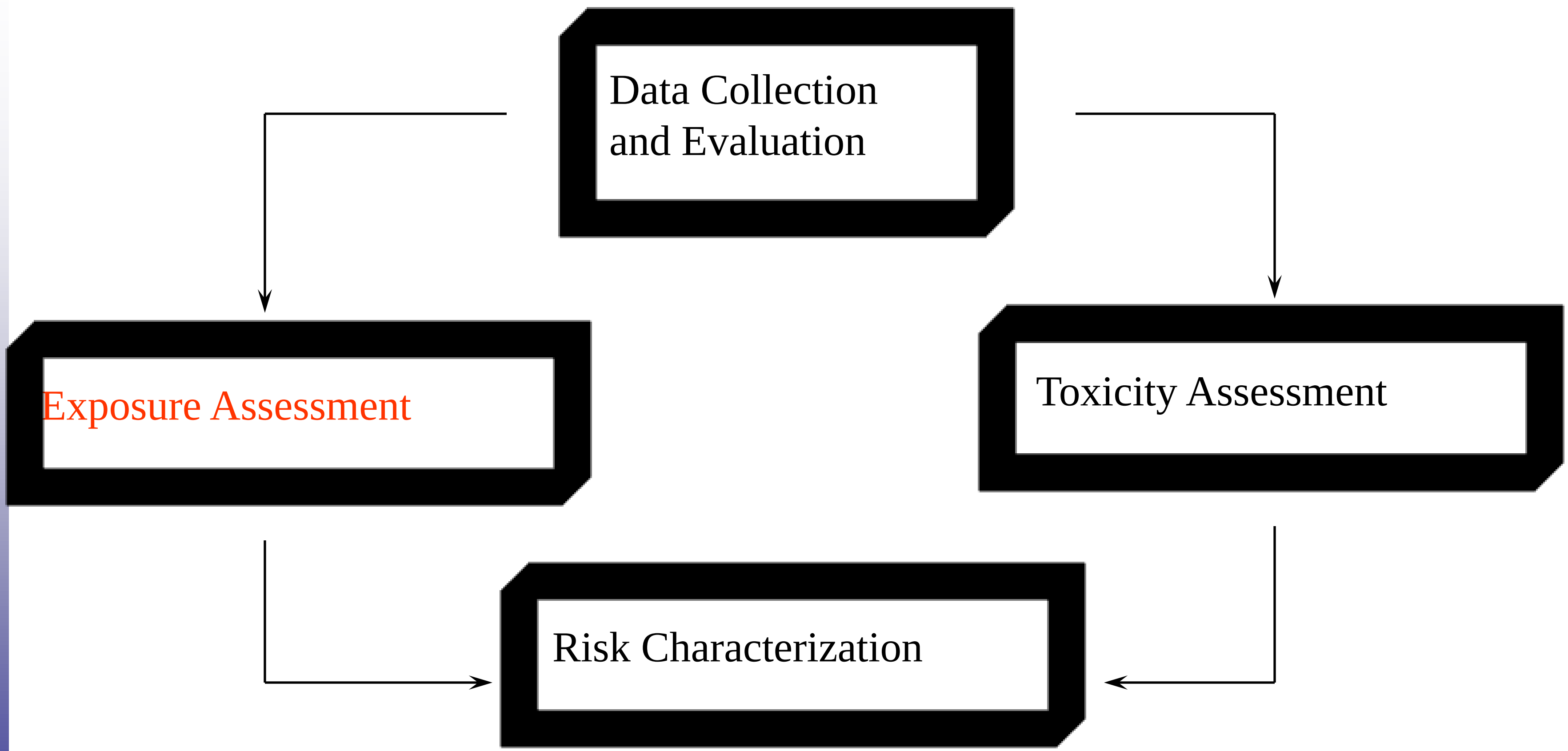
Data Used for Risk Assessment

- Groundwater - unfiltered samples only
  - All data collected during PA/SI were used for risk evaluation
  - 5 well samples were included in the risk assessment
  - Two of the 5 wells represent up-gradient (background) conditions for AOC K area, as groundwater flows from higher elevation to the south to the lower elevation to the Vieques Passage
  - Chemicals detected above screening criteria are identified as COPCs

