BIOENVIRONMENTAL ENGINEERING FIELD MANUAL

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Tables and Figures

Section 1.0: Occupational and Environmental Health Site Assessment (OEHSA) Process

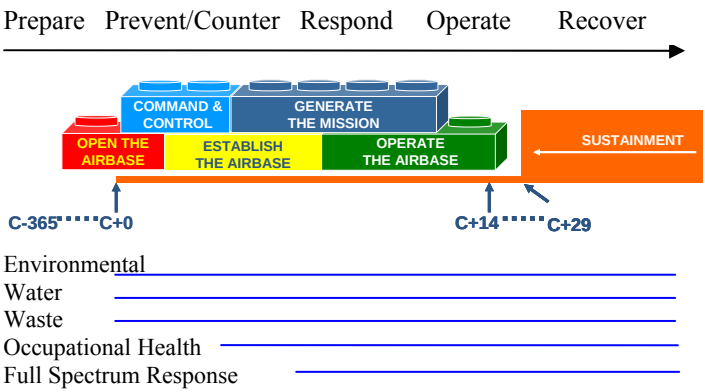
1.0. Introduction: The OEHSA process, including the Health Risk Assessment (HRA) component, is to be followed regardless of the health threat source (i.e., occupational and environmental). The intended results are lower health risks to personnel and improved operational effectiveness. The goal of the HRA is to provide the commander with a concise course of action (COA) that clearly articulates impacts and recommendations to maximize operations and minimize health threats.

1.1. Purpose: While AFMAN 48-154, OEHSA, elaborates on each step of the site assessment process, this field manual describes how to utilize the Conceptual Site Model (CSM) for the gathering and organization of data and then develop a defensible sampling and analysis strategy based on the principles of Data Quality Objectives (DQO), which are a series of steps used to construct a sampling strategy that provides for statistically significant results to support decision-making. It also includes quick references, calculations, field estimates, and other useful tools. The remaining sections of this FM focus on techniques to evaluate occupational, environmental, and crisis response threats.

1.1.1. Overview of OEHSA Strategy: The OEHSA process helps prioritize and quantify the potential health threats to mission goals and objectives. BE will need to organize data into a Conceptual Site Model and analyze it to determine the probability and severity of the OEH threats, prioritize the risks, identify the need for any follow-up sampling, develop control recommendations, and then clearly communicate this information to the commander. This process should be applied to initial, routine and special surveillance in both deployed settings as well as in-garrison.

The field manual is organized based on the time-phases of an operation. Several parallel concepts are shown in the figure below.

Figure 1-1: Phases of Operations and Related Threats



1.2. Initial and Routine Surveillance: Table 1-1 below compares the initial assessment process with the routine assessment process.

Table 1-1: Initial and Routine Assessment Process

Initial Assessment (Garrison and Deployed)	Routine Assessment (Garrison and Deployed)
Obtain administrative data (e.g., workplace supervisor's name, phone number, etc.)	Review and verify administrative data
Identify Areas of Concern (AOCs) for the workplace or site; organize this data into a Conceptual Site Model (CSM)	Review the AOCs and determine if changes have occurred to merit a reorganization of AOCs
Identify workplace similar exposure group(s) (SEG) for personnel exposed to both: o Occupational – Welding, spray priming, spray painting, parts cleaning, etc. o Environmental – Airborne dust and contaminants, burn emissions, contaminated waste water, etc.	Review and verify SEG(s)
For each SEG determine: o Who: How may workers perform the job? o What: Step by step process of task and the chemicals used o Where: Outdoors, spray booth, hanger, etc. o How: Hand sander, power sander, brush on, spray gun, etc. o How much: Quantity of chemical is being used o How long: Duration of exposure	Review and verify process/tasks. o Has the process been changed? o Do they now use sanders versus hand sanders? o Do they accomplish the task in a spray booth now? o Does the process take as long? o Have personnel changed since last assessment? o How tightly is the process controlled? o Is it controlled by a TO or SOP?
Identify the hazard type (e.g., chemical inhalation, absorption or contact; physical such as noise and non-ionizing radiation; and biological hazards such as sewage exposure)	Review and verify hazard type. Is it still an inhalation or contact hazard? Are they still exposed to noise or radiation?
Identify the controls (e.g., engineering, administrative, and PPE)	Review and verify controls. Are controls still being used? What type of glove is used? Are ventilation systems being used?
Perform risk assessment; determine the severity of a hazard/health effect or impact on environment; also evaluate the effectiveness and confidence in control measures	Review and verify risk assessment and quality of controls measures. Are ventilation systems being used and are they operating within the acceptable range? Are they wearing proper gloves to prevent contact hazards?
Identify/prioritize special surveillance requirements	Identify/prioritize remaining special surveillance requirements

Figure 1-2: Health Threats, Vulnerabilities and Hazards

1.2.1. The Conceptual Site Model (CSM): The CSM shows the link between OEH threats and personnel working in similar exposure groups via a clearly defined exposure route. The elements evaluated are:

- Areas of Concern (AOC)
- Potential Primary and Secondary Sources of Release
- Media Pathway
- Activity or Point of Exposure
- Exposure Route
- SEGs Effected

Only AOCs with complete or potentially complete exposure pathways are evaluated and given a risk rating; other pathways are documented but eliminated from further evaluation. All possible sources, pathways, and exposure routes should be considered for a comprehensive evaluation. The viable exposures from Table 1-2 are further evaluated and prioritized according to risk (as discussed in Section 1.2.2), and this prioritization is used as the basis for an overall sampling strategy. A CSM should be treated as a working document and updated as new information and sampling data becomes available.

Complete Exposure Pathway – The media, activity or point of exposure and exposure route all must be present for a pathway to be considered complete.

Potentially Complete Pathway – A gap in the data is present and follow-up sampling is required to determine if a complete pathway exists. Sampling is not necessary if one of the other elements of the pathway can be blocked or removed. Also, seasonal environmental variations may impact an exposure pathway.

Incomplete Pathway – Pathways that are unfeasible or do not have the means to become complete. Incomplete pathways are not considered for further risk evaluation and follow up activities, but should be documented especially if they have been downgraded from a potentially complete pathway.

1.2.1.1. Define the Areas of Concern:

- Homogenous areas – Base housing, industrial flightline operations, administrative areas, waste disposal areas, zones with similar soil characteristics
- Common mission – Firing ranges, aircraft maintenance shops, flight operations, medical elements
- Similar shops – Communications, NDI, munitions maintenance, transportation, logistics
- Specific activity – Paint booth, pesticide mixing, food preparation, remediation sites
- Nearby industrial facilities – All industrial, manufacturing, waste reclamation and disposal, medical and processing facilities within a twenty-mile radius of the site; 250 miles for nuclear power plants

1.2.1.2. Evaluate Potential Primary and Secondary Sources of Release: Perform a site visit; take into consideration nearby facilities and the surrounding area; note any unoccupied facilities.

- Past uses and condition of facilities – Determine if there have been past activities involving the treatment, storage, use, disposal or generation of hazardous materials; these uses should be included in the CSM if they are likely to indicate a complete or potentially complete exposure pathway at the site
- Current use and condition of facilities – Note activities involving the treatment, storage, use, disposal or generation of hazardous materials to include chemical, radiological, biological hazards; identify activities that generate physical hazards (e.g., thermal, ergonomics, non-ionizing radiation, ionizing radiation, and noise)
- Contaminants transported through the environment – Dust or other particulate matter generated off site or on base; path and flow of surface and groundwater; contaminated soil likely to be re-entrained in the air; hazards transferred from one media to another

1.2.1.3. Identify Media Pathway:

- Groundwater – Can a release from the source infiltrate soil into groundwater that may be used for potable or non-potable applications
- Surface water & sediment – Will personnel contact surface water at the source or through applications such as drinking treated water, fire suppression, or washing activities
- Air – Consider both on and off site activities; static and mobile sources; secondary releases from hazards in soil or water which volatilize or become entrained in the air
- Soil – Evaluate if there are possibilities of dermal contact, volatile and semi-volatile hazards, or radioactive materials present
- Food chain – Hazards released into the environment may be consumed and enter the food chain; consider the source/location of food stuff
- Biohazard – Consider medically significant pests and the likelihood of vector-borne diseases

1.2.1.4. Determine the Activity or Point of Exposure:

- Exposure at point of generation – Are there personnel working or living where the hazard source is generated (e.g., exhaust from diesel lifts, waste oil from vehicle maintenance, industrial activities)
- Exposure from source generated elsewhere – Hazardous noise from flightline operations, emissions from burn pit, dust from off-site agricultural activities

1.2.1.5. Identify Exposure Route from the Source to Personnel:

- Ingestion
- Inhalation
- Contact (i.e., dermal)
- Absorption
- Injection

1.2.1.6. Determine the Effected SEGs:

- Are all personnel in a single shop affected?
- Are all personnel who work in the same activities affected?
- Are all personnel who work the same geographic zone affected?
- Are there predisposed personnel (i.e., pesticide workers) that will be affected differently?

Table 1-2: Example of a Conceptual Site Model for a Source Release and the Associated Exposure Pathways

#	Area of Concern	Potential Source of Release	Media Pathway	Activity or Point of Exposure	Exposure Route	SEG Effected
1	Local dump site (off base)	Leaching into groundwater	Drinking water	Drinking water dining facility	Ingestion	All personnel
2	Flightline	Industrial emissions	Air	Dust generation & volatilization	Contact & inhalation	Flightline operations personnel
3	Burn Pit	Air emission	Air/ Soil deposition	Downwind/ Digging operations	Inhalation/ Contact	All personnel CE Ground, COM

Source: CSM table based on ASTM E2318-03, *Standard Guide for Environmental Health Site Assessment Process for Military Deployments*

1.2.2. Prioritization of AOCs: Once the AOCs and their respective exposure hazards have been identified and unfeasible exposure pathways eliminated, determine the risk rating and risk rank of each exposure pathway. These risk ratings can be used to prioritize special surveillance activities, prioritize requirements for process enhancements (i.e., improved

controls), and development of countermeasures to enhance survivability. Table 1-3 shows the derivation of the risk rating for each exposure pathway in Table 1-2; a discussion of the components in the risk rating system begins in Section 1.2.5.

Table 1-3: Determination of Risk Ratings for Exposures from Table 1-2

Exposure #	Confidence in Characterization	Controls	Confidence in Controls	Probability	Severity	Risk Rating	Risk Rank
1	Med	ROWPU	High	C	Mod	Mod	2
2	High	None	Low	B	Neg	Low	3
3	Med	None	Low	A	Mod	High	1

1.2.3. Develop a Sampling Strategy to Determine the Completeness of an Exposure Pathway: When gaps in data have been identified through the CSM, special surveillance or follow-up sampling to determine if an exposure exists and at what level. The sampling design should be based on the principles of Data Quality Objectives (DQO) to determine if an exposure exists and at what level. The DQO process consists of seven steps. It is important to remember that this is a subset of HRA Step 2, not a parallel effort.

1. State the problem to be solved
2. Identify the decision to be made
3. Identify the inputs to the decision
4. Define the study boundaries
5. Develop a decision rule
6. Specify the tolerable limits on decision errors
7. Optimize the design for obtaining data

1.2.3.1. Step 1 – State the Problem to Be Solved:

- Purpose – What is the reason for the survey? Compliance with a standard? General hazard evaluation?
- Decision Maker – Who actually makes the decision? The Commander? The shop supervisor? BE serves in an advisory capacity to the decision maker
- Description of the Problem – Clearly identify the risks in an unambiguous manner
  - For example: Is perchlorate contamination present in Well #7 that could cause a risk to human health and/or the environment
- Resources – These are the tools and skills that BE will use to approach the problem (e.g., experience, instruments, GEMS, etc,)

- Timeline – If not restricted by imminent operational demands, BE should perform a quick initial assessment in all shops including new workplaces and environmental AOCs; eventually a routine surveillance schedule will be established and determined by the level of overall risk

1.2.3.2. Step 2 – Identify the Decision: A clear decision must be established to determine why further analysis is needed. BE needs to have an understanding of the decision to be made rather than taking a shotgun approach to sampling in the hopes or arriving at some new information that will drive a decision. The decision point must be established first.

- Example: Has there been perchlorate contamination in Well #7, and if so, how much perchlorate is present?
- Example: Are the ventilation controls in place effective in keeping chromate levels below the AL for the Corrosion Control Shop?
- Example of a Bad Decision Statement: Does the ventilation system work?

1.2.3.3. Step 3 – Identify Inputs to the Decision:

- Information/Sources – Historical data, BE shop files, Command Core, site visits, etc.
  - Example: Where has perchlorate been used in the past? What information is there on the magnitude of historical uses of the chemical?
- Rationale for Action Level (AL) – Does a compliance standard drive the point at which a hazard needs to be controlled?
  - Example: The State of New Mexico has a limit of 1 ppb (or 1 μg/L) for perchlorates in drinking water as a health based goal
- Identify Methods – Field portable equipment should be used and supplemented by reachback laboratory analysis
  - Example: DoD requires that EPA Method 331.0 or 332.0 be used for DoD owned drinking water supplies

1.2.3.4. Step 4 – Define the Boundaries: Identifying AOCs (Section 1.2.1.1) is a clear first step in determining the boundaries for a sampling plan. An AOC can be defined as a large area where similar activities or homogenous conditions occur. It can also be subdivided into smaller sectors where specific tasks are performed or specific environmental conditions exist. Once the AOC has been determined, consider spatial and temporal boundaries.

- Spatial Boundaries – Typically it is the geographic limits of an AOC; if there are obstacles to spatial boundaries, they should be discussed as well (e.g., a field is located partially on an Air Force base and partially on private property)
  - Example: A single shop, or a group of workplaces that perform the same tasks (e.g., fuels storage), or several geographic locations that have the same characteristics;
- Temporal Boundaries – Time restrictions for certain conditions that change over time (e.g., weather, water table, climate, use of HVAC system, etc.)
- Define the Scale of Decision-Making – identify the smallest sampling unit
  - Example: Only the three wells (to include Well #7) on the west side of the base will be sampled for perchlorate, rather than all wells

- Consider Constraints – Personnel, time, instrumentation, and lack of risk data are the most common

1.2.3.5. Step 5 - Develop the Decision Rules: Decision rules serve as the objective method to evaluate and assess the hazard, which triggers a decision. In most cases, these are based on the quantitative values, such as the AL, or some other numerical parameter (i.e., maximum value, mean, median).

- Sample Population Parameter – Narrowing down when and where to sample based on boundaries and constraints; the population parameter may result in a single sample, but will more likely be the mean of sampling in a homogeneous area or an AOC
  - Example: The desert monsoon season raises the water table and will dilute perchlorate concentrations in the wells, therefore sampling should begin well before the monsoon season
- Specify the AL – This is based on the environment, operational context (in-garrison or deployed), governing regulations, and mission/personnel criticality – this involves coming up with "*if…then…*" statements for the full range of possible outcomes of sampling
  - Examples: If the concentration of perchlorate is determined to exceed the permit limit, then confirmatory analysis will be undertaken
  - If the concentration does not exceed the permit limit, then quarterly sampling will continue for a period of 2 years
  - If the concentration of perchlorate remains below the permit limit for 2 years, then quarterly monitoring for perchlorate will be discontinued

1.2.3.6. Step 6 – Specify Tolerance Limits on Decision Errors:

- Evaluate Sources of Error in Study – Consider both study error and measurement error; the greater the total error, or variability, the more samples will be required to achieve a desired confidence in the results; variability will be discussed in greater detail in section 1.2.3.7

  Study Error – The variability (i.e., high, medium, or low) in the population or environment that is being sampled

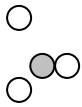
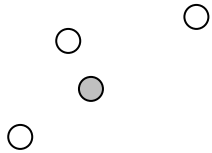
  Measurement Error – The combination of the error that comes with using instruments in the field instead of a controlled laboratory environment, and the sampling and analytical error (SAE) inherent with an analytical method; the SAE will be listed in the details of the method
- Determine Possible Range of Parameter of Interest – Set the boundaries where one could expect to capture the highest and lowest concentrations; a good rule is to make the range one order of magnitude. Set realistic limits based on LOD and instrument capabilities.
  - Example: Historical records have shown average perchlorate concentrations in the area to be 0.5 µg/L, therefore the range will be 0.1 – 1.0 µg/L; note that the detection limit for EPA Method 331.0 (LC/MS) is 0.1 µg/L
- Identify the Decision Errors and Choose the Null Hypothesis – When designing a sampling strategy for an OEHSA, the null hypothesis is that there is an over-exposure

and the burden of proof is on showing that there is no over-exposure (Note: All calculated data in this field manual utilized this hypothesis)
    - Example: The null hypothesis is - Well #7 has a concentration of perchlorate greater than 1 μg/L
- Specify the Gray Region around the AL where Decision Errors are Minor – With USAF occupational HRAs, the gray region is typically bounded on one side by the AL (50% of the OEL) and the OEL on the other
- Assign Probability Limits to Decision Errors – Roughly put, what is the probability of choosing the incorrect decision; in this field manual six potential probability limits or confidence limits were assumed – 1, 5, 10, 20, 30 and 40% (99, 95, 90, 80, 70 and 60% confidence that a correct decision is being is made). Determine desired confidence level in your result before collecting samples.
    - Example: BE wants to be 95% certain that sampling results will lead to a correct decision about whether Well #7 is contaminated with perchlorate above the AL

1.2.3.7. Step 7 – Optimize the Design: Because only a finite amount of time and resources can be committed towards making a decision based on sampling results, optimizing the design is necessary for identifying the most resource-effective data collection design that balances the number of samples required with the desired confidence in the quality of the sample results given the total amount of variability that causes study error. Before any sampling occurs conduct both a qualitative assessment, using professional experience and historical data, and a field estimate or calculation. Afterwards field-portable instruments can be used to characterize the hazard; and if applicable, laboratory analysis to confirm the results.

- Variability – The amount fluctuation between the true condition and the sampling results; the degree of environmental or hazard level conditions affect the study variability
- Geometric Standard Deviation (GSD) –A measure of how spread out a set of numbers are from the geometric mean, it is a quantifiable value for variability; typical AF industrial operations have a GSD of 2.0

Table 1-4: Examples of Environmental Variability for Various Media

Media	Ideal Environment	Low Variability	Medium Variability	High Variability
- True Condition - Sample Result				
Water	No Variability	Oceans, lakes, and ponds that do not receive discharges	Rivers or streams	Rivers or streams that receive industrial discharges or other sources upstream
Air	No Variability	Generally clean environment; most USAF locations	Some industrial processes and emission sources nearby; emissions influence air media	Many emission sources impacting environment
Soil	No Variability	Homogeneous soil area	Soil area contains some hot spots and emission sources	Soil area contains some heterogeneous areas and many hot spots and emission sources

The following tables have been created based on statistical principles with Visual Sample Plan (VSP) software (developed by the EPA and downloadable at http://dqo.pnl.gov/vsp) to provide general guidelines for optimizing a study design based on the desired confidence level and variability of the sampling environment.

There are two approaches that can be taken:

1. ***Determine the Number of Samples Needed from the Prescribed Sampling Requirements*:** Decide on the probability limit and then calculate the number of samples required to achieve this confidence level based on an assumed variability (i.e., GSD) using Table 1-4
2. ***Determine the Confidence in a Limited Sampling*:** If only a few or even single sample can be collected, the probability limits allow for a determination of the confidence in a decision based on highly limited sampling results. Confidence in the sample result(s) is a function of the distance between the result and the standard, as well as the variability of the process/sample data. Table 1-5 correlates the confidence with result/standard ratio.

Use table 1-5 to identify the number of samples which need to be collected to have a certain confidence level in the result. The number of required samples is affected by their variability in the environment. This is based on professional judgment and may lead to the BE checking their assumption (and required samples) part-way through the process by validating that the variability in their data matches their assumed variability.

Table 1-5: Prescribed Sampling Requirements Based on Desired Confidence and Hazard Variability

Confidence in Characterization (Consistency in hazard levels or environmental variability throughout the process)		**High (Low Variability)**	**Moderate (Medium Variability)**	**Low (High Variability)**	**Very Low (Very High Variability)**
Confidence Result Will Yield Correct Decision	**Decision Error (p)**	**GSD= 1.02** Standard Deviation =15%	**GSD=1.3** Standard Deviation =50%	**GSD=2** Standard Deviation =80%	**GSD=54** Standard Deviation =200%
99%	1%	5	25	59	350
95%	5%	3	13	30	175
90%	10%	2	8	18	106
80%	20%	1	4	8	46
70%	30%	1	2	3	18

Example: How many samples must be taken to achieve a 95% confidence level in the determination that Well #7 does not have perchlorate levels at or above the action level? Assume medium variability in the environmental conditions unless you have reason to believe otherwise. The assumption can be checked based on reviewing sampling results.

Table 1-5 identifies that 13 samples should be collected. After collecting 4 samples, the results are loaded into VSP, which calculates that the results have a standard deviation of 15% (GSD=1.02). Based on this information, BE can stop collecting samples since only 3 samples are required to achieve 95% confidence with such a low standard deviation.

In this case the variability in the process was overestimated. BE reevaluated the assumptions, statistical hypothesis, and sample size before collecting the prescribed 25 samples. Following this process is highly recommended for situations where the prescribed sampling requirement seems excessive. Ultimately, no additional sampling was required under these conditions to characterize the hazard to the 95% confidence level. The converse may also be true – BE could underestimate the variability and require more samples than initially collected. This can be determined by this same process.