AOC K - COPC Selection

- Groundwater COPCs identified are:
  - Aluminum (Al)
  - Barium (Ba)
  - Chromium (Cr)
  - Iron (Fe)
  - Manganese (Mn)
  - Thallium (Tl)
  - Vanadium (V)

Next in the Four Step Process



Conceptual Site Model – AOC K

Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Exposure Media	Exposure Route	Maintenance Worker	Construction Worker	Industrial Worker	Residential Adult/Child	Recreational Adult and Child
AOC K (Former Water Supply Well) →	Spill/ Release →	Groundwater →		Groundwater →	Ingestion			X	X	
					Dermal Contact			X	X	
					Inhalation					

X - Quantitatively evaluated exposure pathway

FIGURE

Conceptual Site Model - AOC K

Exposure Assessment

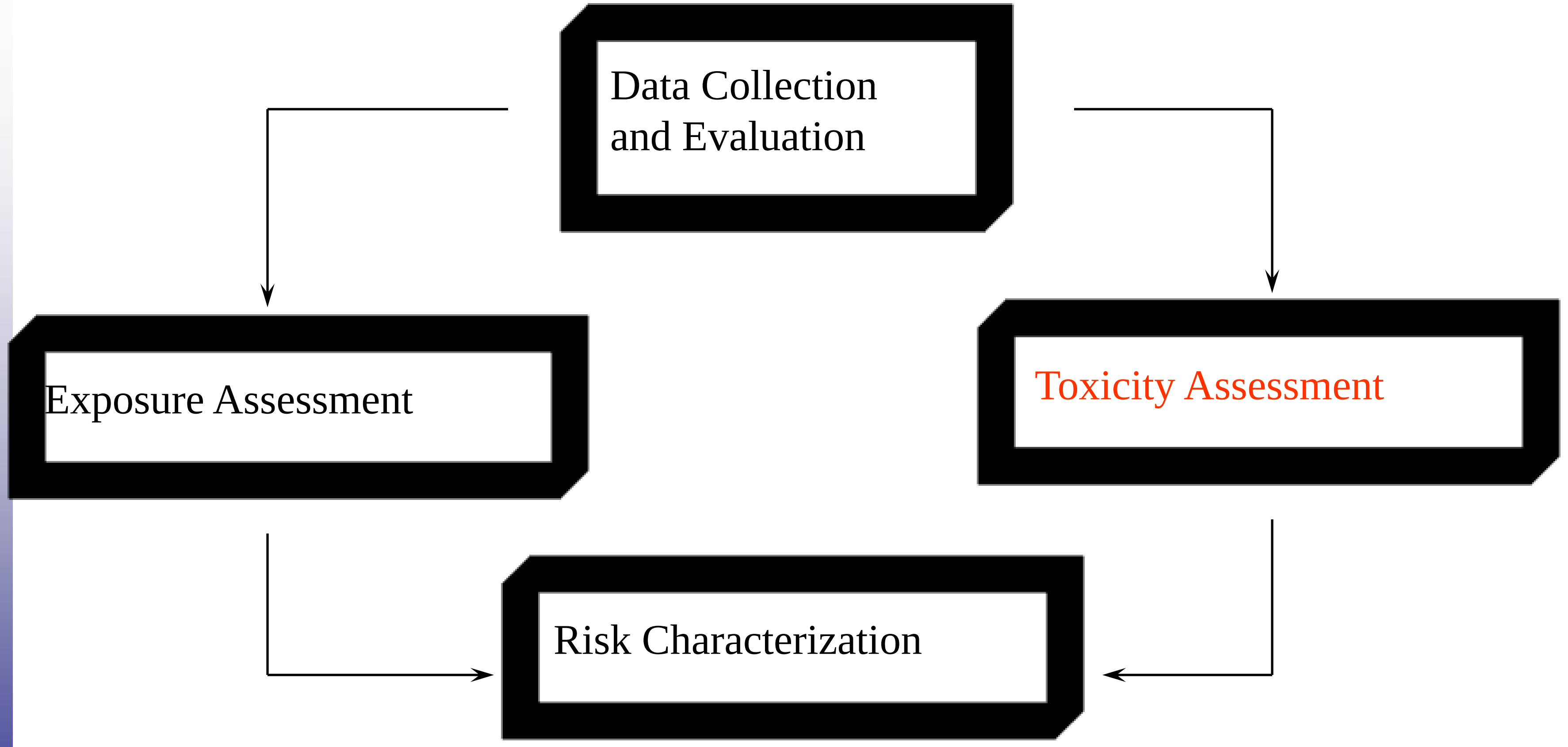
AOC K Exposure Factors for Groundwater

Receptor	Media	Exposure Route and Point of Exposure	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Future				
Industrial Worker	Groundwater	Ingestion and dermal contact with site groundwater	Yes	Although unlikely, pathway assumed for comparison purposes and to provide for a conservative assessment of risk
Residents (adult and child)	Groundwater	Ingestion and dermal contact with site groundwater	Yes	Although the site is unlikely to be considered for residential development, this is a conservative scenario for comparison purposes

Exposure Assessment

- The risk assessment evaluated exposures to site groundwater to:
  - Industrial worker
  - Residential adult and child.
- Receptors are assumed to use groundwater as a potable source
  - Ingestion and dermal contact exposure routes
  - Inhalation pathway is not considered complete, as no volatile chemicals were COPCs

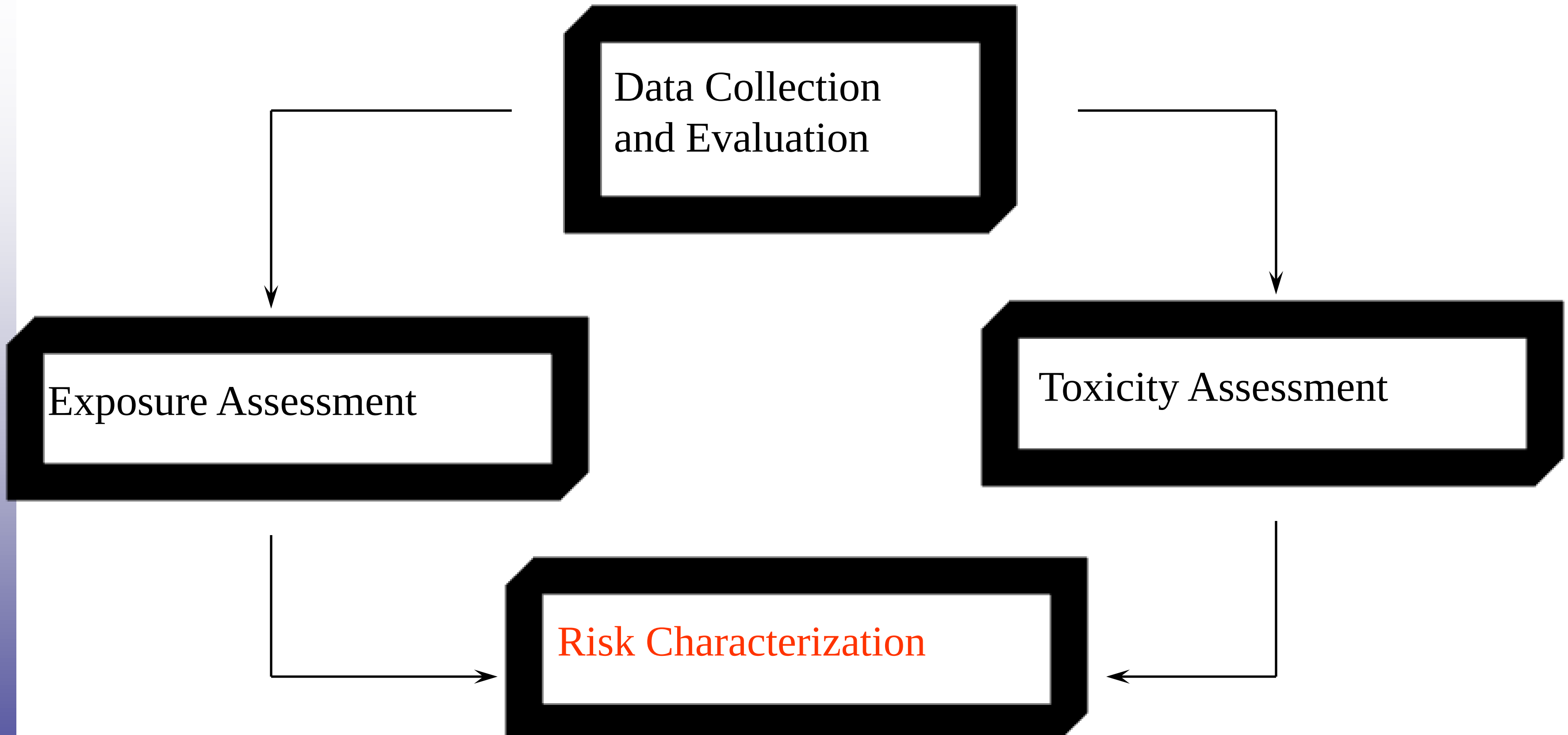
Next in the Four Step Process



Toxicity Assessment

- There were no carcinogenic chemicals of potential concern (COPCs)
- The reference doses were obtained from the same EPA sources as SWMU 14 (previously listed)
- Detailed tables are presented in Appendix D-8 of the report

Next in the Four Step Process



AOC K - Risk Characterization

AOC K Risk Summary

	ELCR				HI			
Receptor	Ingestion	Inhalation	Dermal	Total	Ingestion	Inhalation	Dermal	Total
Industrial Worker								
	Groundwater				*Groundwater*			
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.516	0.000	0.010	1.526
	Total				*Total*			
	0.0E+00	**0.0E+00**	**0.0E+00**	**0.0E+00**	**1.52**	**0.00**	**0.01**	**1.53**
Residential Adult								
	Groundwater				*Groundwater*			
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.245	0.000	0.077	4.322
	Total				*Total*			
	0.0E+00	**0.0E+00**	**0.0E+00**	**0.0E+00**	**4.24**	**0.00**	**0.08**	**4.32**
Residential Child								
	Groundwater				*Groundwater*			
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.904	0.000	0.239	10.143
	Total				*Total*			
	0.0E+00	**0.0E+00**	**0.0E+00**	**0.0E+00**	**9.90**	**0.00**	**0.24**	**10.14**