Table 1-6: Confidence in Sampling Results Based on Variation and Measurement Relative to the OEL

Sampling Environment	GSD	Sample Result / OEL	Probability of Exceeding AL
Environmental Sampling	1.3	0.4	0.05
	1.3	0.5	0.2
	1.3	0.6	0.4
	1.3	0.7	0.6
General Industry IH Sampling	1.5	0.25	0.05
	1.5	0.3	0.1
	1.5	0.4	0.3
	1.5	0.5	0.5
Typical AF IH Sampling	2	0.1	0.05
	2	0.2	0.25
	2	0.3	0.4

Example: If only one sample can be taken of the water in Well #7, what is the confidence that perchlorate levels will not exceed the State of New Mexico's Health Based Goal of 1 µg/L?

Assume:

1) The sample is taken in a moderately variable environmental setting, therefore GSD = 1.3
2) The sample result was 0.1 µg/L

Dividing the sample result by the OEL = 0.1 µg/L / 1 µg/L = 0.1. Therefore, the probability of exceeding the AL is less than 0.05 or 5%, and there is greater than 95% confidence in the sampling result that the hazard will not exceed the OEL (i.e., there is a greater than 95% confidence that the decision will be correct).

1.2.3.7.1. *Outliers* are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. They can be treated with statistical tests, however for the most part, professional judgment on the part of the BE is appropriate. It should be noted that on occasion, outliers could identify hot spots where the concentration of the target analyte is extremely large.

1.2.3.7.2. *Non-Detects* are sample results that fall below the detection limit (DL) for the analytical method or field portable instrument being used. It is not appropriate to give non-detects a zero value when calculating the mean, medium, or mode of a set of sample data. In cases where non-detects are less than 15% of the total number of sample results, then a conservative approach is to assign the non-detects a value equal to the DL in cases where the risk is high (i.e., risk to human health or exceeding a compliance standard). When the risk is lower a value of ½ DL can be assigned to the non-detects. If non-detects make up

more than 15% of the total number of sample results, BE can rely on professional judgment and historical data if available. If uncertain, consult a statistician.

1.2.4. Application of DQOs to the Occupational and Environmental HRA Process: BE can use the prescribed Tables 1-5 and 1-6 to determine the number of samples required to sufficiently characterize a hazard. Table 1-7 presents the approximate analysis time for various field portable instruments. If there is insufficient time to complete the proscribed number of samples, consider using a different, less time consuming sampling and analytical technique. If that is not possible, then changing one or more parameters established in the DQO process (i.e., lower confidence in characterization).

Table 1-7: Field Instrument Capabilities and Analysis Time

Analytical Instrument	Analytical Output	Approximate Analysis Time
Colilert	Detects Coliforms, Fecals, E. coli	24-48 hours
DPD Kit	Quantifies pH, free available chlorine, chloramines, and total chlorine	5 min; add 2 min per additional test
CDS kit	Colorimetric detection	5 minutes
CMS	Quantitative tubes	1-2 minutes
Hazmat ID	ID organic, inorganic, powders, etc.	1 min/test
HACH 2400	Metals, organic, inorganic	10-40 min per test
Hazcat Kit	Chemical presence/absence	10-20 minutes per test
HAPSITE	Hundreds of VOCs per sample	25-30 min per sample
M256	Identifies chemical warfare agents (air)	15-20 min per kit
M272	Identifies and provides semi-quantitative output for chemical warfare agents in water	15 min per test
TVA-1000B	PID/FID semi-quantitative	1 minute per sample
Reachback lab	Full-spectrum	1-3 days + shipping, holding
JBAIDS	Identifies select biological agents	4-6 hours
M1M	Identifies bio-threats (incl toxins)	45-60 min
451P	Measures radiation dose	Continuous
SAM-935	Identifies isotopes	Continuous
EPDs	Tracks gamma/beta dose	Continuous
ADM-300	Quantifies alpha, beta, and gamma radiation	15 min per radiation type

1.2.5. Elements of the Risk Rating System: The flow chart listed below shows how a risk rating is determined for each AOC or each element of an AOC. The risk ranks can be subsequently assigned.

Figure 1-3: Visual Representation of Risk Rating

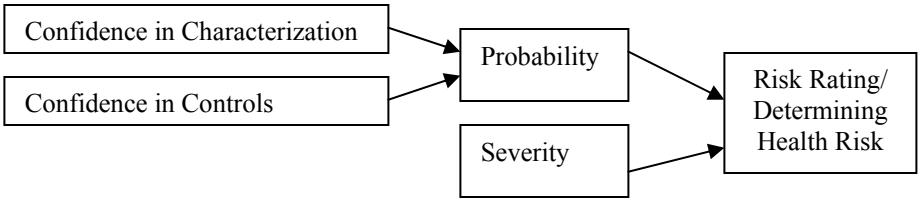


Table 1-8: Confidence in Characterization

Select	Category	Definition
Routine Surveillance / Special Surveillance		Potential health outcome based solely upon a qualitative review of the workplace. No quantitative data available for this or similar activities. The source of the hazard has the potential to generate exposures above the action level.
	Medium	Potential health outcome based upon a detailed administrative and onsite review of activities within the workplace and application of professional judgment supported by application of objective based engineering principles. Screening samples or initial air sampling results are within acceptable limits, but not totally conclusive. Comparison to similar, characterized DoD and or private sector operations (qualitative or quantitative).
	High	The "Medium" rating supported by sufficient quantitative evaluation, or detailed technical reports where environmental factors do not influence exposure. Further quantification is not required. The source of hazard does not have potential to generate significant exposures (for example: soldering with low-output irons).

Table 1-9: Confidence in Controls

Select	Category	Definition
Routine Surveillance / Special Surveillance	Low	Controls inadequate to control exposure. Controls in poor state of repair/non-operational/not actively used.
	Medium	Controls will control worker exposure to acceptable level when adhered to. Examples are reliance solely on administrative controls and/or PPE.
	High	Engineering controls/work practice controls in place and fully operational. Evaluations completed to demonstrate adequate exposure control.

Table 1-10: Determining Probability of Exposure

Confidence in Hazard Characterization	Confidence in Existing Controls		
	Low	Medium	High
Low	A	A	B
Medium	A	B	C
High	B	C	D

Table 1-11: OEH Severity – Describes the extent of the outcome and is based on frequency of exposure and health effects. This may also be a function of the existing controls.

Classification	Description
Catastrophic	Death or incapacitating/irreversible acute OEH-related illness/injury.
Critical	Severe, reversible OEH-related illness/injury; includes chronic and acute illness/injury. Hearing loss is included in this category even though the irreversible effects are recognized.
Moderate	Minor OEH-related illness/injury (e.g. nausea, headache, dermatitis,) that results in reduced capacity to perform.
Negligible	Less than minor occupational illness, (e.g. non-specific skin irritation).

Table 1-12: Determining Health Risk

OEH Hazard Severity	(b) OEH Exposure Probability Factor			
	A	B	C	D
Catastrophic	Extremely High	Extremely High	High	Moderate
Critical	Extremely High	High	Moderate	Low
Moderate	High	Moderate	Moderate	Low
Negligible	Moderate	Low	Low	Low

1.2.6. AOC Categorization and Routine Assessment Frequency Determination: As confidence in the overall assessment increases, and BE enters the sustainment portion of the OEHSA process where areas of concern (AOCs) can be categorized to determine frequency of follow-up routine surveillance. The table below provides some examples that may help determine AOC categories and their respective survey frequencies.

Table 1-13: AOC Categorization and Routine Assessment Frequency

AOC Category		
1 - High	**2 - Medium**	**3 - Low**
Hazards poorly defined or poorly controlled; work environment or processes unstable	Hazards well defined and controlled; work environment and processes stable	No hazards; work environment and processes stable
Inherent OEH risk present with medium to high hazard potential and risk rating	Inherent OEH risk present with relatively low hazard potential and risk rating	Non-existent or negligible sources of OEH risk present
Regulatory assessment requirements, e.g., asbestos (29 CFR 1910.1001)*	Minimal potential for hazards or create significant risk	Full OEH regulatory compliance
Requirement for special purpose occupational exams, other than audiograms*	Requirement for annual audiograms	
Potential for significant OEH regulatory non-compliance	Potential for OEH regulatory non-compliance	
Survey every 12 months in garrison	**Survey every 24 months in garrison**	**Locally Determined**
Survey each AEF rotation while deployed	**Survey each AEF rotation while deployed**	**Locally Determined**

*These regulatory requirements are indicators of higher risk AOCs, however, once they are fully characterized, controlled, and assessed at a lower risk, the AOC category may be lowered.

1.3. OEH Risk Control Decisions: The risk management process begins with identifying alternatives, recommendations, and courses of action for the decision maker. BE should use their expertise to develop several viable alternatives based on the operational context; this will require an understanding of the mission, operational priorities, the commander's risk tolerance, and effectiveness of controls. BE plays a supporting role in the last 3 steps of the HRA process and must remain engaged with commanders and effected personnel to ensure effective risk management.

1.3.1. Courses of Action (COA) consist of viable alternatives for mitigating risks. The table below shows several examples of COAs that BE may recommend to mitigate health risks. The commander or supervisor will ultimately make the risk control decision and direct its implementation.

Table 1-14: Example Courses of Action

Control	Environmental	Occupational	Crisis Response
	Contaminated soil in tent city	Mixing 2-part composite material	Chemical attack
Engineering	o Barrier material o Remove soil o Treat/fixate in-situ o Spray/wet soil o Plant vegetation	o Install hood o Improve dilution ventilation	o Collective protection o Harden facilities o Improve vent controls
Admin	o Relocate o Limit outside presence during high winds	o Rotate workers o Use less hazardous products o Work outside	o Limit unnecessary exposures to 10 min o Cover critical equipment o 10 ft rule
PPE	o Don gas mask when outside o Use dust mask	o Wear respirator o Wear gloves	o MOPP4

1.3.2. Risk Communication: In order to be effective and credible, BE must understand the operational context. Ultimately, the decision resides with the commander who may decide to accept health risks in lieu of an operational benefit. If the commander accepts a health risk, BE is responsible for documenting and tracking the exposure, as well as communicating the risk and mitigation measures to the effected personnel.

1.3.3. Implementation of Risk Controls: BE must engage with those implementing the controls and supervisors to ensure that the controls are implemented correctly. Examples include:

- Correct PPE (i.e., manufacturer and model) is procured
- Personnel are trained on PPE (e.g., fit testing)

- Ventilation systems are designed, constructed and perform IAW acceptable design or performance standards
- Work/rest cycles are implemented properly

1.3.4. Supervise and Evaluate: BE supports commanders and shop personnel by evaluating the effectiveness of the controls that were implemented. This step in the process serves as a "check" to ensure that the controls are working properly as intended and may lead the BE to other steps in the process (i.e., special surveillance) to re-evaluate and make additional recommendations. Examples include:

- Routine ventilation surveys to ensure operational effectiveness
- Training workers on how to use the manometer on a vent booth to determine filter change-out decision points
- Air sampling to determine effectiveness of process changes
- Reviewing/auditing activity procedures for regulated areas
- Determining that PPE is being used properly for the right activities

Section 2.0: OEHSA - Environmental

2.1. Introduction: The Air Force has developed the Occupational and Environmental Health Site Assessment (OEHSA) guide as a tool to enable military personnel to evaluate occupational and environmental conditions and assess the risk of military personnel acquiring diseases and non-battle injuries. One component of the OEHSA is the Health Risk Assessment (HRA). The same techniques and procedures used during traditional in-garrison OH surveillance apply to environment or community health threats (e.g., field screening and compliance sampling) and deployed operations. Data is collected to identify, analyze, control, and document pertinent environmental hazards concerning:

- Source of release
- Environmental media pathways (e.g., soil, air, water, and drinking water)
- Activity/point of exposure
- Exposure route and similar exposure groups (SEG)

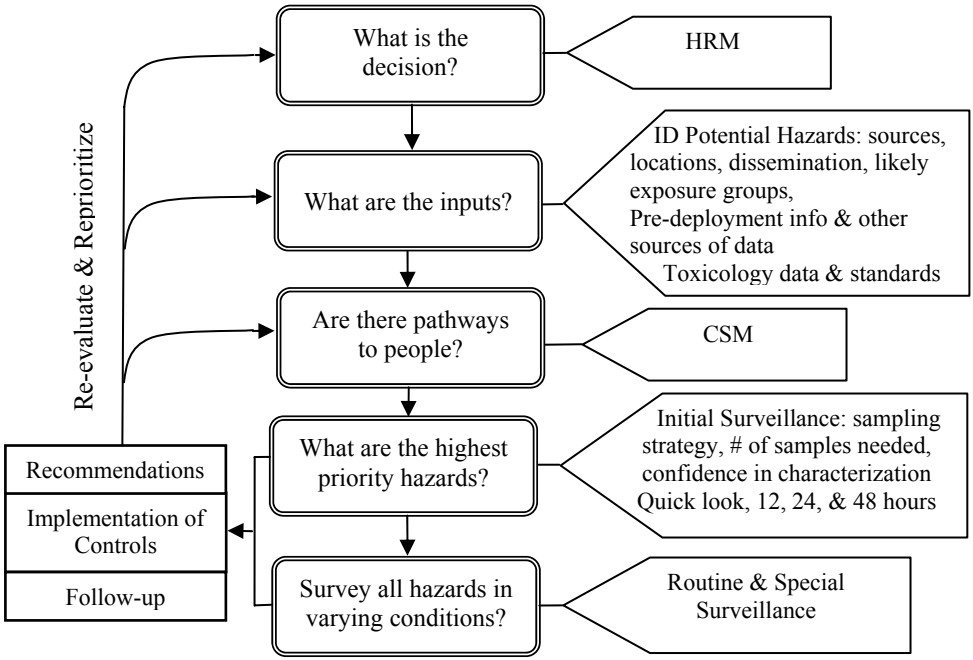
2.2. Overview of OEHSA Strategy: Use a data management surveillance system – ESOH-MIS, Command Core Systems, or GEMS to:

- Long-term surveillance and documentation of exposures throughout the garrison-deployed transition
- Documentation of notable exposures in individual health records

The following steps describe execution of the OEHSA process. Figure 2-1 illustrates the process:

1. Identify the decision to be made
2. Track all data, references, site-specific information, and determine applicable standards
3. Develop a Conceptual Site Model (CSM) for environmental areas of concern (AOC) to help identify threats and make recommendations to support effective planning, layout of bed-down locations and changes to base layout
4. Develop a sampling strategy to support a solid health risk assessment
5. Conduct environmental health sampling and analysis to assess risks to personnel
6. Communicate health risks and recommend controls to commanders in support of health risk management (HRM)

Figure 2-1: Process of Performing OESHA – Environmental



2.3. Health Risk Management (HRM)

2.3.1. Overview: BE is responsible for executing the HRA expeditiously and clearly communicating information, recommendations, and alternatives to commanders about the risk and control of environmental threats. There are several key decisions that are being made by commanders or supervisors which should be supported by BE HRA input; BE should anticipate these key decisions and take steps to address them. Decision-makers do not always know who to go to for additional information, so BE must be proactive in projecting their capabilities. From an environmental perspective, decisions that need to be supported with a HRA include:

- Determining/assessing bed-down location
- Relocation of facilities
- Siting waste management facilities, collection sites and disposal sites
- Siting recreation areas, specifically water use
- Implementing TIC/TIM VA recommendations

2.3.2. Additional Considerations in Environmental HRM: When executing an HRA, key factors that need to be considered in determining the risk level, subsequent courses of action and recommendations include (adapted in part from US Army Center for Health Promotion and Preventive Medicine, Technical Guide 248, 2001):

- Type of mission; operational context

- Living conditions (e.g., field, hardened facilities, hotel, base housing)
- Geographical conditions (e.g., temperature, humidity, altitude)
- Threat characteristics (e.g., toxicity, volatility, transmissibility, communicability)
- Exposure parameters (i.e., frequency, duration, concentration)
- Additive effect of multiple source exposures
- Personal protective equipment
- Length of deployment or operation
- Medical treatment sources (e.g., US Forces, coalition, local, non-governmental organizations)

Refer to Section 1.2.5. Elements of the Risk Rating System in Chapter 1 for a review of the steps involved in assigning a risk rating and prioritizing environmental hazards.

2.3.2.1. Control Recommendations: BE should provide recommendations to commanders based on applicable standards and/or toxicological data. Multiple control options that can decrease the probability or severity of a hazard should be identified, evaluated and presented in terms of operational support. Engineering controls are the preferred options over protective equipment, however providing control options that are not feasible does not support the commander's objective of successfully completing the mission.

Example: A complete pathway was identified linking chromium in a single hot spot of contaminated soil at the entrance of one isolated sleeping tent in a deployed location on the periphery of a flood plain. Sampling has determined that the concentration of chromium is slightly below applicable environmental standards. Control options provided to the commander are:

- Remove contaminated soil ASAP
- Remove personnel from tent near contamination and distribute them among other tents
- Provide containment for contaminated soil and remove before rainy season
- Relocate the tent since the source may be transported to the site via flood water

2.3.2.2. Risk Communication: Effective reporting to wing and medical leadership on the environmental health hazard as they affect the mission is the key to implementation of controls. Use the report format guidance in (Appendix L) to facilitate OEHSA reporting.

2.4. Employing a Surveillance System

2.4.1. Overview: The goal of data management is to provide long-term surveillance and documentation of exposures throughout the garrison-deployed transition. Therefore, EH conditions posing potential adverse health effects must be identified and documented into the applicable medical record. Completed health assessments regarding actual or perceived environmental exposures should be provided to medical providers on OEHED (SF 600 template).

2.4.2. Data Management System: Use Environmental Safety Occupational Health Management & Information System (ESOH-MIS) (i.e., DOEHRS-IH, GEMS, and/or

Command Core System) to safeguard confidentially, and collect and maintain military personnel data (including demographic and occupational data). Consult higher headquarters if the use of other means such as open text documents, spreadsheets, or other media is authorized.

2.4.3. Data Acquisition (Pre-Deployment/Planning): Start intelligence gathering to identify areas of concern (AOC) before arriving on station or before performing a site visit. Sources of exposures potentially affecting personnel or operational space may be found on or off base. Consider weather, climate, terrain, and topography and their effect on the mission when identifying AOCs. The fundamentals of identifying AOCs can be found in Chapter 1 of this manual.

Use the Sources of Information and Key Questions checklist in Appendix A and the internet sources listed in Appendix B to help complete this step. Acquire and evaluate information from observations, intelligence, conversations, measurements, and historical documentation to provide maximum situational awareness. Obtain and review supporting documents listed in Table 2-1.

Table 2-1: Document Review for OEHSA - Environmental

Deployed	**In-Garrison**
COMAFFOR's supporting plan to the combatant commander's operation plan	Environmental site assessments
CBRNE active and passive defense plans	Environmental audits
OPLAN Annex Q	Environmental permits
All deliberate plans from the bed-down base; AFI 10-2501, *Air Force Emergency Management Program Planning and Operations*	Registration for UST and AST
Medical contingency response plan (MCRP); refer to AFI 41-106 *Medical Readiness Planning and Training* or equivalent	IRP site assessments
The Base Expeditionary Support Plan; AFI 10-404, *Base Support and Expeditionary Site Planning*	Historical documents, photos, maps
Site-specific bed-down plans	
Final governing standards	
Base Response Plan 10-2	
Both Deployed and In-Garrison	
Historical and current property use of site/base (e.g., agricultural, industrial, commercial and/or residential use)	
Known hazardous waste sites	
Known contamination and pollution in air, water and soil	
Typical climate conditions including normal and extreme temperatures, seasonal precipitation, and seasonal prevalent wind directions and velocities	
Known property use including type of infrastructures (e.g., buildings, transportation networks, water treatment and distribution systems, wastewater collection and treatment systems and known power generation and transmission systems)	
Maps, topographic and geological information relevant to the area	

2.4.4. Risk Assessment Standards & Toxicology Data: Use the resources listed below to provide applicable environmental risk assessment standards and toxicological information. Some of the standards listed below are compliance drivers, however toxicological data should be evaluated as well.

- US Army TG 230 - Air, Water, and Soil Military Exposure Guidelines (MEGs): These standards are based on toxicological studies and can assist in making a risk based decision during deployments and while in-garrison. Values in these tables are associated with threshold health effects relative to the health effects of the given chemical.
- US EPA National Ambient Air Quality Standards (NAAQS): EPA regulations apply while in-garrison and any exposures should be documented. These regulations may not apply to the bed-down site, however the information can be used to guide the health risk assessment.
    - Clean Air Primary Standard – Sets limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly
    - Secondary Standards – Sets limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings
    - The EPA Office of Air Quality Planning and Standards (OAQPS) National Ambient Air Quality Standards for six principal criteria pollutants (i.e., nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), particulate matter (PM), carbon monoxide (CO), and lead (Pb)
- ACGIH Threshold Limit Values (TLV) and OSHA Permissible Exposure Limits (PEL): These regulations are enforceable in-garrison and compliance is mandatory. While OSHA regulations are not enforceable at the bed-down location, it is important to consider OSHA PELs and ACGIH TLVs when assessing the exposures from local environmental and industrial activities to personnel. Also, AFOSH Standards are enforceable.
- EPA Integrated Risk Information System: Reference Doses for non-carcinogenic toxicity and Slope Factors (Carcinogenic Potency Factors) for carcinogens.

2.5. Conceptual Site Modeling: Follow this process to develop sampling strategies for each AOC.

2.5.1. Identify Environmental AOCs: Identify AOCs during pre-deployment planning or upon inception of the sampling strategy on-site. In some cases AOCs may already be developed or they may become apparent when a potential health threat arises. The CSM should be specific to the AOC and is used to reflect complete or potentially complete exposure pathways associated with the AOC. A detailed overview of the elements of a CSM can be found in Chapter 1. Uncertainties associated with the CSM help drive the need for further evaluation. As the OEHSA is conducted or as changes in the mission occur, the CSM should be refined and validated. Table 2-2 in Chapter 2 of the BE Technical Guide provides a list of processes and hazardous substances associated with various industries, and may help in the identification of potential sources within AOCs.

2.5.1.1. Environmental AOC Boundaries: To assign an exposure to personnel, it is necessary to perform monitoring on each individual every time he or she completes a task until the monitoring yields statistically significant results. Since this is not always possible, BE must pursue the best strategy for making sampling data representative of the exposure that all members of a SEG receive. This can be done in part by delineating the boundaries of an AOC using homogenous conditions. Homogenous areas show no or little change in environmental conditions. This allows data collected within the area to be representative of the entire area and simplifies the sampling strategy.

2.5.1.2. Defining Homogeneous Conditions: In a large AOC, geological conditions may be more variable making it difficult to classify homogenous areas. Extensive sampling data may support the AOC boundary definition, but this could take a long time. Heterogeneous areas have discrete or continuous changes (e.g., changing weather conditions) in their characteristics throughout the AOC. Developing a sampling strategy around a heterogeneous area should be avoided due to the variability in site characteristics. It may be possible to define pseudo-homogeneous areas based on predominant weather conditions (i.e., temperature, wind direction, wind speed range, stability), surface geology, and soil characteristics. These "homogeneous" conditions define an AOC or a subset of an AOC which enable BE to develop a sampling strategy which will yield representative results faster with less sampling events.

Use the checklist in Appendix C to conduct reconnaissance within each AOC and to further develop the CSM.

2.5.2. Completing the CSM by Environmental Media: The sections below provide examples of potential sources, source locations, and exposure pathways to be used as a starting point for evaluating all of the AOCs at a base or specific location. Use the next section as a guideline in developing a comprehensive CSM for each AOC.

2.5.2.1. Air: Survey the AOC and surrounding AOCs for airborne hazards. Consider dust, fumes, gases, or particulates that may present threats via contact, ingestion, and/or inhalation. Migration of threats from other environmental media to air should be considered (i.e., re-aerosolization of constituents on the ground, industrial plant emissions, vaporization, etc.).

Potential Sources

- Toxic Industrial Chemicals (TICs) and Toxic Industrial Materials (TIMs) - Commercial sources and large quantities of insecticides, herbicides, fertilizers, raw chemicals/solvents, chlorine gas, acids, explosive gases, flammable liquids, nuclear materials, chemical and biological materials
- Chemical of potential concern; some materials may be made more toxic with relatively simple chemical modifications
- Naturally occurring phenomena such as dust, particulates and gases such as ozone

Potential Source Locations
- Industrial plants, agricultural operations, environmental treatment plants, research laboratories, nuclear medicine, nuclear power plants facilities
- Locations where releases have been confirmed
- On-base activities
- Distribution and magnitude of contamination
- Stationary versus mobile sources

Method of Dissemination or Release
- Permitted emission
- Un-permitted or open release
- Mechanical mixing (i.e., wind)
- Attack operations from enemy or collateral damage

Likely Exposure Groups (SEG)
- Base residents and active duty – inhalation of local industry contaminants
- Base residents and active duty – inhalation of dust from local environment
- Base residents – inhalation of radon
- AGE Shop flight line workers – inhalation of aircraft exhaust/dust
- Aircraft Maintenance Shop – inhalation and ingestion of dust from construction

2.5.2.2. Soil: Consider contact threats from dermal absorption or radioactively contaminated soil as well as the potential for ingestion of re-entrained soil. Depth and stratification should also be considered when determining health threats.

Within each AOC, areas of homogenous contaminant conditions may be indicated by the following characteristics:
- Same soil conditions (e.g., clay, sand, sediment, etc)
- Stressed and non-stressed areas of vegetation
- Similar industrial or hazardous waste storage areas
- Recreational areas
- High-traffic and low-traffic areas
- Land use (e.g., industry, housing, etc.)

Potential Sources
- Hazardous materials stored on-site or past use
- Deposition from nearby air emissions
- Deposition from flooding of polluted waters
- Adsorption from upward migration of VOCs from contaminated ground water
- Infiltration from leaking sewage
- Land application

Method of Release
- Volatilization
- Re-entrainment in the air via mechanical mixing/wind

- Infiltration/migration to groundwater
- Runoff
- Physical disturbance

Likely Exposure Groups (SEG)
- CE Roads and Grounds – contact and inhalation
- CE Plumbing Shop – contact
- Security Forces – contact
- CATM – contact and inhalation
- Base housing residents – contact and ingestion (children)

2.5.2.3. Water Sources: Identify watershed boundaries, flood plains, vegetation, forests, organic debris in the water, and source waters (surface and groundwater). Identify point (industrial, wastewater, etc.) and non-point (runoff, recharge, etc.) discharges into waterways within the watershed. Include the potential for accidental or deliberate spills or industrial pollution discharges. The scope of water sources should not only include untreated surface waters (e.g., lakes, rivers, snow, ice, seawater) and ground sources, but also the existing municipal supply may be considered a raw water source until sufficient testing is performed to determine its potability. Table 2-1 in Chapter 2 of the Technical Guide presents several sources of possible water contamination based on activities that may be present at an air base.

Water conditions differ based on whether the water is stagnant (i.e., pond, lake, ocean) or flowing (i.e., stream or river). Additionally, industrial discharges to the water affect the consistency of the water quality and contaminant loading, not only between several bodies of water, but between different locations in a single body of water. The impact is dependent on the concentration of the contaminant in the discharge and the flow rate of the water compared with the flow rate of the discharge. Variability in contaminants may be estimated indirectly by evaluating the flow rate of the water body and distance downstream from the discharge. The following factors may be considered when defining homogeneous conditions and AOC boundaries:
- Groundwater
  - Subsurface geology, including layering, continuity and other characteristics
  - Hydrogeologic information identifying water bearing zones, hydrologic parameters and impermeable strata
  - Soil boring and monitor well logs and locations
  - Depth/head of aquifer
  - Confined or unconfined
- Surface water
  - Routes of drainage ditches on the facility and how the water migrates to other surface areas such as creek and lakes
  - Emergency fire fighting water reservoirs constructed by fire department
  - Areas of influence (i.e., drainage area, polluted surface water impacting groundwater)
  - How the water is used before it gets to us (i.e., irrigation ditch for farmers, etc.)
  - Convergence with other inputs or sources

Potential Sources

- Groundwater
  - Contaminated soil, leaking storage tanks
  - Surface water influence
  - Short circuiting through wells
  - Previous contamination and activities
- Surface water
  - Direct discharges from industrial plants
  - Indirect discharges from runoff
  - Saboteurs

Methods of Release

- Leaking, spills, percolation through soil
- Discharges
- Runoff
- Open dumping

Likely Exposure Groups (SEG)

- All base water consumers – ingestion
- Swimming pool/Natural bathing/Recreational patrons – contact and ingestion
- CE Utilities personnel – contact
- CE Plumbing Shop – contact
- Aircraft personnel – ingestion from aircraft watering points (e.g., water coolers, water tank trucks)
- Personnel and operations located in the floodplain - contact

2.6. Application of the CSM: Use the CSM to develop and prioritize the sampling strategy based on the assessment of threats, pathways, and potential exposure routes outlined in the CSM. Rule out exposure pathways if any of the following elements are missing: *(1)* a mechanism for environmental health threat release, *(2)* a transport medium if personnel/receptors are not located at the source, and *(3)* a point of potential contact with the environmental health threat. Table 2-2 shows an example of a CSM for 3 AOCs illustrated in Figure 2-1.

Table 2-2: Conceptual Site Model

AOC	Potential Source of Release	Media Pathway (Air, Soil, Water)	Activity or Point of Exposure	Exposure Route	SEG Effected
Local dump site (off base)	Leaching into groundwater	Drinking water	Drinking water dining facility	Ingestion	Base wide
	Vaporization or Volatilization	Air	Working on base	Inhalation & ingestion	Base wide
	Dust and dirt	Soil	Working on base	Inhalation & ingestion	Base wide
Flightline	Aircraft exhaust	Air	Dust generation & volatilization	Contact & inhalation	Flightline operations personnel
	Chemicals used in past maintenance ops	Soil	Lawn maintenance, dust generation & volatilization	Ingestion & contact	Flightline ops personnel
	Aircraft deicing	Surface Water	Working near pond	Ingestion & contact	Flightline ops personnel
Tent City	PAH contaminated soil volatilization	Air	Sleeping in tent with PAH in headspace	Inhalation	Personnel sleeping tents 3-8

Figure 2-2: Camp Falcon Site Assessment Model (adapted from AFMAN 48-154)

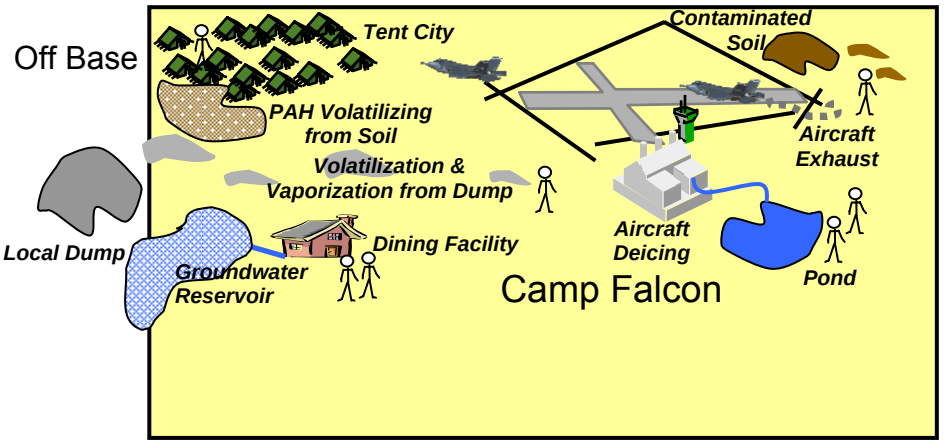


Table 2-3 provides an example of a worksheet used to determine whether or not to further evaluate an AOC and its associated pathway in a CSM. In the evolution of the CSM, it is as important to document what was not selected for evaluation as well as the items that were selected.

Table 2-3: Example of a Worksheet for a Evaluating a Pathway of an AOC in Developing a Conceptual Site Model

SEG	Pathway, Medium, & Route of Exposure	Pathway Selected for Evaluation?	Reason for Selection or Non-Selection
Flightline shops	Indoor inhalation of air particulates	**i. Yes**	Contaminated air from outside can enter indoor environments
CE Heavy Equipment shop	Inhalation (vapors and particulates), dermal contact, and ingestion of surface soil	Yes	Activities will generate dust and dirt on site creating potential for inhalation and dermal contact
Entire base	Leaching to groundwater from soil contaminants	No	Ground water will not be utilized at the site
Dormitory Residents	Indoor inhalation of vapor emissions from subsurface soil	No	Building remains under positive pressure

Adapted from E 2318 – 03 Standard Guide for Environmental Health Site Assessment Process for Military Deployments

2.7. Initial Assessment

2.7.1. Identify and Assess High Risk Hazards: By this point, the following tasks have been accomplished:

- Objective for any field sampling is clearly defined (i.e., what is the issue, problem, or pending decision?)
- Inputs have been evaluated (i.e., historical data, standards, toxicological info, etc)
- Boundaries are delineated (temporal/spatial based on homogeneous conditions)
- Potential pathways identified by AOC in the CSM

The next step is to conduct initial sampling and analysis of the highest priority hazards (ranked 1) to identify potential short-term or acute risks. Use a GPS for marking sampling and monitoring areas. Table 2-4 provides a guide for determining what contaminants of concern to evaluate first based on the local media. It also states whether the screening method uses field analytical equipment (labeled as F) or reach back analysis (labeled as RB). The CSM should be used to determine which pathways are valid and which are not valid. The table is a guideline to help prioritize sampling events based on severity of contaminants in each media.

For example, during an initial walk-around of a new site being evaluated for bed-down/base housing, a dirt field under consideration for tent-city/housing is identified as an AOC. Based on Table 2-4, the following analyses should be conducted first:

- Soil – Metals and radionuclides with field portable instruments
- Air – Polycyclic aromatic hydrocarbons with field portable instruments

Table 2-4: Sampling Priority Stratified by Media and Contaminant

Contaminant of Concern	Soil		Water		Air		Surfaces	
	Analysis	Rank	Analysis	Rank	Analysis	Rank	Analysis	Rank
Dioxins or furans	F[1]	4	RB	5	RB	4	RB	4
Explosives	RB[2]	3	F	5	F	4	F	4
Metals	F	1	F	4	F	2	F	
Particulate matter	NA	NA	F	5	F	2	NA	NA
Pesticides	F	3	F	4	F	3	F	4
Physical parameters	RB	5	F	5	NA	NA	NA	NA
Polychlorinated biphenyls	F	4	F	4	RB	4	RB	4
Polycyclic aromatic hydrocarbons	F	2	F	4	F	1	NA	NA
Radionuclides	F	1	F	4	F	2	F	3
Semi-VOCs	F	2	F	4	Both	3	F	4

[1]F - Field analysis

[2]RB - Reachback analysis

Source: *Enhanced and adapted from U.S. Army TG 251, A Soldiers Guide to Environmental and Occupation Field Sampling for Military Deployment, Table 2-1*

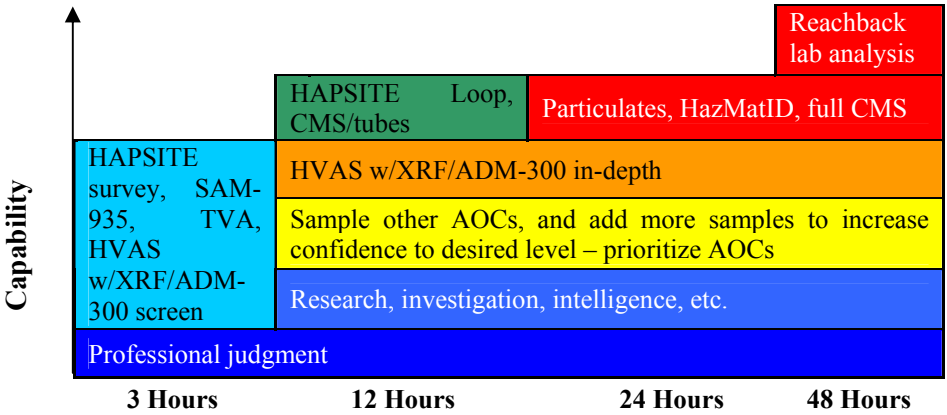
2.7.2. Generalized sampling guidelines for air, soil, surface and water media are listed below. Specific procedures for potable water are in chapter 3.

2.7.2.1. Air – Initial Survey

- ***Quick-look Assessment* –** Should be conducted when there is not much time to make a recommendation. This should include a visual site assessment of the primary AOCs with the SAM935 and HAPSITE survey method in tow. If time permits, conduct one initial HVAS screen with XRF and ADM-300.
- ***12-hour Assessment* –** Includes the quick-look assessment as well as utilizing the CMS or colorimetric tubes for specific hazards/threats when they are identified or suspected. Conduct 12 HAPSITE loop method runs around the primary AOCs. Use the HVAS in conjunction with the XRF and ADM-300, identify and/or quantify metals and radiation hazards, respectively.

- ***24-hour Assessment*** – Increase the number of samples to build confidence in characterization beyond the 12-hour assessment. Additionally, BE should utilize the XMX (See Appendix U) and dry filter to identify respirable hazards (e.g., particulates, metals, etc.). The liquid impinger should be used with neutral pH water and analyzed with the pH meter to determine the presence of any corrosive agents (e.g., gases, vapors, solids).
- ***48-hour Assessment*** – Builds off the 24-hour assessment with employment of the HAPSITE concentrator method in 12 locations; full CMS scan for gases that are not detected by the HAPSITE readily (i.e., low MW compounds, inorganics, etc.). Additional HVAS-XRF/ADM samples should be taken. Filter paper should be scanned with the HazMatID.
- ***Beyond 48 hours*** – Additional field techniques may be employed along with reachback lab analysis. BE should provide the reachback lab with a summary of analysis conducted thus far and determine if and what further analysis is needed to fully characterize the air media. This will likely include specific industrial emissions when there is a potential for exposure to on-base personnel.

Figure 2-3: Air Sampling Instrument Capabilities & Prioritization



Field Instruments for Screening Air Media

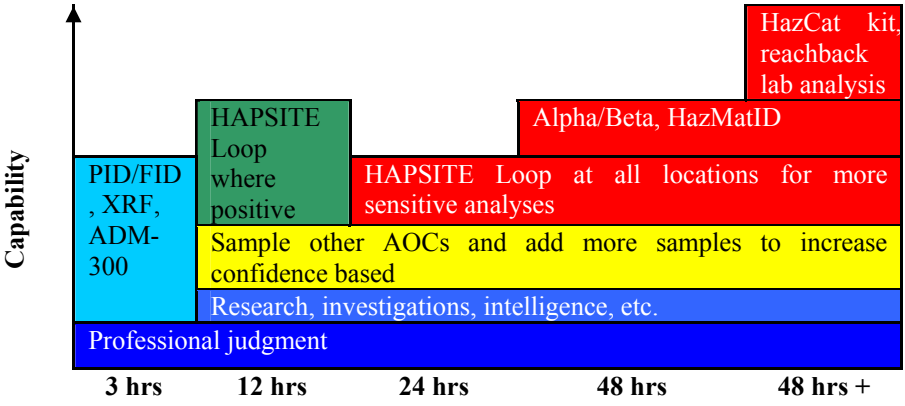
- Volatiles – TVA-1000B (See Appendix E), HAPSITE survey method (See Appendix F)
- Metals – HVAS (See Appendix G) with XRF
- Radiation – HVAS with ADM-300 (See Appendix H) and SAM935 (See Appendix I)
- Particulates – HVAS gravimetric analysis/visual; XMX with HACH2400 (TSS)

2.7.2.2. Soil – Initial Survey

- ***Quick-look Assessment*** – This is conducted by screening high priority AOC soil and soil-gas with the TVA-1000B, ADM-300, XRF and HazCat kit. This surveillance combination provides a broad spectrum analysis. These analyses should be conducted within the first hour when a potential pathway includes soil.

- ***12-hour Assessment*** **–** Should be conducted in the top two or three AOCs. Composite soil samples should be collected and analyzed with the TVA-1000B, ADM-300, XRF, and HAPSITE as needed. Positive results should be further assessed with the HAPSITE loop method and the SAM-935.
- ***24-hour Assessment*** **–** Conduct to increase confidence in characterization. Use the alpha/beta probes for radioactive particles. Use the HazMatID to screen for non-volatile constituents of concern.
- ***48-hour Assessment*** **–** Collect additional samples to increase confidence in preliminary sampling results. Use of the HazCat kit to identify hazards that were detected earlier. Additional AOCs should be included as time is available.
- ***Beyond 48-hours*** – Samples should also be collected for a full-spectrum analysis at a reachback lab. Additional AOCs both on and off the installation should be evaluated as time permits.

Figure 2-4: Soil Sampling Instrument Capabilities & Prioritization



Field Instruments for Screening Soil Media

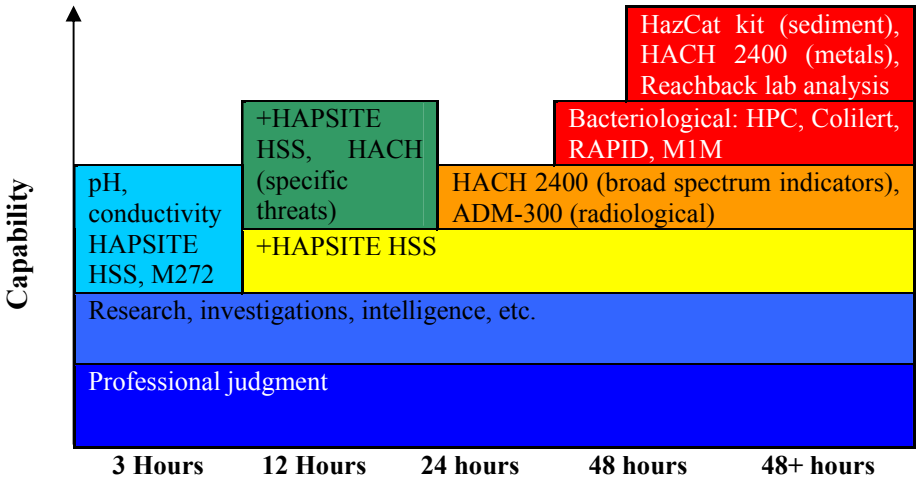
- Volatiles – TVA-1000B, HAPSITE
- Nonvolatiles – HazMatID (See Appendix T), HazCat kit (See Appendix S)
- Pesticides – HazCat kit
- Explosives – HazMatID
- Metals – HazCat kit
- Radiation – ADM-300, SAM935

2.7.2.3. Surface Water – Initial Survey

- ***Quick-look Assessment*** – Allows BE to rapidly identify and quantify immediately dangerous hazards. This is conducted with a pH meter, M272 kit, and HAPSITE HSS 8260 method. These analyses should be conducted within the first 3 hours of deployment when water may contain constituents that pose risks to personnel.