Risk Characterization

- Industrial worker exposure to site groundwater indicated HI>1.0, however, no target organ specific HI was above 1.0, thus do not present unacceptable health hazards.
- Exposure to future residential adults and children present a HI above 1.0, primarily due to iron and thallium in groundwater.
- Historical USGS investigation concluded that site groundwater iron and manganese levels are due to the volcanic rock formation characteristic of this area of Vieques.
- The background wells, up-gradient of the site has higher thallium levels than the three down-gradient wells.

Comparison with Background Metals

Parameter	Units	Range of Background Concentrations			Background UTL	Maximum Detected Site Concentration	Average Site Detected Concentration
		Minimum	-	Maximum			
Aluminum	µg/L	130	-	3,500	3,500	9,100	3,173
Barium	µg/L	15	-	960	960	390	205
Iron	µg/L	480	-	4,800	4,800	9,600	3,075
Manganese	µg/L	100	-	17,000	17,000	1,300	394
Thallium*	µg/L	4.8	-	18	18	9.3	8.7
Vanadium	µg/L	1.8	-	75	75	64	23

Note:
* - thallium was highest in up-gradient wells AOC-K-MW-01 and AOC-K-MW-03
µg/L – micrograms per liter
UTL – Upper tolerance limit at 95%

Questions/Comments