- ***12-hour Assessment*** – Conduct additional HAPSITE HSS analyses and employ the HACH 2400 kit for specific threats.
- ***24-hour Assessment*** – Prescribes broad spectrum analyses (i.e., TOC, BOD, COD) with the HACH 2400 kit and radiological analyses which can be conducted using the ADM-300 with filter paper through which sufficient quantities of water (at least 4 liters) have passed.
- ***48-hour Assessment*** – Includes bacteriological monitoring using HPC, Colilert, and RAPID to establish presence or absence of key threats (e.g., chryptosporidium, E. coli, and V. cholera).
- ***Beyond 48-hours*** – Additional methods may include the use of the HazCat kit to evaluate sediment, as well as other HACH protocols for metals and other contaminants. While this assessment template establishes and prioritizes field analytical methods, sampling strategies may be modified based on threats and projected water uses.

Figure 2-5: Water Sampling Instrument Capabilities & Prioritization



Field Instruments for Screening Water Media

- Volatiles – HAPSITE, HACH 2400, HazCat kit
- Pesticides – HACH 2400, HazCat kit
- Metals – Hach 2400, HazCat kit
- Radiation – ADM-300; SAM935

2.8. Routine and Special Surveillance

2.8.1. Overview of Routine and Special Surveillance Strategy: After the initial assessment, a routine surveillance schedule should be established to regularly monitor environmental hazard conditions. Additionally, special surveillance will be conducted to fully characterize the environment. Changing environmental conditions (i.e., contaminant

migration, weather, etc.) and time available to conduct the assessments will determine the type and number of analyses that will be conducted during each sampling event (or sortie). After developing a sampling strategy for each AOC, prioritize surveillance activities per media using Table 2-4 as a guide. Execute the sampling strategy using field portable instruments and when appropriate, augment with reachback analysis. Appendix J contains contact information for reachback laboratories. The sampling and analysis plan should address the following elements:

- The purpose of sampling and rationale for sampling strategies employed – what decision will be made based on the sampling? What is the decision point (concentration, etc.)?
- Sampling design to be used (e.g., simple random, systematic random, judgment, or a combination of strategies)
- The environmental media to be sampled and target analytes
- The sampling equipment and/or direct reading instrumentation that will be used; factors such as detection limit, analytical turnaround time, maintenance calibration requirements, equipment portability, power requirements, and degree of acceptable sampling and measurement errors must be considered
- The type and number of samples that are needed to characterized an AOC to a desired confidence level (99%, 95%, 90%, 80%)
- Size of the AOC or release area
- Number of sampling points within the AOC
- Sample locations to be selected with consideration to surrounding operations that minimize non-background sources such as vehicle traffic, dirt roads and vehicle idling; maintain a minimum of 15 to 20 feet from any nearby structure such as trees and hills
- Consider upwind sources based on predominant meteorological conditions
- Quality assurance/quality control and decontamination procedures
- Probability of exposure
- Analytical methods and sample collection requirements necessary for reachback analysis

2.8.2. Air Sampling Strategy: Changes in weather conditions affect the concentration of contaminants in air much more significantly than in water or soil. Daily or evenly hourly variations will affect personnel exposures; limited ambient air sampling does not represent year-round conditions and associated exposures. Sampling for airborne contaminants must be prioritized by greatest health risks (see tiers below), and re-sampled with changing weather conditions (see sorties). Predominant weather conditions (such as prevailing winds) should be prioritized based on frequency and used to define homogeneous conditions.

- ***First Sampling Sortie***: The first sortie should be conducted under predominant weather conditions (prevailing winds are the most predominant factor in most cases). These can be obtained from the MEDIC CD, WX personnel, and intelligence. If in doubt, predominant wind direction is typically consistent with the runway direction. BE should initially focus on assessing the living and working AOCs.
- ***Second Sampling Sortie***: The second sortie should be conducted under the next likely weather conditions (e.g., wind direction changes more than 30 degrees, temperature changes more than 20 degrees, stability reverses, or wind speed is above 30 knots).

- ***Third Sampling Sortie***: The third sampling sortie will evaluate industrial facilities that produce air emissions. This sortie starts with collecting intelligence and information on the facility for consideration in selecting an applicable sampling strategy.

Using Table 2-4 as a guide, each sampling sortie will have several tiers (priority analyses):
- **Tier 1** – The most hazardous constituents and likely exposure routes; polycyclic aromatic hydrocarbons, radionuclides, particulate matter, and metals
- **Tier 2** – Consists of the next group of hazard priorities; pesticides and semi-volatile organic compounds
- **Tier 3** – The lowest hazard constituent grouping and includes reachback lab methods; explosives**,** dioxins or furans, and polychlorinated biphenyls

2.8.2.1. Estimating Concentrations of Air Emissions: Airborne concentrations of hazards may be estimated using a Gaussian distribution model. Refer to the technical guide for more information on this method.

2.8.2.2. Confidence in Characterization:

Increases Confidence in Characterization	Decreases Confidence in Characterization
Homogenous conditions within AOC	Heterogeneous conditions within AOC
Low contaminant variability within AOC	High contaminant variability within AOC
Insignificant changes in weather	Highly variable weather

Higher variability in the environment (e.g., suspected contaminants, terrain characteristics and uses, weather) will typically drive more sampling to accurately achieve the desired confidence in characterization. Hot spots, when identified can be considered areas of low contaminant variability. If hot spots are suspected but have not been identified, the area is considered to have high contaminant variability.

Table 2-5: Air – General Guidelines for Assessing Contaminant Variability

Ideal Environment	Low Variability	Medium Variability	High Variability
No Variability	Generally clean environment; most USAF locations	Some industrial processes and emission sources nearby; emissions influence air media	Many emission sources impacting environment

2.8.2.3. Number of Samples Needed: Tables 1-5 and 1-6 in Chapter 1 of this manual provides general guidance to determine the number of samples needed to achieve the requisite confidence level (e.g., 95% confident in the results). This is a starting point. As samples are collected and analyzed, the consistency of the results should be determined by calculation, or with assistance from the reachback lab. The consistency in the results will ultimately determine the number of samples required to characterize the hazard to a statistically relevant level.

Table 2-5 in Chapter 2 of the Technical Guide provides tables that show the number of samples needed according to type of instrument (e.g., TVA 1000B, HAPSITE, ADM-300, etc.) and contaminant variability.

2.8.2.4. Air Instrument Capabilities: Use Table 2-6 to determine the capability (detection, identification, and quantification limits) of various field portable instruments and applicability to the sampling strategy. If contaminants of concern (CoC) are suspected, cross-reference with the analytical instruments presented in the table to determine whether that instrument can detect, identify, and quantify the CoC down to a required level. Table 2-6 is color coded to help illustrate the equipment capability in terms of MEGs or TLVs. The color-coding is similar for each instrument.

- Red: Can not detect the analyte
- Yellow: Can detect and/or identify the analyte
- Green: Can detect and/or identify the analyte at a concentration <= the MEG/TLV
- Blue: Unknown instrument capability with respect to this analyte

Table 2-6: Air MEG Table

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Acenaphthylene 208-96-8	NA	NA		20-500 ppm			
Acenaphthene 83-32-9	NA	NA		20-500 ppm			
Acetaldehyde 75-07-0	C [25]	NA		20-500 ppm			
Acetic acid 64-19-7	25 [10] STEL[15]	NA		2.0- 50 ppm		CL**** 10 ppm	
Acetone 67-64-1	1188 [500] STEL [750]	NA		40-600 ppm	10	10 ppm	0.005 mg/m^3
Acetone Cyanohydrin 75-86-5	C 5 mg/m^3	8				Y	
Acetonitrile 75-05-8	34 [20]	67				10 ppm	0.026 mg/m^3
Aciflorfen 5094-66-6	NA	NA					
Acrolein 107-02-8	C [0.1]	0.07				Y	
Acrylamide 79-06-1	0.03 mg/m^3	NA				CS****	
Acrylic Acid 79-10-7	5.9 [2]	3			**Note 1**	10 ppm	0.001 mg/m^3
Acrylonitrile 107-13-1	1 [2]	4.4					0.001mg/m^3
Alachlor (Lasso) 15972-60-8	ND	NA					
Aldrin 309-00-2	0.25 [1.7]	0.25					
Allyl Alcohol 107-18-6	1 [0.5]	5			10 ppm	10 ppm	
Allyl Amine 107-11-9	NA	NA					
Allyl Chloride 107-05-1	[1] STEL [2]	NA					
Ametryn 834-12-8	NA	NA					
Ammonia 7664-41-7	17 [25]	17		10-150 ppm	10 ppm	10 ppm	
Ammonium Sulfamate 7773-06-0	10 mg/m^3	NA				NCS***	
Amyl Alcohol 71-41-0	NA	NA			10 ppm	10 ppm	c5
Aniline 62-53-3	8 [2]	3.8				Y	

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Anthracene 120-12-7	NA	NA					14C
Antimony 744-36-0	0.5 mg/m^3	NA				NCS	
Antimony Trioxide 1309-64-4	NA	NA				NCS	
Arsenic 7440-38-2	0.01 mg/m^3	NA				NCS	
Arsenic Trichloride 7784-34-1	NA	0.01				NA	
Arsine 7784-42-1	1.6 [0.05]	0.17		CDS 0.1 ppm			
Azobenzene 103-33-3 Must Be Preheated to Burn	NA	NA					
Barium 7440-39-3	0.5 mg/m^3	NA					
Benzene 71-43-2	1.6 [0.5] STEL [2.5]	1.6		0.5-10 and 10-250 ppm	10 ppm	10 ppm	0.022 mg/m^3
Benzidine 92-87-5	NA	NA				CS	
Benzo(a)anthracene 56-55-3	NA	NA		20-500 ppm			c18
Benzo(a)pyrene 50-32-8	NA	NA				**Note 2**	c20
Benzo(b)fluoranthene 205-99-2	NA	NA		20-500 ppm		Not Rated	c20
Benzo(k)fluoranthene 207-08-9	NA	NA		20-500 ppm		Not Rated	c20
Benzyl Chloride 100-44-7	5.2 [1]	NA			10 ppm	CL 10 ppm	
Beryllium 7440-41-7	0.002 mg/m^3 STEL 0.01 mg/m^3	NA				NCS	
Bibenzo(a,h)anthracene 53-70-3	NA	NA				CS	
Bis (2-ethylhexyl) phthalate 117-81-7	5 mg/m^3	NA				Cmbtl if Heated	
Bis (2-chloro-1-methylethyl) ether 108-60-1	NA	NA				CL	
Bis (2-chloroethyl)ether 111-44-4	[5] STEL [10]	NA				CL	
Boron 7440-42-8	ND	NA					
Boron Tribromide 10294-33-4	C [1]	10				NCL	
Boron Trifluoride 7637-07-2	C [1]	0.6				NG****	
Bromine 7726-95-6	6.53 [0.1] STEL [0.2]	0.063				NCL	
Bromine Pentafluoride 7789-30-2	0.715 [0.1]	0.7				NCL	
Bromoform 75-25-2	[0.5]	NA				NCL	0.011 mg/m^3
Bromomethane [METHYL BROMIDE] 74-83-9	[1]	4					
1,3-Butadiene 106-99-0	4.4 [2]	NA		1-25 ppm	10 ppm	10 ppm	
n-Butane 106-97-8	1900 [800]	NA			10 ppm	10 ppm	
1-Butanol 71-36-3	61 [20]	NA			10 ppm	10 ppm	
1-Butene 106-98-9	NA	NA			10 ppm	10 ppm	
n-Butyl Acetate 123-86-4	713 [150] STEL 950.51 [200]	NA			10 ppm	10 ppm	0.012 mg/m^3
Butyl Acrylate 141-32-2	11 [2]	NA			10 ppm	CL10 ppm	0.011 mg/m^3

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
n-Butyl Isocyanate 111-36-4	NA	NA			?		
sec-Butylbenzene 135-98-8	NA	NA		20-500 ppm			0.016 mg/m^3
Cadmium (compounds)	0.002 mg/m^3 (Resp Fraction)	NA	0.01**				
Cadmium (elemental) 7440-43-9	0.01 mg/m^3 0.002 mg/m^3 (R)	NA	0.01**			NCS	
Carbon Disulfide 75-15-0	31.12 [10]	3			10 ppm	10 ppm	
Carbon Monoxide 630-08-0	28.62 [25]	28		5-150 ppm			
Carbon Tetrachloride 56-23-5	769 [5] STEL 62.9 [10]	33			n	NCL	0.009 mg/m^3
Carbonyl Fluoride 353-50-4	5.39 [2] STEL 330 [5]	5				NG	
Chlordane (techgrade CAS 12789-03-6) 57-74-9	0.5 mg/m^3	NA				NCL	
Chlorine 7782-50-5	35.45 [0.5] STEL 2.89 [1]	1.5		0.2-10 ppm		NG	
Chlorine Dioxide 10049-04-4	0.276 [0.1] STEL 0.828 [0.3]	0.4 [0.15]				FG	
Chlorine Trifluoride 7790-91-2	C [0.1]	0.5				NCL/ NG	
1-Chloro-1,1-difluoroethane 75-68-3	NA	NA					
2-Chloro-1,3-butadiene 126-99-8	[10]	NA					
Chloroacetaldehyde 107-20-0	C [1]	3.2				CL	
Chloroacetone 78-95-5	C [1]	3.8					
Chloroacetophenone [CN] 532-27-4	[0.05 ppm]	0.32				CS	0.031 mg/m3
Chloroacetyl Chloride 79-04-9	[0.05] STEL [0.15]	0.23				NCL	
Chlorobenzilate 510-15-6	NA	NA				May Burn	
Chlorobenzene 108-90-7	46 [10]	NA			10 ppm	10 ppm	0.0006
Chlorobenzylidenemalonitrile o- [CS] 2698-41-1	C [0.05]	0.39				CS	
Chlorofluorocarbon-113 (CFC-113) 76-13-1	[1000] STEL [1250]	NA				NCL	0.01 mg/m^3
Chlorodifluoromethane 75-45-6	[1000]	NA				NG	
Chloroethyl-ethyl-sulfide 693-07-2	NA	0.008					0.004 mg/m^3
Chloroform 67-66-3	[10]	48				10 ppm	0.01 mg/m^3
Chloromethane (methyl chloride) 74-87-3	[50] STEL [100]	NA			**Note 1**	10 ppm	0.001 mg/m^3
Chloromethyl methyl ether 107-30-2	NA	NA					
Chloropicrin 76-06-2	[0.1]	0.7				NCL	

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
2-Chloropropane 75-29-6	NA	NA					0.008 mg/m^3
2-Chlorotoluene 95-49-8	259 [50]	NA			10 ppm	10 ppm	0.013 mg/m^3
Chromium III Compounds 16065-83-1	0.5 mg/m^3	NA	0.0035***			NCS	
Chromium (total) 7440-47-3	0.5 mg/m^3	NA	0.0035***			NCS	
Chromium VI Compounds (insoluble) 18540-29-9	0.01 mg/m^3	NA	0.0035***				
Chromium VI Compounds (water-soluble) 18540-29-9	0.05 mg/m^3	NA	0.0035***				
Chrysene 218-01-9	NA	NA					c18
m-Cresol 108-39-4	22 [5]	NA			10 ppm	CL10 ppm	
Crotonaldehyde 4170-30-3	C [0.3]	0.55				Y	
Crotonaidehyde-trans 123-73-9	NA	NA					
Cumene 98-82-8	[50]	NA		20-500 ppm			0.014 mg/m^3
Cyanogen 460-19-5	[10]	20					
Cyanogen Chloride 506-77-4	C [0.3]	0.6				NG	
Cyclohexane 110-82-7	344 [100]	NA			10 ppm	10 ppm	0.005 mg/m^3
Cyclohexylamine 108-91-8	[10]	NA					
Cyclopentadiene 542-92-7	[75]	NA		20-500 ppm			
DDT (p,p') 50-29-3	1 mg/m^3	NA				CS	
n-Decane 124-18-5	NA	NA			10 ppm	10 ppm	0.014 mg/m^3
Diborane 19287-45-7	[0.1]	0.1					
1,2-Dibromo-3-chloropropane 96-12-8	NA	NA				CL	0.023 mg/m^3
1,4-Dichloro-2-butene 764-41-0	[0.005]	NA					
Dichlorobenzene (1,2-) 95-50-1	[25] STEL [50]	NA				CL	0.012 mg/m^3
Dichlorobenzene (1,4-) 106-46-7	[10]	NA				CS	0.016 mg/m^3
Dichlorodifluoromethane (CFC 12) 75-71-8	4950 [1000]	NA				NG	0.0012
Dichlorodimethylsilane 75-78-5	NA	4.7					
Dichloroethane (1,1-) 75-34-3	[100]	400				FL	0.015 mg/m^3
Dichloroethane (1,2-) 107-06-2	[10]	NA				FL	0.014 mg/m^3
Dichloroethylene (trans-1,1-) 156-60-5	[200]	1100					0.017 mg/m^3
Dichloroethylene (cis-1,2-) 156-59-2	[200]	560					0.013 mg/m^3
Dichloroethylene (1,1-) [Dichloroethene 1,1-] 75-35-4	[5]	NA				FL	0.017 mg/m^3
Dichloro-1-fluoroethane (1,1-) 1717-00-6	NA	NA				CL	
Dichloropropane (1,2-) 78-87-5	[75] STEL [110]	NA				FL	0.014 mg/m^3
Dichloropropene (1,3-) 542-75-6	[1]	NA				FL	
Dichlorvos 62-73-7	0.1 mg/m3	NA				CL	

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Dicyclopentadiene 77-73-6	[5]	NA		20-500 ppm			
Dieldrin 60-57-1	0.25 mg/m^3	0.25				No	
Diesel Engine Emissions	NA	NA					
Diesel Fuel Smoke	NA	5					
Difluoroethane (1,1-) 75-37-6	NA	NA					
Diisopropylmethyl-phosphonate [DIMP] 1445-75-6	NA	NA					c7
Diketene 674-82-8	NA	NA					
Dimethyl Disulfide [DMDS] 624-92-0		NA					0.007 mg/m^3
Dimethyl Formamide 68-12-2	30 [10]	NA			10 ppm	10 ppm	
Dimethyl Hydrazine (1,1-) 57-14-7	[0.01]	NA				Yes	
Dimethyl Hydrazine (1,2-) 540-73-8	NA	NA					
Dimethyl Methylphosphonate [DMMP] 756-79-6	NA	NA				CL	
Dimethyl Sulfate 77-78-1	[0.1]	0.5				CL	
Dimethylamine 124-40-3	[5] STEL [15]	18				FG	
Dimethylformamide (N,N-) 68-12-2	[10]	NA				CL	
Diphenylhydrazine (1,2-) 122-66-7	NA	NA					
Endrin 72-20-8	0.1 mg/m^3	0.1				No	c12
Epichlorohydrin 106-89-8	[0.5]	NA					
Epoxybutane (1,2-) 106-88-7	NA	NA					
Ethane 74-84-0	[1000]	NA		20-500 ppm (Hydrocarbon)		10 ppm	
Ethoxyethanol (2-) 110-80-5	[5]	NA				CL	
2-Ethoxyethanol (EGEE) 110-80-5	18 [5]	NA			10 ppm	CL 10ppm	
Ethyl Acetate 141-78-6	1440 [400]	NA			10 ppm	10 ppm	0.02 mg/m^3
Ethyl Acrylate 140-88-5	20 [5]	NA			10 ppm	10 ppm	0.006 mg/m^3
Ethyl Alcohol 64-17-5	1880 [1000]	NA		100-2500 ppm.	10 ppm	10 ppm	0.004 mg/m^3
Ethyl Benzene 100-41-4	[100] STEL [125]	440		20-500 ppm (Hydrocarbon)	10 ppm	10 ppm	0.014 mg/m^3
Ethyl Chloride [Chloroethane] 75-00-3	[100]	NA					0.008 mg/m^3
Ethyl Lactate 687-47-8	NA	NA			10 ppm	10 ppm	
Ethylene 74-85-1	[200]	NA		20-500 ppm (Hydrocarbon)	**Note 1**	10 ppm	
Ethylene Diamine 107-15-3	[10]	NA					
Ehtylene Dibromide 106-93-4	NA	NA				NCL	0.018 mg/m^3
Ethylene Glycol 107-21-1	C 100 mg/m^3	NA				CL	
Ethylene Glycol Monobutyl Ether 111-76-2	[20]	NA				CL	
Ethylene Oxide 75-21-8	[1]	1.8			**Note 1**	10 ppm	

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Ethylenimine 151-56-4	[0.5]	0.92				Yes	
Fluoranthene 206-44-0	NA	NA					
Fluorene 86-73-7	NA	NA					
Fluorine (soluable fluoride) 7782-41-4	[1] STEL [2]	2.6				NG	
Fog Oil Smoke	NA	5					
Formaldehyde 50-00-0	C [0.3]	0.37				10 ppm	
Furan 110-00-9	NA	NA					
Furfural 98-01-1	[2]	NA				CL	
GA (Tabun) (Nerve Agent) 77-81-6	NA	0.001		CDS 0.025 ppm	0.61 ppm	0.61 ppm	0.0063 ppt 20-min
GB (Sarin) (Nerve Agent) 107-44-8	NA	0.001		CDS 0.025 ppm	4.46 ppm	0.60 ppm	0.0007 ppt 20-min
GD (Soman) (Nerve Agent) 96-64-0	NA	0.0005		CDS 0.025 ppm			0.001 ppt 20-min
GF (Cyclosarin) (Nerve Agent) 329-99-7	NA	0.0005		CDS 0.025 ppm			0.0004 ppt 20-min
Glycidaldehyde 765-34-4	NA	NA					
Heptachlor 76-44-8	0.05 mg/m3	NA				NCS	
Heptachlor Epoxide 1024-57-3	0.05 mg/m3	NA					
n-Heptane 142-82-5	1640 [400]	NA			10 ppm	10 ppm	0.009 mg/m^3
Hexachlorobenzene 118-74-1	0.002 mg/m3	NA					
Hexachlorobutadiene 87-68-3	[0.02]	0.24					0.021 mg/m^3
Hexachlorocyclohexane (alpha-HCH) 319-84-6	NA	NA				Not Rated	
Hexachlorocyclohexane (beta-HCH) 319-85-7	NA	NA				Low Flammability	
Hexachlorocyclohexane technical-HCH) 608-73-1	NA	NA				NCS	
Hexachlorocyclopentadiene 77-47-4	[0.01]	0.1				NCL	
Hexachlorodibenzodioxin Mix 19408-74-3	NA	NA				CS	
Hexachloroethane 67-72-1	[1]	10				NCS	
Hexachloroethane (Smoke)	[1]	0.2				NCL	
Hexafluoropropene (Hexafluoropropylene) 116-15-4	NA	NA				Not Readily Ignitable	
Hexamethylene Diisocyanate (1,6-) 822-06-0	[0.005]	NA				CL	
n-Hexane 110-54-3	[50]	180			10 ppm	10 ppm	0.008 mg/m^3
Hexane (other isomers)	[500] STEL [1000]	NA					
Hydrazine 302-01-2	[0.01]	0.13					h4n2
Hydrogen Bromide 10035-10-6	C [2]	9.9				NG	
Hydrogen Chloride 7647-01-0	C [2]	2.7		20-500 ppm.		NG	
Hydrogen Cyanide 74-90-8	C [4.7]	1.1		CDS 1 ppm			
Hydrogen Fluoride 7664-39-3	[0.5] C [2]	0.82				NG	

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Hydrogen Selenide 7783-07-5	[0.05]	0.2					
Hydrogen Sulfide 7783-06-4	[10] STEL [15]	0.46		20-500 ppm 100-2500 ppm.			
Indeno (1,2,3-c,d) pyrene 193-39-5	NA	NA		20-500 ppm (Hydrocarbon)			
Iodomethane 74-88-4	[2]	NA			NO TVA 1000 Relative response Factor	NCL 10 ppm No Resp. Factor	
Iron Pentacarbonyl 13463-40-6	[0.1] STEL [0.2]	ND				FL	
Isobutyl Alcohol 78-83-1	152 [50]	NA			10 ppm	10 ppm	
Isobutylene 115-11-7	NA	NA		20-500 ppm	10 ppm	10 ppm	
Isobutyronitrile 78-82-0	NA	NA					
Isopropyl Alcohol 67-63-0	983 [400]	NA		40-1000 ppm	10 ppm	10 ppm	0.026 mg/m^3
Isopropyl Ether 108-20-3	1040 [250]	NA			10 ppm	10 ppm	0.014 mg/m^3
Lead 7439-92-1	0.05 mg/m^3	NA	0.006 ***			NCS	
Lewisite 541-25-3	NA	0.003		CDS 3 mg/m3			
Lindane (gamma-BHC) 58-89-9	0.5 mg/m^3	0.5				NCS	
Manganese 7439-96-5	0.2 mg/m^3	NA	0.002***			CS	
Mercury (inorganic) 7439-97-6	0.025 mg/m^3	NA	0.003***				
Mercury (Methyl) [organic] 22967-92-6	NA	NA					
Methoxyethanol (2-) 109-86-4	NA	NA				CL	
Methyl Alcohol 67-56-1	262 [200]	350		20-500 ppm	**Note 1**	10 ppm	
Methyl Bromide 74-83-9	[1]	ND					
Methyl Chloroform (1,1,1-Trichloroethane) 71-55-6	[350] STEL [450]	1300					0.026 mg/m^3
Methyl Ethyl Ketone (2-Butanone) 78-93-3	590 [200] STEL 884.6 [300]	NA			10 ppm	10 ppm	0.016 mg/m^3
Methyl Hydrazine 60-34-4	[0.01]	0.02					
Methyl Isobutyl Ketone (MIBK) 108-10-1	205 [50]	NA			10 ppm	10 ppm	0.032 mg/m^3
Methyl Isocyanate 624-83-9	[0.02]	0.05					
Methyl Mercaptan 74-93-1	[0.5]	1					
Methyl Styrene (mixture) 25013-15-4	[50] STEL [100]	NA		CMS Chip set 20-500 ppm (Hydrocarbon)		CL	
Methyl Tert-butyl Ether (MTBE) 1634-04-4	[50]	NA			10 ppm	10 ppm	0.011 mg/m^3
Methylacrylonitrile 126-98-7	[1]	NA					
Methylamine (mono) 74-89-5	[5] STEL [15]	13					
Methylcyclohexane 108-87-2	[400]	NA			10 ppm	10 ppm	
Methylene bis (2-chloroaniline) (4,4-) 101-14-4	[0.01]	NA				?	
Methylene Chloride 75-09-2	[50]	175			**Note 1**	CL 10 ppm	0.012 mg/m^3

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Methylene Diphenyl Isocyanate (4,4-) 101-68-8	[0.005]	NA				CS	
Naphthalene 91-20-3	[10] STEL [15]	NA		20-500 ppm (Hydrocarbon)		CS	0.010 mg/m^3
Nickel (elemental/metal) 7440-02-0	1.5 mg/m^3	NA	0.0015* **			CS	
Nickel (elemental/metal) 7440-02-0	0.2 mg/m^3	NA	0.0015* **			CS	
Nickel (elemental/metal) 7440-02-0	0.1 mg/m^3	NA	0.0015* **			CS	
Nickel Carbonyl 13463-39-3	[0.05]	NA				FL	
Nickel Refinery Dust (No CAS)		NA	0.0015* **				
Nickel Subsulfide 12035-72-2	0.1 mg/m3	NA				CS	
Nitric Acid 7697-37-2	[2] STEL [4]	1.3				NCL	
Nitric Oxide 10102-43-9	[25]	0.61		.50-150 ppm , 10-200 ppm Nitrous Gases		NCL	
Nitroaniline (2-) 88-74-4	NA	NA				SF	
Nitrobenzene 98-95-3	[1]	NA				CL	0.018 mg/m^3
Nitrogen Dioxide 10102-44-0	[3] STEL [5]	0.94		0.50-25 (.50-150 ppm, 10-200 ppm Nitrous Gases)		NCL/ Gas	
Nitropropane (2-) 79-46-9	[10]	NA					
Nitrosodiethylamine (N-) 55-18-5	NA	NA				CL	
Nitrosodimethylamine (N-) 62-75-9	NA	NA				CL	
Nitroso-di-n-butylamine (N-) 924-16-3	NA	NA				Not Rated	
Nitrosopyrrolidine (N-) 930-55-2	NA	NA				SF	
Nitrous Oxide 10024-97-2	[50]	46		0.5-150 ppm 10-200 ppm		NG	
n-Nonane 111-84-2	1050 [200]	NA		20-500 ppm	10 ppm	10 ppm	
n-Octane 111-65-9	1401 [300]	NA		20-500 ppm	10 ppm	10 ppm	0.006 mg/m^3
Ozone 10028-15-6	[0.05] Hevy Wrk [0.08] Mod Wrk [0.10] Lgt Wrk [0.20] All Wrk Loads ≤ 2Hrs)			25-1000 ppm		NG	
Paraquat 4685-14-7	0.5 mg/m^3 0.1 mg/m^3 (Resp Fract)	0.1					
Parathion 56-38-2	0.05 mg/m^3 (Resp Fract)	0.1					
Particulate <10 ∞ (PM-10)	NA	NA					
Particulate <10 ∞ (PM-2.5)	NA	NA					
n-Pentane 109-66-0	1770 [600]	NA		20-500 ppm	**Note 1**	10 ppm	
Perchloromethyl Mercaptan 594-42-3	[0.1]	0.04				NCL	
Phenanthrene 85-01-8	NA	NA					
Phenol 108-95-2	[5]	7.3				N	

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Phosgene 75-44-5	[0.1]	0.4		0.05-2 ppm.		NG	
Phosphine 7803-51-2	[0.3] STEL [1]	0.4		1-25 ppm, 20-500 ppm, and 200-5000 ppm.		FG	
Phosphoric Acid 7664-38-2	1 mg/m^3 STEL 3 mg/m^3	NA				NCS	
Phosphorus (white, yellow) 7723-14-0	NA	0.1				FS	
Phosphorus Oxychloride (Phosphoryl trichloride) 10025-87-3	[0.1]	0.6					
Phosphorus Smoke (Red)	NA	1					
Phosphorus Trichloride 719-12-2	[0.2] STEL [0.5]	1.5					
Phthalic Anhydride 85-44-9	[1]	NA				CS	
Polychloroinated Biphenyls (PCBs) 1336-36-3	ND	NA				**Note 2**	
Propane 74-98-6	4508 [2500]	1,800		100-2000 ppm.	**Note 1**	10 ppm	
Propionitrile 107-12-0	NA	NA					
Propylbenzene (n-) 103-65-1	NA	NA					0.014 mg/m^3
Propylene 115-07-1	344 [200]	NA		20-500 ppm	10 ppm	10 ppm	
Propylene Glycol Monomethyl Ether (PGME) 107-98-2	369 [100]	NA			10 ppm	10 ppm	
Propylene Glycol Methyl Ether Acetate (PGMEA) 108-65-6	DFG MAK 270 [50]	NA			10 ppm	10 ppm	
Propyleneimine 75-55-8	[2]	NA					
Propylene Oxide 75-56-9	[2]	26					
Pyrene 129-00-0	NA	NA					c16
Selenium Hexafluoride 7783-79-1	[0.05]	0.4				NG	
Sliver 7440-22-4	0.1 mg/m^3 (Cmps as Ag) 0.01 mg/m^3	NA	0.005**			NCS	
Stibine 7803-52-3	[0.1]	0.5					
Strontium 7440-24-6	NA	NA	0.0004***				
Styrene 100-42-5	[20] STEL [40]	NA			**Note 1**	10 ppm	0.014 mg/m^3
Sulfur Dioxide 7446-09-5	[2] STEL [5]	5		5-150 ppm.		NGs	
Sulfur Mustard [HD] (blister agent, mustard gas) 505-60-2	NA	0.008		CDS 1 mg/m3	0.29 ppm	4.27 ppm	0.0008 ppt 20-min
Sulfur Trioxide 7446-11-9	NA	1					
Sulfuric Acid 7664-93-9	0.2 mg/m^3	1				NCL	
Sulfuryl Fluoride 2699-79-8	[5] STEL [10]	20				NG	
2,3,7,8-TCDD [Tetrachlorobenzodioxin] (dioxin) 1746-01-6	NA	NA				?	

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Tellurium Hexafluoride 7783-80-4	[0.02]	0.2				NG	
Tetrachloroethane (1,1,1,2-) 630-20-6	NA	NA				?	0.0004
Tetrachloroethane (1,1,2,2-) 79-34-5	[1]	7					0.013 mg/m^3
Tetrachloroethylene 127-18-4	[25] STEL [100]	240		5-150 ppm.	10 ppm	10 ppm	0.013 mg/m^3
Tetraethyl Lead (as Pb) 78-00-2	0.1 mg/m^3	0.1	0.0006* **			CL	
Tetrafluoroethane (1,1,1,2-) 811-97-2	NA	33000			10 ppm	NA	
Tetramethyl Lead (as Pb) 75-74-1	0.15 mg/m^3	0.1	0.0006* **			CL	
Tetrahydrofuran 109-99-9	590 [200]	NA			10 ppm	10 ppm	0.017 mg/m^3
Tetranitromethane 509-14-8	[0.005]	1.2				CL	
Titanium Tetrachloride 7550-45-0	NA	0.5					
Toluene 108-88-3	[50]	750		10-300 ppm.	10 ppm	10 ppm	0.019 mg/m^3
Toluene 2,4- Diisocyanate 584-84-9	[0.005] STEL [0.02]	0.071				CL	
Toluene Diisocyanate (2,6-) 91-08-7	[0.005] STEL [0.02]	0.071				CL	
Toxaphene 8001-35-2	0.5 mg/m^3 STEL 1 mg/m^3	NA				NCS	
Trichloro-1,2,2-trifluoroethane (1,1,2-) 76-13-1	[1000] STEL [1250]	NA				NCL	
Trichlorobenzene (1,2,4-) 120-82-1	C [5]	NA				CL	0.018 mg/m^3
Trichloroethane (1,1,1-) 71-55-6	[350] STEL [450]	NA					0.026 mg/m^3
Trichloroethane (1,1,2-) 79-00-5	[10]	NA				CL	0.012 mg/m^3
Trichloroethylene 79-01-6	[50] STEL [100]	270		5-100 ppm.	10 ppm	10 ppm	0.005 mg/m^3
Trichlorofluoromethane 75-69-4	C [1000]	NA				NCL	0.013 mg/m^3
Trichloromethyl Silane 75-79-6	NA	3.7					
Trichlorophenol (2,4,6-) 88-06-2	NA	NA				Not Rated	
Trichloropropane (1,2,3-) 96-18-4	[10]	60					0.018 mg/m^3
Triethylamine 121-44-8	4.1 [1] STEL [3]	NA			10 ppm	10 ppm	
Trimethylbenzene (1,3,5-) 108-67-8	[25]	NA		20-500 ppm (Hydrocarbon)			
Trimethylbenzene (1,2,4-) 95-63-6	[25]	NA		20-500 ppm (Hydrocarbon)			0.014 mg/m^3
Tungsten Hexafluoride 7783-82-6	NA	1				NG	
Uranium Hexafluoride 7783-81-5	NA	NA				NC	
Vanadium 7440-62-2	NA	NA					

Chemical CAS No.	TLV mg/m3 [ppm]	8-Hour Air-MEG mg/m^3	XRF (mg/m^3)	Dräger Tube	PID ppm	FID ppm	HAPSITE
Vinyl Acetate 108-05-4	[10] STEL [15]	NA			10 ppm	10 ppm	
Vinyl Bromide 593-60-2	[0.5]	NA					
Vinyl Chloride 75-01-4	2.6 [1]	NA		0.30-10 ppm 10-250 ppm	10 ppm	10 ppm	0.0005
Vinylidene Fluoride 75-38-7	1310 [500]	NA			**Note 1**	10 ppm	
VX (nerve agent) 50782-69-9	NA	0.000071					0.0006 ppt 20-min as VX-G
Xylene (mixed) 1330-20-7	[100] STEL [150]	440		10-300 ppm.	10 ppm	10 ppm	0.028 mg/m3
Xylene (m) 108-38-3	[100]	440 (I)		10-300 ppm.	10 ppm	10 ppm	0.028 mg/m3
Xylene (p) 106-42-3	[100]	440 (I)		10-300 ppm.	10 ppm	10 ppm	0.028 mg/m3
Xylene (o) 95-47-6	[100]	440 (I)		10-300 ppm.	10 ppm	10 ppm	0.014 mg/m3
Zinc 7440-66-6	NA	NA	0.002***			Zinc Powder	
Note: Lead value based upon 6 ug (Niton 700 series metal LOD) and 1000 L collective Per NIOSH 7702 method. **Formula:** C (mg/m^3)= w(ug measured concentration) / V(volume sampled, 1000 L)							
Note ** Measurements based upon facsimile of NIOSH method 7702 using Niton Xli 700 series XRF with ^{241} Am Isotope (14 mCi)							
Note *** Measurements based upon facsimile of NIOSH method 7702 using Niton Xli 700 series XRF with ^{109} Cd Isotope (10 mCi)							
Note**** CL=Combustible Liquid CS=Combustible Solid							
Note**** NCL=Noncombustible Liquid NCS=Noncombustible Solid							
Note****** NG=Nonflammable Gas FG =Flammable Gas SF=Slightly Flammable							
Note 1: PID Lamp (eV) 11.8 used to achieve 10 ppm							
Note 2: May Burn, But Not Readily Ignitable							

2.8.2.5. Control Measures for Air: Selection of control measures will be situation-dependent and will involve a balancing of resources based on costs and benefits, consideration of time constraints and operational context. The hierarchy of controls for an air media hazard is engineering, administrative and PPE. If exposures are greater than the MEG's, every effort should be made to reduce exposures using the controls recommended below:

Table 2-7: Air Media Controls

Engineering	Administrative	PPE
Substitute use of less hazardous materials	Moving location of operations	Respiratory protection
Substitute process/change process to remove hazard	Training on proper techniques to decrease exposures	
Substitute equipment to reduce hazard	Equipment preventative maintenance	
Use of ventilation/increase dispersion	Managing deployment length/work schedules	
Isolate areas/build barriers or enclosures to prevent	Providing prophylactics/ medical interventions that	

Engineering	Administrative	PPE
chemical release or human exposures	will reduce severity of effect	
Use of air filters at source	Enforcing personal hygiene standards	
Active dust suppression measures		
Collective protection		

Source: *Information extracted in part from Army Technical Guide 230; additional information added*

2.8.3. Soil Sampling Strategy: Prioritize each AOC and screen for the elements of highest risk according to the tiers listed below; characterize the potential exposure routes and frequency of personnel exposure. After soil hazards are prioritized, conduct routine and special sampling, analysis and monitoring. See Appendix K for Soil Gas Screening Procedures. Document results and reprioritize additional sampling based on results.

- **Tier 1** – Highest risk constituents – Consists of identifying VOCs emitted from the soil that present a vapor accumulation hazard in contained areas such as tents. Identification of soil-gas VOCs can be accomplished with the TVA-1000B or the HAPSITE survey method. Each instrument can detect some compounds that the other instrument cannot, but together both can detect a broad-spectrum of volatile hazards.
- **Tier 2** – Moderate risk constituents – Consists of radiation and metal hazards that can be re-entrained in the air through disturbances such as aircraft, vehicles, and wind. These can be detected with the ADM-300 alpha and beta probes, and the XRF.
- **Tier 3** – Low risk constituents – Consists of contact hazards that include semi- and non-volatile compounds, and gamma radiation sources. These can be identified with the HazMatID, HazCat kit, and the ADM-300, respectively.

2.8.3.1. Confidence in Characterization: When the number of variables is minimized, an AOC can be characterized with fewer samples. Unlike air sampling that is highly dependent on changing weather conditions, the concentration of contaminants in soil is less dynamic. There may be seasonal (i.e., winter versus summer) or periodic variations (i.e., high versus low pressure) that impact the concentration of more volatile compounds.

Soil constituents tend to have low variability at homogeneous sites (as determined visually). Large homogeneous areas without the presence of local emission sources or historical contamination represent a low-variability soil environment. A heterogeneous soil environment with some hot spots and emission sources nearby represents a moderate-variability, soil environment. A heterogeneous soil environment with many hot spots and emission sources nearby represents a high-variability soil environment. Note that emission sources may be industrial air emissions, mobile air emissions, underground storage tanks, contaminated aquifers, previously contaminated sites (e.g., spills, bomb-laden territory, etc.), industrial or agricultural runoff from water basins, and nearby surface waters. Also, as the number and randomness of distressed vegetation/soil areas increases, the variability of contaminants within an area should be assumed to increase.

Table 2-8: Soil – General Guidelines for Assessing Contaminant Variability

Ideal Environment	Low Variability	Medium Variability	High Variability
No Variability	Homogeneous soil area	Soil area contains some hot spots and emission sources	Soil area contains some heterogeneous areas and many hot spots and emission sources

2.8.3.2. Number of Samples Needed: Use Tables 1-5 and 1-6 as a general guide to determine number of samples needed to achieve the desired confidence level. BE may be able to reduce the number of samples needed by delineating homogeneous areas and therefore decreasing the variability. This is not always practical, but may be an option.

Table 2-8 in Chapter 2 of the Technical Guide provides tables that show the number of samples needed according to type of soil sampling instrument (e.g., HAPSITE HSS, XRF, HazCat, etc.) and contaminant variability.

2.8.3.3. Instrument Capability in Soil Media Based on Constituent of Concern (CoC): Table 2-9 is organized in the same manner as Table 2-6. Refer to Section 2.8.2.4 for instructions on use. The table is additionally useful for identifying CoCs that pose contact hazards; look for the skin notation.

Table 2-9: Soil MEG

Compound/CAS Number	1-year Soil MEGs (mg/kg)	XRF	HAPSITE	TVA 1000		HazCat	
				PID	FID	Obvious Method	Sophisticated Method
Acenaphthene 83-32-9	1,300				CS	Note 1	
Acetone 67-64-1	16		0.005 mg/m^3	10 ppm	10 ppm	400 mg/kg	25-50 mg/kg
Alachlor 15972-60-8	1,000				CL		
Aldrin 309-00-2	3					Note 1	
Anthracene (120-12-7)	6.1		14C				
Aroclor-1016 (PCB) [12674-11-2]	7.4						
Aroclor-1221 (PCB) [11104-28-2]	5.4						
Aroclor-1232 (PCB) [11141-16-5]	5.4						
Aroclor-1242 (PCB) [53469-21-9])	5.4						
Aroclor-1248 (PCB) [12672-29-6]	5.4						
Aroclor-1254 (PCB) [11097-69-1]	5.4						
Aroclor-1260 (PCB) [11096-82-5]	5.4						
Arsenic 7440-38-2	1,100					8 mg/kg	
Barium 7440-39-3	18,000					62-125 mg/kg	
Benzene 71-43-2	310		0.022 mg/m^3	10 ppm	10 ppm	100-500 mg/kg	
Benzo(a)anthracene 56-55-3	2,500		c18				

Compound/CAS Number	1-year Soil MEGs (mg/kg)	XRF	HAPSITE	TVA 1000		HazCat	
				PID	FID	Obvious Method	Sophisticated Method
Benzo(a)pyrene 50-32-8	250		c20				
Benzo(b)fluoranthene 205-99-2	2,500		c20				
Benzo(k)fluoranthene 207-08-9	3,100		c20				
Beryllium 7440-41-7	16,000				Metal Dusts and Powders are Flammable		
Bis (2-ethylhexyl) phthalate 117-81-7	2,900				Slightly Flammable		
Butylbenzene (sec-) 135-98-8	230		0.016 mg/m^3				
Cadmium (elemental) 7440-43-9	130	0.01**			Metal Dusts and Powders are Flammable		3 mg/kg
Carbon Disulfide 75-15-0	720			10 ppm	10 ppm		
Chlordane (techgrade CAS 12789-03-6) [57-74-9]	62					**Note 2**	
Chloromethane (Methyl Chloride) 74-87-3	3,700		0.001 mg/m^3	**Note 5**	10 ppm	**Note 3**	
Chlorothalonil 1897-45-6	1,500		c8			**Note 3**	
Chromium (total) 7440-47-3	5,700	0.0035 ***				5 mg/kg	1 mg/kg
Chromium III compounds 16065-83-1	390,000	0.0035 ***				5 mg/kg	1 mg/kg
Chromium VI compounds (insoluble) 18540-29-9	5,300	0.0035 ***				5 mg/kg	1 mg/kg
Chromium VI compounds (water-soluble) 18540-29-9	5,300	0.0035 ***				5 mg/kg	1 mg/kg
Chrysene 218-01-9	3,100		c18				
p-Cresol 106-44-5	520						
Cumene 98-82-8	640		0.014 mg/m^3				
Cyanide 57-12-5	110,000					80-160 mg/kg	20-60 mg/kg
DDE (p,p') 72-55-9	52				CS	**Note 3**	
DDT(p,p') 50-29-3	52					**Note 3**	
Diazinon 333-41-5	52					**Note 4**	
Dibromo-3-chloropropane (1,2-) [96-12-8]	210		0.023 mg/m^3				
Dicamba 1918-00-9	3,100						
2,4-D [Dichlorophenoxyacetic Acid] 94-75-7	1,000		c8				
Dieldrin 60-57-1	5.2						
Di-n-butyl phthalate 84-74-2	26,000		?		CL		
Di-n-octyl phthalate 117-84-0	4,200		?		CL		
Dinitrobenzene (1,3-) [99-65-0]	450						
Dinoseb 88-85-7	100		c10				
Disulfoton 298-04-4	30					**Note 4**	
Endosulfan I [959-98-8]	1,600					**Note 2**	
Endosulfan II [33213-65-9]	1,600					**Note 2**	
Endosulfan Sulfate 1031-07-8	1,600					**Note 2**	
Endrin 72-20-8	45		c12				

Compound/CAS Number	1-year Soil MEGs (mg/kg)	XRF	HAPSITE	TVA 1000		HazCat	
				PID	FID	Obvious Method	Sophisticated Method
Ethyl Benzene 100-41-4	230		0.014 mg/m^3	10 ppm	10 ppm		
Ethylene Dibromide 106-93-4	0.37		0.018 mg/m^3			FG for Halogenated Hydrocarbon Pesticides	
Fenamiphos 22224-92-6	52					**Note 4**	
Fluoranthene 206-44-0	42,000						
Fluorene 86-73-7	90						
Fonofos 944-22-9	220					**Note 4**	
GA [Tabun] (nerve agent) 77-81-6	4.6		0.0063 ppt 20-min	0.61 ppm	0.61 ppm	70 mg/kg	
GB [Sarin] (nerve agent) 107-44-8	2.7		0.0007 ppt 20-min	4.46 ppm	0.60 ppm	70 mg/kg	
GD [Soman] (nerve agent) 96-64-0	0.27		0.001 ppt 20-min			70 mg/kg	
GF [Cyclosarin] (nerve agent) 329-99-7	0.27		0.0004 ppt 20-min			70 mg/kg	
Heptachlor 76-44-8	52					**Note 2**	
Heptachlor Epoxide 1024-57-3	1.5					**Note 2**	
Hexachlorobenzene 118-74-1	31					**Note 2**	
Indeno(1,2,3-cd)pyrene 193-39-5	1,000						
Lead 7439-92-1	2,200	0.006 ***	NA			31-62 mg/kg	5 mg/kg
Lewisite 541-25-3	11					70 mg/kg	
Lindane [gamma-BHC] 58-89-9	560					**Note 2**	
Malathion 121-75-5	2,200					**Note 4**	
MCPP 93-65-2	100						
Mercury [inorganic] 7439-97-6	33	0.003* **				250-500 mg/kg	
Mercury (Methyl) [organic] 22967-92-6	31					250-500 mg/kg	
Methyl Ethyl Ketone 78-93-3	34,000		0.016 mg/m^3	10 ppm	10 ppm	FG for Ketones	
2-Methylnapthalene 91-57-6	2.6				SF		
Methyl Parathion 298-00-0	310					**Note 4**	
Molybdenum (Trioxide) 7439-98-7	1,300						
Naphthalene 91-20-3	220		0.010 mg/m^3				
Nickel (elemental/metal) 7440-02-0	5,300	0.0015 ***				16-500 mg/kg	
Nickel (soluble compounds) 7718-54-9	5,300	0.0015 ***				16-500 mg/kg	
Oxamyl [Vydate] 23135-22-0	3,000		c7			FG for Carbamate Pesticides	
Paraquat 1910-42-5	1,100						
Pentachlorophenol 87-86-5	3,100					**Note 2**	
Phenanthrene 85-01-8	270						

Compound/CAS Number	1-year Soil MEGs (mg/kg)	XRF	HAPSITE	TVA 1000		HazCat	
				PID	FID	Obvious Method	Sophisticated Method
Polychlorinated Biphenyls [PCBs] 1336-36-3	2.1						
Propylbenzene (n-) 103-65-1	240		0.014 mg/m^3				
Pyrene 129-00-0	31,000		c16				
Selenium 7782-49-2	1,300						
Silver 7440-22-4	1,300	0.005**				1000 mg/kg	50-100 mg/kg
Simazine 122-34-9	520						
Strontium 7440-24-6	140,000	0.0004***					
Sulfur Mustard [HD] (blister agent, mustard gas) 505-60-2	0.51		0.0008 ppt 20-min	0.29 ppm	4.27 ppm		
2,4,5-T [93-76-5]	2,600				CS		
2,3,7,8-TCDD [Tetrachlorodibenzodioxin](dioxin) 1746-01-6	0.0048					**Note 3**	
Terbufos 13071-79-9	2.6						
Tetraethyl Lead 78-00-2	0.026	0.0006***				31-62 mg/kg	5 mg/kg
Toluene 108-88-3	520		0.019 mg/m^3	10 ppm	10 ppm	100-500 mg/kg	
Toxaphene 8001-35-2	100					**Note 2**	
Trifluralin 1582-09-8	740		c13				
Trimethylbenzene (1,3,5-) [108-67-8]	250						
Trimethylbenzene (1,2,4-) [95-63-6]	5.8		0.014 mg/m^3				
Vanadium 7440-62-2	1,600		NA				
VX (nerve agent) 50782-69-9	0.079		0.0006 ppt 20-min as VX-G				
Xylene (mixed, o, m, p) 1330-20-7	210		0.028 mg/m3	10 ppm	10 ppm	100-500 mg/kg	
Zinc 7440-66-6	69,000	0.002***			Zinc Powder is Flammable		

Note Lead value based upon 6 ug (Niton 700 series metal LOD) and 1000 L collective Per NIOSH 7702 method. **Formula:** C (mg/m^3)= w(ug measured concentration) / V(volume sampled, 1000 L)

Note ** Measurements based upon facsimile of NIOSH method 7702 using Niton Xli 700 series XRF with ^{241} Am Isotope (14 mCi)

Note *** Measurements based upon facsimile of NIOSH method 7702 using Niton Xli 700 series XRF with ^{109} Cd Isotope (10 mCi)

Note **** Chemical Found in HazMatID Optional Library

Note(s): CL=Combustible Liquids CS=Combustible Solids SF= Slightly Flammable

Note 1: FG Detected Only

Note 2: FG for Chlorinated Hydrocarbon Pesticides

Note 3: FG for Chlorinated Hydrocarbons

Note 4: FG for Organophosphate Pesticides

Note 5: PID Lamp (eV) 11.8 used to achieve 10 ppm

2.8.3.4. Control Measures for Soil

Table 2-10: Soil Control Measures

Engineering	Administrative	PPE
Implement active dust suppression measures to minimize the pathway dust and contaminant exposure to personnel	Coordinate with CE to oversee waste disposal practices. Review & approve waste disposal plans and practices to minimize breeding of pathogens. Focus on human waste, kitchen and bath liquid waste, garbage, solid waste and toxic wastes.	Utilize respiratory protection during high winds when contaminants are re-entrained in the air
Apply encapsulant or fixant to soil		Use foot covers when indoors to minimize contamination transfer to living and working areas
Vent contaminated area to create downward airflow		Wear gloves when handling soil such as sand-bagging operations
Seal/cover contaminated soil with clay layer to limit exposure pathway	Mark and limit access to hazardous areas (i.e., UXO, CBR contamination areas)	Designate outdoor and indoor boot policies; wear boot covers outdoors
Establish positive pressure collective protection facilities	Ensure personnel are located upwind and upslope	
Remove contaminated soil	Designate shelter in place procedures if conditions changes (i.e., off-gassing is enhanced under low pressure, contaminants are re-entrained in air due to high winds)	
Plant vegetation	Monitor the environmental impact of pesticide application, including aerial spraying	

2.8.4. Surface Water Sampling Strategy: Review AOCs that have surface water as part of the CSM pathway and prioritize routine and special surveillance sampling based on highest risk to personnel. Any surface water located within the perimeter of an AOC that personnel or equipment may come into contact with must be sampled. Additionally, soil sediment may be an indicator of historical conditions that may affect surface waters or be affected by surface water hazards. The HAPSITE HSS, ADM-300, HazCat kit, and reachback labs may support sediment analyses. Sampling should be conducted under conditions that approximate homogeneous environmental conditions. Note that Chapter 3 – Water addresses potable water issues. The tiers below provide guidelines for relative risk of contaminants. When evaluating the AOC, note any changes in environmental conditions that may result in an increased future risk to personnel.

For example, an initial surface water test of a stream that runs through base indicates pH levels around neutral; however, seasonal agricultural operations are beginning at a

farm just upstream of the base. Use of agrarian chemicals may lead to a future change in the pH.

- **Tier 1** – High-risk contaminants – Consists of identifying VOCs emitted from the water that present an inhalation hazard. It also includes identifying corrosives that could present both an inhalation and contact hazard.
- **Tier 2** – Moderate risk contaminants – Consists of evaluating water for contact hazards such as semi-VOCs, corrosives, non-volatiles, bacteria, and radiation.
- **Tier 3** – Low risk contaminants – Evaluation for metals and other constituents in water that are present in the local municipality and nearby industrial facilities.

2.8.4.1. Confidence in Characterization: Variability for surface water depends greatly on whether or not the body of water receives discharges. In situations where water is flowing and there are multiple sources of discharge, more samples will be required to sufficiently characterize the hazards.

Table 2-11: Surface Water – General Guidelines for Assessing Contaminant Variability

Ideal Environment	Low Variability	Medium Variability	High Variability
No Variability	Oceans, lakes, and ponds that do not receive discharges	Rivers or streams, stagnant water sources that receive excess runoff	Rivers or streams that receive industrial discharges or other sources upstream

Some additional parameters that affect the variability of the water media include:

- Low versus high tide
- High versus low flow for streams
- After or during rain events because of the potential for run-off containing contaminants

2.8.4.2. Number of Samples Needed: Refer to Tables 1-5 & 1-6 in Chapter 1 of this manual for instruction on determining the number of samples needed given the environmental variability. Additionally, Technical Guide Chapter 2, Table 2-10 show the number of samples needed according to type of soil sampling instrument (e.g., HACH 2400, M272, etc.) and contaminant variability.

2.8.4.3. Instrument Capability in Surface Water Based on Constituent of Concern (CoC): Use Table 2-12 to determine the capability (i.e., detection, identification, and quantification limits) of various field portable instruments and applicability to the sampling strategy. This table should be used to identify constituents that pose a skin/contact hazard for non-potable water. The limits shown are for potable water and ingestion may be an indicator of the toxicity. It is organized in the same manner as Table 2-6; refer to Section 2.8.2.4 for guidance.

Table 2-12: Surface Water MEGs

Contact Hazards	Guidelines/Std		HACH 2400 (ppm)	PID	FID	HAPSITE (ppb)	M272	Hazcat
	5-day	2-week						
Acetone cyanohydrin 75-86-5								
Acetonitrile 75-05-8								FG
Acrolein 107-02-8								FG
Acrylamide 79-06-1	0.7	0.14						
Acrylic Acid 79-10-7						1		
Acrylonitrile 107-13-1	0.14	0.14				1		FG
Aldrin 309-00-2	0.0001	0.0001						FG
Allyl Alcohol 107-18-6								FG
Ammonium Perfluorooctanoate 3825-26-1								
Aniline 62-53-3								
Anthracene 120-12-27								
Antimony 744-36-0	0.002	0.002						
Arsenic 7440-38-2	0.1	-	.002-.2					
Benzene 71-43-2	0.1	0.1		y		0.6		
Benzotrichloride 98-07-7								
Bis (2-dethylhexyl)-phthalate 117-81-7								
(DMAEE) 3033-62-3								
Boron 7440-42-8	1.7	0.4	0.2-14					
Bromoform 75-25-2	2	1				0.8		
n-Butylamine 109-73-9								
sec-Butylbenzene 135-98-8						0.3		
n-Butyl glycidyl ether (BGE) 2426-08-6								
o-sec-Butylphenol 89-72-5								
Captafol 2425-06-1								
Carbon disulfide 75-15-0	0.05	0.05						
Carbon tetrachloride 56-23-5	2	0.07		n		1.2		FG
Catechol 120-80-9								
Chloroamben 133-90-4	1.2	1.2						
Chlordane 57-74-9	0.03	0.03						FG
Chlorinated camphene (Toxaphene) 8001-35-2								
Chloroacetone 78-95-5								
Chloroacetyl chloride 79-04-9								
o-Chlorobenzylidene Malononitrile 2698-41-1								
Chlorodiphenyl (42% chlorine) 53469-21-9								FG
1-Chloro-2-propanol (127-00-4) and 2-Chloro-1-propanol (78-89-7)								
β-Chloropene 126-99-8								
2-Chloropropionic Acid 598-78-7								
Chlorpyrifos 2921-88-2	0.014	0.014						FG
Cresol, All isomers (1319-77-3, 95-48-7; 108-39-4; 106-44-5)								
Crotonaldehyde 4170-30-3								
Cumene 98-82-8								
Cyclohexanol 108-93-0								
Cyclohexanone 108-94-1								
Cyclonite 121-82-4								
Cyanide 57-12-5 *TB MED 577	2	2	0.001				20	
p,p'-DDT 50-29-3								FG
Decarborane 17702-41-9								
Demeton 8065-48-3								

Contact Hazards	Guidelines/Std		HACH 2400 (ppm)	PID	FID	HAPSITE (ppb)	M272	Hazcat
	5-day	2-week						
Diazinon 333-41-5	0.009	0.009						FG
2-N-Dibutyllaminoethanol 102-81-8								
Dibutyl Phenyl Phosphate 2528-36-1								
Dichloroacetic acid 79-43-6	0.5	0.5				c2		
3,3'-Dichlorobenzidine 91-94-1								
1,4-Dichloro-2-butene 764-41-0								
Dichloroethyl ether 111-44-4								
1,3-Dichloropropene 542-75-6	0.014	0.014						FG
Dichlorvos 62-73-7								
Dicrotophos 141-66-2								
Dieldrin 60-57-1	0.00023	0.00023						
Diesel Fuel (68334-30-5; 68476-30-2; 68476-31-3; 68476-34-6; 77650-28-30) as total hydrocarbons								
Diethanolamine 111-42-2								
Diethylamine 109-89-7								
Diisopropylamine 108-18-9								
N,N-Dimethylacetamide 127-19-5								
Dimethylaniline (N,N-Dimethylaniline) 121-69-7								
Dimethylformamide 68-12-2								
1,1-Dimethylhydrazine 57-14-7								
Dimethyl sulfate 77-78-1								
Dinitrobenzene, all isomers (528-29-0, 99-65-0, 100-25-4)	0.02	0.02						
Dinitrol-o-cresol 534-52-1								
Dinitrotoluene 25321-14-6								
Dioxane (1,4-) 123-91-1	2	0.2						
Dioxathion 78-34-2								
Diquat (2764-72-9-72-9; 85-00-7; 6385-62-2)								
Disulfoton 298-04-4	0.005	0.005						
Endosulfan 115-29-7								FG
Endrin 72-20-8	-0.01	0.007						
Epichlorohydrin 106-89-8	0.07	0.07						
EPN 2104-64-5								
Ethion 563-12-2								
2-Ethoxyethanol (EGEE) 110-80-5								
2-Ethoxyethyl acetate (EGEEA) 111-15-9								
Ethylamine 75-04-7								
Ethyl bromide 74-96-4								
Ethyl chloride 75-00-3								
Ethylene chlorohydrin 107-07-3								
Ethylenediamine 107-15-3								
Ethylene dibromide 106-93-4	0.004	0.004						
Ethylene glycol dinitrate (EGDN) 628-96-6								FG
Ethylenimine 151-56-4								
N-Ethylmorpholine 100-74-3								
Fenamiphos 22224-92-6	0.004	0.004						FG
Fensulfothion 115-90-2								
Fenthion 55-38-9								
Fonofos 944-22-9	0.009	0.009						
Formamide 75-12-7								FG
Furfural 98-01-1								

Contact Hazards	Guidelines/Std		HACH 2400 (ppm)	PID	FID	HAPSITE (ppb)	M272	Hazcat
	5-day	2-week						
Furfuryl alcohol 98-00-0								
GA [Tabun] 77-81-6 *TB MED 577	0.046						0.02	
GB [Sarin] 107-44-8	0.0093						0.02	
GD [Soman] 96-64-0 *TB MED 577	0.004						0.02	
Heptachlor (76-44-8) and Heptachlor epoxide (1024-57-3)	0.005	0.005						FG
Hexachlorobutadiene 87-68-3	0.14	0.14				1.5		FG
Hexachloroethane 67-72-1	2.4	2.4						FG
Hexamethyl phosphoramide 680-31-9								
n-Hexane 110-54-3								
Hydrazine 302-01-2			0.004					
2-Hydroxypropyl acrylate 999-61-1								
Isooctyl alcohol 26952-21-6								
2-Isopropoxyethanol 109-59-1								
N-Isopropylaniline 768-52-5								
Lewisite 542-25-3 *TB MED 577	0.027						2	
Lindane 58-89-9	0.2	0.2						FG
Malathion 121-75-5	0.1	0.1						FG
Manganese cycopentadienyl tricarbonyl 12079-65-1 as Mn								
Mercury (7439-97-6) as Hg (Alkyl compounds, Aryl compounds, Elemental and inorganic forms			0.1-					
Methanol 67-56-1								
2-Methoxyethanol (EGME) 109-86-4								
2-Methoxyethyl acetate (EGMEA) 110-49-6								
DPGME 34590-94-8								
Methyl actylate 96-33-3								
Methylacrylonitrile 126-98-7								
N-Methyl aniline 100-61-8								
Methyl bromide 74-83-9								
Methyl n-butyl ketone 591-78-6								
Methyl chloride 74-87-3						1		
o-Methylcyclohexanone 583-60-8								
2-Methylcyclopentadienyl manganese tricarbonyl 12108-13-3 as Mn								
Methyl demeton 8022-00-2								
4,4'-Methylene bis(2-chloroaniline (MBOCA;MOCA) 101-14-4								
4,4'-Methylene dianiline 101-77-9								
Methyl ethyl ketone 78-93-3								FG
Methyl hydrazine 60-34-4								
Methyl iodide 74-88-4								
Methyl isoamyl carbinol 108-11-2								
Methyl isocynate 624-83-9								
Methyl parathion 298-00-0	0.15	0.15						
Methyl vinyl ketone 78-94-4								

Contact Hazards	Guidelines/Std		HACH 2400 (ppm)	PID	FID	HAPSITE (ppb)	M272	Hazcat
	5-day	2-week						
Mevinphos 7786-34-7								
Monocrotophos 6923-22-4								
Morpholine 110-91-8								
Naled 300-76-5								
Naphthalene 91-20-3	0.25	0.25				5		
Nicotine 54-11-5								
p-Nitroaniline 100-01-6								
Nitrobenzene 98-95-3								
p-Nitrochlorobenzene 100-00-5								
4-Nitrodiphenyl 92-93-3								
Nitroglycerin (NG) 55-63-0								
N-Nitrosodimethylamine 62-75-9								
Nitrotoluene, all isomers (88-72-2; 99-08-1; 99-99-0)								
Octachloronaphthalene 2234-13-1								
Parathion 56-38-2								
Pentachloronaphthalene 1321-64-8								
Pentachlorophenol 87-86-5	0.5	0.14						
Phenanthrene 85-01-8								
Phenol 108-95-2	3	3	0.002					
Phenothiazine 92-84-2								
Phenyl glycidyl ether (PGE) 122-60-1								
Phenyl hydrazine 100-63-0								
Phenylmercaptan 108-98-5								
Phorate 298-02-2								
Propargyl alcohol 107-19-7								
Propylene glycol dinitrate 6423-43-4								
Propylenimine 75-55-8								
Pyrene 129-00-0								
Sodium fluoroacetate 62-74-8								
Sulfotep (TEDP) 3689-24-5								
Sulfur mustard [HD] 505-60-2 *TB MED 577	0.047						2	
TCDD (2,3,7,8-) 1746-01-6	5.00E-07	5.00E-08						
Temephos 3383-96-8								
Terbufos 13071-79-9	0.002	0.002						FG
1,1,2,2-tetrachloroethane 79-34-5						4		FG
Tetraethyl lead, as Pb 78-00-2								
TEPP 107-49-3								
Tetrahydrofuran 109-99-9								FG
Tetramethyl lead, as Pb 75-74-1								
Tetramethyl succinonitrile 3333-52-6								
Thallium and soluble compounds, as Tl 7440-28-0	0.003	0.003						
Thioglycolic acid 68-11-1								
Tin 7440-31-5 as Sn Metal								
o-Tolidine 119-93-7								
Toluene 108-88-3	10	1				0.6		
m-Toluidine 108-44-1								
0-Toluidine 95-53-4								
p-Toluidine 106-49-0								
Trichloroethane (1,1,2-) 79-00-5	0.3	0.2				0.4		FG

Contact Hazards	Guidelines/Std		HACH 2400 (ppm)	PID	FID	HAPSITE (ppb)	M272	Hazcat
	5-day	2-week						
Trichloronaphthalene 1321-65-9								
1,2,3,-Trichloropropane 96-18-4	0.3	0.3				0.6		FG
Trimethylbenzene (1,3,5-) 108-67-8				Y		0.6		
Triethylamine 121-44-8								FG
Trinitrotoluene (2,4,6-) 118-96-7								
Triorthocresyl phosphate 78-30-8								
Vinyl cyclohexene dioxide 106-87-6								
VX 50782-69-9 *TB MED 577	0.005							
Xylene (1330-20-7) o,m, & p isomers (95-47-6; 108-38-3; 106-42-3)	20	20				1.4		
Biological Toxins						**HHA**	**JBAIDS**	**M1M**
Botulinum 107231-12-9 (Bacteriaial Toxin)			LD_{50} (Human) Inhalation: (0.02 mg/min/m^3)					
Clostridium Perfringens Toxins (Bacterial Toxin)			LD_{50} (Humans) ?					
Microcystins (Cyanginosins) (Bacterial Toxin) 101043-37-2			LD_{50} (Humans) ?					
Palytoxin (11077-03-5, 77734-92-0, 7734-91-9) (Marine Toxin)								
Ricin Mycotoxin (Plant Toxin) 9009-86-3			LD_{50} micrograms/kg (Humans) Inhalation: 3.0 Intraperitoneal: 2.6					
Saxitoxin (Marine Toxin) 35523-89-8			LD_{50} (Humans) ?					
Staphylococcal enterotoxin B (Bacterial Toxin) 185261-03-4 and 210293-63-3			25 micrograms induces vomiting in humans. More toxic to humans under stress.					
T-2 toxin 21259-20-1 *TB MED 577 (Fungal Mycoxins Toxin)			0.0087					
Tetrodotoxin 4368-28-9 (Marine Toxin)			LD_{50} (Humans) ?					
Trichothecene mycotoxins (Fungal Toxins) 2623-22-5, 26934-87-2, 23282-20-4, 23255-69-8, 34114-99-3, 2198-92-7 and 51481-10-8								

2.8.4.4. Controls for Surface Water: While contaminants discharged to surface waters off base are outside the control of the base, there are several options for controls that may apply depending on the proximity to surface water and the risk of flooding the base.

Table 2-13: Surface Water Control Measure

Engineering	Administrative	PPE
A small body of contaminated surface water may be treated with aeration, filtering, or applying buffers or nutrients to enhance natural degradation of contaminants; coordinate with CE	Restrict recreational swimming or water sports, and limit activities to times when water monitoring results are within an acceptable range	For extreme cases where highly volatile and dangerous compounds are present, respiratory protection may be warranted Boots, waders and gloves may be used when water contact is unavoidable

Section 3.0: BEE Field Manual: Water Security

3.1. Water Security: BE must be proactive in determining the safety of the water system, identify, viable alternatives, and communicate the associated risks to commanders. Initially, the commander will typically ask BE for a recommendation or input. However, after the initial decision is made, commanders will likely assume that the initial recommendation is still valid unless they are told otherwise. Therefore, it is important for BE to provide on-going vigilance, routine, and special surveillance to support risk management through recommendations, updates, alternatives, and course of action.

The commander may make the following three decisions regarding water:

- Selection of a safe and viable water source for potable operations
- Selection of a safe and viable water source for non-potable operations
- Approving a source of water for recreation (swimming)

Securing safe water: BE needs to organize water quality concerns into a Conceptual Site Model (CSM) and analyze it to determine the probability and severity of the OEH threats, prioritize the risks, develop control recommendations, and then clearly communicate this information to the commander. The table below illustrates examples for the requirements of a conceptual site model for water-related exposures. There are 3 main categories of water source systems to be considered: (1) bottled water and water trucks; (2) host nation provided to included treated and un-treated; and (3) US/Coalition provided from source through treatment.

Table 3-1: Example for Water Conceptual Site Model

CSM Fields	Examples
Area of Concern	Bottled water, Industry (local dump), ROWPU system, Public water system, Harvest Falcon showers
Primary Hazard Release	Injected into source/system, Spills into Source Water, Backflow into System, Backsiphonage, Runoff
Secondary Hazard Release	Percolation, Leachate, Physical Reaction (volatilization), Re-suspension of Hazard
Media Pathway	Groundwater, Surface Water, Distribution System, Air
Activity or Point of Exposure	Water Buffalo, Dining Facility, Bottled Water Distribution Point, Recreational Waters, Showers, Flightline Operations
Exposure Route	Ingestion, Contact, Absorption, Inhalation
SEG Effected	All personnel, Grounds Maintenance, CE Maintenance, Tent City, Hospital, Flightline

Evaluate each water category alternative according to the following 4 factors: (1) supply and demand; (2) threats; (3) vulnerabilities; and (4) quality. Sometimes multiple sources/systems combinations are used. For example, the base may drink bottled water and shower with treated water provided by the host nation. Therefore, each factor must be addressed to determine the safety of the water in use.

3.2. Quantity: To assess the supply and demand use Table 3-2 to estimate water demand as a function of population (climate dependent) and uses (drinking, showering, washing dishes, food prep, decon, fire-fighting, etc.). Then evaluate the supply from various alternative sources. Ultimately, the optimal configuration may be a mixture of different sources for different end uses. According to AFPAM 10-219v5, bare bases should maintain a supply of water (3 days of potable and 2 days of non-potable water).

Table 3-2: Water Supply Estimates (adapted from AFPAM 10-219v5)

Use	Water Usage Factor (gal/person/day)
Potable Water	
Drinking	4
Personal Hygiene	2.7
Shower	1.3 initial field showers; 4.5 sustainment
Food Preparation	3
Medical, based on EMEDs TTP	1
Heat Treatment	1
Non-dining ice production	0.5
Dining ice production	0.1
Non Potable	
Laundry	2
Construction	1
Aircraft Operations	2
Vehicle Operation	0.3
Graves Registration	0.2
Loss 10%	2-2.3
Total	**21.6-25.1**

Additional requirements may include the Transportable Blood Transshipment Center (TBTC) which requires 800 pounds of ice per day (96 gallons per day), firefighting water requirements depend on the type of aircraft and size of fuel tanks, contamination control areas, and patient decontamination which consumes 28 gallons per minute of operation (5,000 gallons should be available for 3 hours of continuous patient decontamination).

More accurate usage rates can be determined by measuring the time it takes to consume water from a bladder or other known volume. For example, you could measure how much is used in an average day and use that quantity to estimate overall usage rates.

3.3. Threats: There is a variety of threats to water sources/systems depending on the operation, location, and security situation. Two components comprise a threat: credibility and intent. Other factors influence these main components such as existence of the threat, specificity, history, and capability of the adversary. Also, threats may be naturally occurring such as water-borne disease or adversary-related. Use checklist 3-1 and the threat matrix to assess the water threat.

Checklist 3-1: Threat Assessment Checklist

	Credibility	YES/NO	Rating
	Confidence in assessment of adversary's capabilities		
	Have you consulted the sources of intel AND are they reporting an assessment for this threat?		
	Is disease endemic to this area; does a threat exist?		
A	Rate your confidence in intel/info assessment using scale based on your answer above: (Rating: 0.1-1 pts) 1 = highly confident		
B	History of threat: Which best describes the history of this threat reporting? (Rating: 1–10 pts) 10 pts =Continuous and accurate reporting 1-5 pts=isolated and current/non-current		
	Frequency and Independence of Threat Reporting		
C	How many distinct/independent reports of this threat are there? How widespread is the threat/disease? (Rating: 0.25-1 pts) 1 pt=widespread and numerous 0.25 = isolated and single threat		
D	Multiply ratings to determine confidence: A x B x C= (max 10)		
	Capability of Adversary/Probability of Occurrence		
E	Rate the adversary's access to the threat agent. For naturally occurring threats, rate as the probability of occurring in the environment. (Rating: 1–10 pts) 10 pts = confirmed development and weaponized; likely to occur in next year; 5 pts = suspected development and weaponized; may occur in the next year		
F	Rate the adversary's ability to execute the threat directly (in-person) or indirectly (missile, grenade, contaminated shrapnel) - sum of applicable statements. (Rating: 20 pts total) Rate using sum of ratings below (F1 +F2).		
F1	-Adversary can deliver the agent to the water source, system or storage system. Threat agent can enter the system. (Rating: 1-10 pts) 10 pts = all 3		
F2	- Adversary/disease threat can disrupt, destroy, or delay the purveyance of safe water (Rating: 1–10 pts) 10 pts = all 3		
G	Multiply the ratings to determine capability: E x F = (max 200)		
	Severity: Rate the severity of the health threat from the hazard. (Rating: 0.1–1 pts). 1 pt = high severity 0.1 very low severity		
	- Build a conceptual site model for the threat to determine potential hazards and exposure routes		
H	- Model or estimate the impact of the threat on the system and personnel; use AFMIC/CDC resources for disease threat.		
	CREDIBILITY RATING = D x G x H = (max 2000)		

	INTENT/SPECIFICITY	Rating
a	What is the scope of the threat; choose one that is most applicable? i.e. global, regional, state, base, etc. (Rating: 1 – 10 pts) 10 pts = base/city specific 2 pts = global	
b	How specific is the threat? (Rating: 1- 10 pts) 10 pts = specific threat 1 pt = general in nature	
c	What is your confidence in the adversary's intent, or likelihood of disease outbreak? (Rating: 0-1.0 pts) 1 pt = highly confident; 0 = no confidence	
d	**INTENT RATING= a x b x c**	

Use the threat matrix to determine the overall threat rating (multiply the Intent and the Credibility ratings for each threat) to rank-order the threats.

Figure 3-1: Threat Matrix

		Intent Rating		
		High	Moderate	Low
Credibility	**Rating**	>80	≥50	<50
High	>1500	Very High	High	Moderate
Moderate	>750	High	Moderate	Low
Low	<750	Moderate	Low	Very Low

3.3.1. Water Vulnerability Assessment (WVA) Process

A WVA is best accomplished with inputs from a cross-functional team composed of representatives from base organizations. All functional areas may not be present in the deployed environment, however equivalent functions may be found within the host nation, on-site contractors, etc. Below is a short description of what each functional may contribute.

- **OWS:** Weather events pertinent to region
- **SF/OSI/IN:** Threat assessment, local vulnerabilities, intrusion history, FPCON measures, base security plan
- **BE:** Monitoring data, contingency response actions, lab agreements (shortfalls)
- **CEO/Host Nation:** Utility maps/drawings, valve, pump locations, ops data, infrastructure security measures/assessment, contingency resources, recurring maintenance, BPDs, Treatment equipment, sampling logs
- **CEF:** System requirements, emergency resources, determine peak storage

3.3.1.1. Key Steps: Characterize the water system and determine the potable water mission objectives and prioritize them. Examples include: Mission-critical operations, force protection, firefighting, potability (what drinking water standards must be met), sanitation, and other (e.g., non-critical industrial processes, irrigation, etc.) The key steps in the WVA process are:

- Data gathering
- Obtain/review pertinent documents and standards
- Describe how the system operates (overview)
- Interview SME's
- Perform site survey

3.3.1.2. Determine Critical Control Points (CCPs): CCPs have been identified for both contingency avoidance and contingency response. Contingency *avoidance* CCPs are associated with essential physical water components and interdependent systems. Contingency *response* CCPs are associated with the installation's capability to quickly and effectively respond, mitigate, and recover.

3.3.1.3. Identify Critical Limits: Critical Limits consist of maximum and/or optimum parameters to distinguish between safe and unsafe, or acceptable and unacceptable levels. These parameters can be either quantitative or qualitative. Examples include level of physical security measures, storage capacity, drinking water physical/chemical parameters, infrastructure or equipment recurring maintenance frequencies, level of redundancy or backup capability, type and frequency of training, breadth and detail of contingency response plans, etc.

3.3.1.4. Identify Critical Limit Monitoring Procedures: Monitoring is a planned sequence to verify that Critical Limits are being met. These procedures may be mandatory requirements established by those sources mentioned above, or Best Management Practices adopted from US Environmental Protection Agency (EPA) guidance or industry standards, such as the American Water Works Association (AWWA).

3.3.1.5. Collate Data, Identify Deficiencies and Corrective Actions: In this step the assessor organizes the multitude of data from interviews, site surveys, etc. It is best to build a table listing each CCP, its associated Critical Limit, deficiencies, and suggested corrective actions. This table may be organized by contingency avoidance and response items. To determine deficiencies, the assessor should evaluate existing controls and countermeasures.

3.3.2. Risk Assessment: The risk assessment starts with an evaluation of likely events/incidents. Actual incidents of attacks on AF drinking water systems have included insiders, vandals, and activist groups. The al Qaeda terrorist organization made threats as recent as May 2003 to attack US drinking water systems.

4 Step Predicting Adverse Consequences

1. ID threat and potential magnitude – extent of damage
2. ID likely disruption hazards, supply shortages and duration of effects – line breaks, pump failures, storage capacity loss – use 24 hour basis
3. ID likely contamination hazards and estimate the impacts and duration of effects – hazard to people and lost supply for other uses
4. Summarize likely degree of effects on CCPs and subsequent effects on supply and quality

Common Threat Types include:
• Terrorist/Enemy Operatives
• Disenfranchised Individuals (e.g., fanatics, revenge-seekers)
• Extremist Groups (e.g., militants)
• Insiders (e.g., disgruntled employees, contractors)
• Collusion (insider and outsider)
• Thrill Seekers/Vandals

Finally, rank each vulnerability by its relative risk and develop a corrective action plan starting with the highest priority (risk) vulnerabilities. The corrective action plan should include the development of a water contingency response plan which addresses those items that cannot be permanently fixed by outlining procedures to react to contingencies. For example, procedures for obtaining addition water supplies should be identified (both potable and non-potable); emergency treatment procedures should be identified; post-attack or heightened threat monitoring procedures should be established.

3.3.3. Water Vulnerabilities: Table 3-3 contains a list of potential vulnerabilities in a water system with corresponding countermeasures. Use the list to identify common vulnerabilities that can be exploited. Lastly, determine if the threats identified above can be executed based on the vulnerabilities, as well as vulnerabilities that are not addressed. Use the threat list when exploring vulnerability contingencies and use the threat rating to estimate a probability of occurrence in the WVA methodology. The risk assessment determination, of the likelihood of threats becoming reality based on vulnerabilities, will be classified **SECRET** and should be stored in an approved safe. The BEE should work with CE Utilities, Readiness, and Environmental sections to prioritize countermeasures that are needed to mitigate existing vulnerabilities. Interim control measures should be outlined in a water contingency response plan.

Table 3-3: Water Vulnerabilities

Source	Vulnerability	Countermeasures
Water Sources	Groundwater or surface water contamination from hazardous sources	Conduct Source Water Assessment and implement monitoring program
	Bottled water plant contamination or sabotage	Inspect bottling plant, obtain monitoring results and VETCOM approval of the source, inspect transport shipment, packaging, and individual bottle seals; monitor transportation method and route with OSI
Water System	X-connections No/inadequate backflow prevention devices	Identify potential for cross-connections, types of x-connections, and risk associated with type of x-connections – perform cross connection survey; use batch water supply employing tanks/bladders
	Un-secured access points at source, treatment, system, and storage with gaining priority closer to POU	Employ BPDs, seal access points on bladders, buffaloes, and tanks; employ visual/security surveillance system with SFS

Source	Vulnerability	Countermeasures
	Un-secured storage tanks	Employ physical barriers C-wire, IR surveillance
	Inadequate storage tank capacity Unclean storage tanks	Ensure supply is sufficient incase of interrupted supply or quality problem with source water; Storage capacity should equal daily use multiplied by time it would take to replace existing supply
	Condition of system can be determined through observations of pressure throughout the day, color, odor, noting line breaks, etc.	Variability in the water system should be followed with increased frequency in monitoring to better characterize the highs and lows
	WX related impacts such as winds, runoff effects to the source water, power outages impact on pumps	Ensure contingencies are addressed in response plan
	Inadequate physical security or protection measures	Apply lighting, fencing, cameras
	Insufficient quantity of water	Increase size of storage tank farm
Water Treatment	Inadequate treatment for specific threats	Add applicable treatment to treatment train; store water in holding tank/bladder, sample for threats, and then release water for use
Water Contingency Response	Inadequate redundancies for critical components	Incorporate redundancies into design to avoid single point failures
	Inadequate response plans	Develop water contingency response plan
	Single source of supply	Identify alternate/back-up supply source and treatment options
	Inadequate number of valves throughout the system to isolate contaminants, loss of pressure, etc.	Incorporate shut off valves at key points in the system
	Inadequate volume for firefighting	Identify alternate non-potable sources

3.4. Quality of Water: The quality of water can be determined using both a qualitative and quantitative approach.

3.4.1. Qualitative Approach: The BEE should make a qualitative assessment in determining the water quality. This should be done initially since it does not take much time and can provide a reasonable assessment of the overall water quality. Table 3-4 outlines the elements that should be considered in this assessment. Sum the total points for each section and use Table 3-5 to estimate the risk. Additionally, Appendix N, *Water System Certification Process* outlines steps for the Water System Certification Process as well as the bottled water plant inspection process. This can be used for a more comprehensive assessment.

Table 3-4: Qualitative Assessment of Water Quality

Rating Points	Water Source Description	Total Points
(5)	AF Controlled: Groundwater	
(3)	Host Nation Controlled: Groundwater	
(3)	AF Controlled: Surface water	
(1)	Host Nation Controlled: Surface water	
(4)	AF Controlled: Groundwater under the influence of surface water	
(2)	Host Nation Controlled: Groundwater under the influence of surface water	
(4)	Bottle Water: VETCOM approved source	
(3)	Bottle Water: Non-VETCOM approved	
	System Rating	
(8)	Loop System	
(2)	Branch: Self explanatory	
(5)	Backflow Protectors Installed	
	Cross-connection Rating	
(5)	Survey and corrective action plan in place	
(3)	Suspected cross-connections	
(0)	Known cross-connections	
(5)	System Pressure Maintained Above 25 psi	
	Treatment Plant	
(10)	Disinfection in the system	
(5)	Filtration process	
(5)	Disinfection process	
(5)	Cleanliness, organization, maintenance	
	FOR BOTTLE Water (only)	
(10)	Bottle water plant inspected by US in past year	
(5)	Bottles packaged in a sealed box or container	
(5)	Boxes transported in a sealed truck	
(5)	OSI tracked transport from plant to destination and found no significant problems	
(10)	Bottle caps seal properly (i.e. no leaking under pressure without breaking seal)	
(10)	Bottling plant treats the water with at least filtration process	
	Operations and Maintenance Rating	
(5)	Operators on duty 24/7	
(5)	Recurring work plan in-place	
(5)	BPD exercise plan	
(5)	Daily monitoring throughout system	
(5)	Shut off valves located throughout the system	
(5)	Records maintained that support O&M observations/interview	
	Monitoring Rating	
(10)	Monitors for bacti, Cl, pH or other indicators daily	
(5)	Monitors for bacti, Cl, pH or other indicators weekly	
(3)	Monitors for bacti, Cl, pH or other indicators monthly	
(3)	Analyzed for VOCs in past 5 years	
(3)	Analyzed for herbicides/pesticides in past 5 years	
(3)	Analyzed for metals in past 3 years	
(10)	Compliance with EPA, EU, or commensurate standards	
(20)	Compliance with EPA, EU, or commensurate standards (FOR BOTTLED water)	
(5)	Lab analysis conducted by an independent lab	

Table 3-5: Qualitative Assessment Matrix

Category	High Risk	Moderate Risk	Low Risk
Source water	<=2	3	4-5
System	<25	25-34	35-45
Bottled Water	<25	25-34	35-45
O&M	<15	15-24	25-30
Monitoring	<15	15-24	25-34

3.4.2. Quantitative Approach: The quality of water can further be assessed by taking measurements. The primary field instruments are the HACH 2400, presence/absence coliform water test (i.e. Colilert), and HAPSITE Headspace System. Radiation monitoring may be performed by filtering water through a filter paper and using an ADM-300 to detect alpha, beta, and gamma radiation. Water must meet different standards based on the end-use (potable vs. non-potable). In order to have confidence in the results there are several data quality objectives that must be satisfied. These have been pre-determined and are included in this guide as a quick reference. First, the number of samples to be taken is determined by the type of water system and the level of confidence needed in the assessment. Based on the equipment listed above, the correlation in table 3-6 has been calculated (number of samples vs. confidence). This table has been adapted from Table 1-5 for potable water operations.

Table 3-6: Required Number of Samples Based on Required Confidence

Confidence in Characterization (Consistency of water provided)	High	Moderate	Low	Very Low
Confidence result will yield correct decision	Batch system	Bottled water ROWPU ocean	Water from unreliable system	Water from very unreliable system
99%	5	25	59	350
95%	3	13	30	175
90%	2	8	18	106
80%	1	4	8	46
70%	1	2	3	18

For this type of assessment there are 3 categories of water systems: (1) bottled water, (2) batch water such as trucks, bladders, tanks, and (3) continuous flow such as drawing water direct from the tap for a specific use. It should be noted that a batch system is optimal for determining water quality since it is treated as being completely mixed where as a continuous flow system is more subject to fluctuations in quality thereby requiring more frequent monitoring.

If only one sample can be taken, use the following table to derive confidence in the result based on a comparison of the result to the standard, expressed as fraction of MCL in this table. This table has been adapted for water operations from Table 1-6.

Table: 3-7: Confidence Determination Based on One Sample

Confidence in Characterization (Consistency of water provided)	**High**	**Moderate**	**Low**
Confidence result will yield correct decision	Batch system	Bottled water ROWPU ocean	Water from unreliable system
	GSD=1.3	GSD=1.5	GSD=2.0
	Result as Fraction of MCL/MEG		
95%	.4	.25	.1
90%	.45	.3	.12
80%	.5	.35	.18
70%	.55	.4	.23

Use figure 3-2 to devise a comprehensive sampling strategy when time is of the essence. Based on how much time is available to complete the assessment, utilize the corresponding equipment set to prioritize the types of samples and analyses to be conducted. With more time, the sampling strategy will encompass more capability.

3.4.2.1. Potable water: To characterize the water, use Table 3-9 which lists key analytes, chemicals and their standards, and equipment used to detect each compound. A rough comparison of the results with the standards is sufficient for an initial assessment; however, further analysis using the DQO spreadsheet or the EPA Visual Sample Plan software (http://dqo.pnl.gov/vsp/) will help determine potential problem areas more definitively, as well as estimating a characterization rating. If the prescribed number of samples are analyzed and the results are below 50% of the MEG/MCL. Then, you can be confident that the true concentration is below the MEG/MCL according to the confidence table. In addition, equipment is color-coded based upon detection, identification, and detection limit capabilities for each analyte. Furthermore, analytes are color coded based on a summary of the detection equipment capabilities.

- Green denotes fully capable - i.e., the detector can detect, identify, and quantify to below the standard
- Yellow denotes some capability - i.e., the detector can detect or identify, but not necessarily at or below the standard
- Red denotes no capability - i.e., the detector can not detect the analyte.

Figure 3-2: Capability Enhancement as a Function of Decision Time

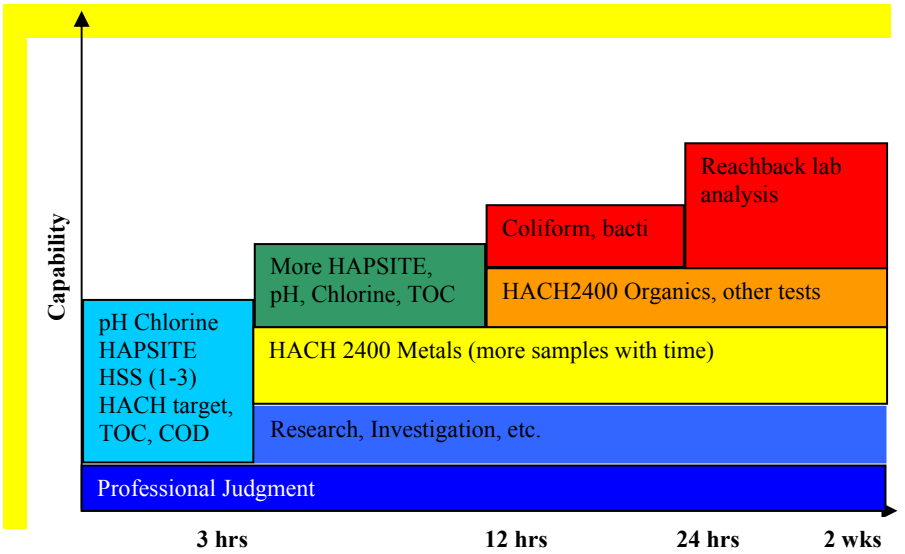


Table 3-8: Characterization of Water

Analytical Instrument/Method	Analytical Output	Approximate Analysis Time
Colilert (Presence/Absence)	Detects Coliforms, Fecal Coliforms, and E. Coli	24-48 hours
DPD Kit	Quantifies pH, Free Available Chlorine, Chloramines, and Total Chlorine	5 minutes (add 2 minutes per additional test)
HACH 2400	Metals, organic compounds, indicators (TOC, COD, TSS, etc)	10-40 min per analyte (test)
HAPSITE HSS	Hundreds of VOCs per sample	30 min per sample (plus heating time)
TVA-1000B	Semi-quantitative output for total VOCs using 2 methods	1 minute per sample
M272	Identifies and provides semi-quantitative output for Chemical Warfare Agents	15 min per agent
Hazcat Kit	Identifies presence of metals, organic, inorganic, and most family groups of compounds	15-30 minutes for group test and classification (requires multiple tests for unknowns)
Reachback lab analysis	Full-spectrum	1-3 days (plus shipping, holding, receiving time)
JBAIDS	Identifies select biological agents	4-6 hours
M1M	Identifies bio-threat agents (incl toxins)	
ADM-300	Quantifies alpha, beta, gamma radiation	15 min per radiation type

Table 3-9: Source Water Quality Guidelines and Equipment Capability

Chemical	EPA Stds-MCL mg/L	<7 Day Water MEGs (mg/L)		1-year Water MEGs (mg/L)		Hach 2400 (ppb)	HAPSITE [1]	PID (ppm 10.6 eV)	FID (ppm)	HazCat (ppm)
		5 L/day	15 L/day	5 L/day	15 L/day					Obvious Method*
Acenaphthylene		NA	NA	4.2	1.4					
Acenaphthene		NA	NA	8.4	2.8					FG [2]
Acetic Acid		NA	NA	NA	NA					FG
Acetone		NA	NA	14	4.7				10	400 ppm
Acifluorfen		2.8	0.9	NA	NA					
Acrolein		NA	NA	NA	NA					FG
Acrylamide		2	0.7	0.02	0.007					
Acrylic Acid		NA	NA	NA	NA					
Acrylonitrile		0.5	0.14	NA	NA					FG
Adipate (diethylhexyl)		28	28	NA	NA					
Alachlor	0.002	0.14	0.05	0.14	0.05					
Aldicarb		0.01	0.005	0.01	0.005					FG
Aldicarb Sulfone		0.01	0.005	0.01	0.005					FG
Aldicarb Sulfoxide		0.01	0.005	0.01	0.005					FG
Aldrin		4E-04	0.0001	4E-04	1E-04					FG
Allyl Alcohol		NA	NA	NA	NA					FG
Aluminum		NA	NA	28	9.3	2				
Ametryn		12	4	NA	NA					
Ammonia		30	30	4.2	1.4					FG
Ammonium Sulfamate		90	30	NA	NA					FG
Amyl Alcohol		NA	NA	NA	NA					FG
Anthracene					47					
Antimony	0.006				0.002					
Aroclor-1016		NA	NA	0.001	3E-04					
Aroclor-1221		NA	NA	3E-04	1E-04					
Aroclor-1232		NA	NA	3E-04	1E-04					
Aroclor-1242		NA	NA	3E-04	1E-04					
Aroclor-1248		NA	NA	3E-04	1E-04					
Aroclor-1254		NA	NA	3E-04	1E-04					
Aroclor-1260		NA	NA	3E-04	1E-04					
Arsenic *TB MED 577	0.01	0.3*	0.1*	0.004	0.001	20				8 ppm
Asbestos >10 micrometers	7	NA	NA	NA	NA					
Atrazine	0.003	0.7	0.23	0.49	0.16	3				
Barium	2	0.98	0.33	0.98	0.33	1				62-125
Baygon (Propoxur)		0.06	0.02	0.06	0.02					FG
Bentazon		0.4	0.1	0.4	0.1					
Benzene	0.005	0.3	0.1	0.04	0.01		0.6(1)		10	100-500
Benzo(a)anthracene		NA	NA	0.14	0.05					
Benzo(a)pyrene	0.0002	NA	NA	0.01	0.005					
Benzo(b)fluoranthene		NA	NA	0.14	0.05					
Benzo(k)fluoranthene		NA	NA	1.4	0.5					
Benzyl Chloride		NA	NA	NA	NA					
Beryllium	0.004	36	12	0.02	0.007					
Bis(2-ethylhexyl)-		14	4.7	0.28	0.06					
Bis(2-chloro-1-		5.6	2	NA	NA					FG
Boron		5.6	1.9	1.3	0.42	200				
Bromacil		7	2	NA	NA					
Bromate	0.01	NA	NA	0.06	0.02					
Bromine		NA	NA	NA	NA	50				
Bromobenzene		5.6	1.9	NA	NA		0.5(1)			
Bromochloromethane		1.4	0.5	0.14	0.05		1			FG
Bromodichloro-methane		8.4	2.8	0.3	0.1		0.5(1)			FG

Chemical	EPA Stds-MCL mg/L	<7 Day Water MEGs (mg/L)		1-year Water MEGs (mg/L)		Hach 2400 (ppb)	HAPSITE [1]	PID (ppm 10.6 eV)	FID (ppm)	HazCat (ppm)
		5 L/day	15 L/day	5 L/day	15 L/day					Obvious Method*
Bromoform		7	2	2.8	0.93		0.8(1)			
Bromomethane		0.2	0.07	0.04	0.01		1			FG
1,3-butadiene		NA	NA	NA	NA					
Butyl Acetate		NA	NA	NA	NA					FG
Butyl Acrylate		NA	NA	NA	NA					FG
n-Butyl Benzene		NA	NA	NA	NA		0.6(1)			
t-Butyl Benzene		NA	NA	NA	NA		0.8(1)			
Butylate		3	1	NA	NA					
Sec-Butylbenzene		NA	NA	0.15	0.05		0.3(1)			
Butylbenzylphthlate		NA	NA	28	9.3					
BZ 6581-06-2 *TB MED		0.007	0.002	NA	NA					
Cadmium	0.005	0.06	0.02	0.007	0.002	50				7 ppm
Calcium		NA	NA	500	170					
Carbaryl (Sevin)		1.4	0.5	1.4	0.47					FG
Carbofuran	0.04	0.07	0.02	0.07	0.02					FG
Carbon Disulfide		0.14	0.05	0.14	0.05				10	
Carbon Tetrachloride	0.005	5.6	2	0.1	0.03		0.001			FG
Carboxin		1.4	0.5	NA	NA					
Chloral Hydrate		1.4	0.5	NA	NA					
Chloramben		3.5	1.2	NA	NA					
Chloramine		NA	NA	NA	NA	40				FG
Chlordane (techgrade	0.002	NA	NA	0.007	0.003					FG
Chloride 16887-00-6 *TB		600	600*	600*	600*	100				
Chlorite	1	1.2	0.39	0.42	0.14					
Chlorobenzene	0.1	3	1	0.28	0.09		0.6(1)			
Chlorodibromo-methane		8.4	2.8	NA	NA		0.3(1)			FG
Chloroisopropyl Ether		5.6	5.6	NA	NA					FG
Choloroethane		NA	NA	NA	NA		0.5(1)	10.9	100	FG
Chloroform		6	2	1.4	0.5		0.6(1)			FG
Chloromethane [Methyl		12	4	0.5	0.17		0.001		10	FG
Chlorophenol (2-)		0.8	0.3	NA	NA					FG
Chlorothalonil		0.35	0.12	0.2	0.07					FG
Chlorotoluene (o-) (2-)		2.8	0.9	0.28	0.09					
Chlorotoluene (p-) (4-)		2.8	0.9	0.28	0.09					
Chlorpyrifos		0.04	0.01	NA	NA					FG
Chromium III		NA	NA	21	7					5 ppm
Chromium (total)	0.1	2	0.7	0.3	0.1	10				5 ppm
Chromium IV compounds		NA	NA	0.3	0.1					5 ppm
Chrysene		NA	NA	4.2	1.4					
Cobalt		NA	NA	NA	NA	10				
Copper	1.3	NA	NA	0.42	0.14	40				
Copper (II) (Salts, Oxide)	1.3	NA	NA	1	1	40				
m-Cresol		NA	NA	NA	NA					
Cumene		NA	NA	1.4	0.47					
Cyanazine		0.14	0.05	NA	NA					
Cyanide 57-12-5 *TB	0.2	6*	2*	0.28	0.09	1				80-160
Cyclohexane		NA	NA	NA	NA					
Dalapon	0.2	4.2	1.4	0.42	0.14					
DCPA [Dacthal]		105	35	NA	NA					
Detergent (Foaming		0.5(I)	0.5(I)	0.5(I)	0.5(I)					
DDD(p,p')		NA	NA	0.28	0.09					FG
DDE (p,p')		NA	NA	0.28	0.09					FG
DDT (p,p')		NA	NA	0.007	0.002					FG
Di-(2-ethylhexyl) Adipate	0.4	28	9.3	8.4	2.8					

Chemical	EPA Stds-MCL mg/L	<7 Day Water MEGs (mg/L)		1-year Water MEGs (mg/L)		Hach 2400 (ppb)	HAPSITE [1]	PID (ppm 10.6 eV)	FID (ppm)	HazCat (ppm)
		5 L/day	15 L/day	5 L/day	15 L/day					Obvious Method*
Diazinon		0.03	0.009	0.007	0.002					FG
Dibromochloromethane		8.4	2.8	1.1	0.37					FG
1,2-dibromoethane		NA	NA	NA	NA		0.7			
Dibromomethane		NA	NA	0.1	0.05		1			
Dibromo-3-chloropropane	0.0002	0.28	0.09	0.03	0.009		1.5			
Dibromoacetonitrile		2.8	0.94	NA	NA					FG
Dibromochloromethane		NA	NA	2.8	0.9		(1)			FG
Dicamba		0.4	0.14	0.4	0.14					
Dichloroacetic Acid		1.5	0.5	NA	NA					
Dichloroacetonitrile		1.4	0.5	NA	NA					FG
Dichlorobenzene (1,2-)	0.6	13	4.2	1.3	0.42					FG
Dichlorobenzene (1,3-)		13	4.2	1.3	0.42					FG
Dichlorobenzene (1,4-)	0.075	15	5	5.6	1.9					FG
Dichlorodifluoromethane		60	20	13	4.2		1.2			FG
1,1-Dichloroethane		NA	NA	NA	NA		0.5			FG
Dichloroethane (1,2-)	0.005	1	0.3	0.28	0.09		0.2			FG
Dichloroethylene (trans-	0.1	28	9.4	NA	NA		7			FG
Dichloroethylene (cis-1,2-)	0.07	5.6	2	NA	NA		0.5			FG
Dichloroethylene (1,1-)	0.007	2.8	1	0.13	0.04		0.7			FG
Dichloromethane	0.005	14	2.8	NA	NA		0.9			FG
Dichlorophenol (2,4-)		0.04	0.01	NA	NA					FG
2,4-D (Dichlorophenoxy	0.07	1.5	0.5	0.14	0.05					
2,4-DB		NA	NA	0.37	NA					
Dichloropropane (1,1-)		NA	NA	NA	NA		0.7			FG
Dichloropropane (1,2-)	0.005	1.4	0.47	0.98	0.33		3.9			FG
Dichloropropene (1,3-)		0.04	0.01	NA	NA					FG
Dichloropropane (1,3-)		NA	NA	NA	NA		0.4			FG
cis-1,3-Dichloropropane		NA	NA	NA	NA		0.6			FG
trans-1,2-Dichloroprane		NA	NA	NA	NA		0.7			FG
Dieldrin		7E-04	0.0002	7E-04	2E-04					
Diesel Exhaust Emissions		NA	NA	NA	NA					
Diethylphthalate		98	33	84	28					
Di-n-butylphthalate		NA	NA	14	5					
Di(2-ethylhexyl) adipate	0.4	NA	NA	NA	NA					
Di(2-ethylhexyl) phthalate	0.006	14	14	NA	NA					
Diisopropylmethyl-		30	10	NA	NA					
Dimethrin		17	5.5	NA	NA					
Dimethylformamide		NA	NA	NA	NA					
Dimethyl Methyl		2.5	2.5	NA	NA					
Dinitrobenzene (1,3-)		0.06	0.02	0.06	0.02					
Dinitrotoluene(2,4_)		0.6	0.2	NA	NA					
Dinitrotoluene (2,6-)		0.6	0.2	NA	NA					
Dinoseb	0.007	0.42	0.14	0.014	0.005					
Dioxane (1,4-)		5.6	2	NA	NA					FG
Dioxin (2,3,7,8-TCDD)	3E-08	NA	NA	NA	NA					
Diphenamid		0.4	0.13	NA	NA					
Diphenylamine		1.6	0.6	NA	NA					FG
Diquat	0.02	NA	NA	0.03	0.01					
Disulfoton		0.01	0.005	0.004	0.001					FG
Dithiane (1,4-)		0.5	0.2	NA	NA					
Diuron		1.4	0.5	NA	NA					
EA		0.015	0.005	NA	NA					
Endosulfan I		NA	NA	0.08	0.03					FG
Endosulfan II		NA	NA	0.08	0.03					FG

Chemical	EPA Stds-MCL mg/L	<7 Day Water MEGs (mg/L)		1-year Water MEGs (mg/L)		Hach 2400 (ppb)	HAPSITE [1]	PID (ppm 10.6 eV)	FID (ppm)	HazCat (ppm)
		5 L/day	15 L/day	5 L/day	15 L/day					Obvious Method*
Endosulfan Sulfate		NA	NA	0.08	0.03					FG
Endothall	0.1	1.1	0.4	0.28	0.09					
Endrin	0.002	0.04	0.01	0.006	0.002					
Endrin Aldehyde		0.04	0.01	0.006	0.002					FG
Epichlorohydrin	0.01%	0.2	0.07	0.03	0.01					
Ethyl Acetate		NA	NA	NA	NA					FG
Ethyl Acrylate		NA	NA	NA	NA					FG
Ethyl Benzene	0.7	45	15	1.4	0.5		0.5			
Ethyl Chloride		NA	NA	5.6	1.9					FG
Ethylene Dibromide	0.0000	0.01	0.004	0.001	4E-04					FG
Ethylene Glycol		26	9	NA	NA					FG
Ethylene Thiourea (ETU)		0.35	0.1	NA	NA					
Fenamiphos		0.01	0.004	0.007	0.002					FG
Fluometron		2.1	0.7	NA	NA					
Fluoranthene		NA	NA	5.6	1.9					
Fluorene		NA	NA	5.6	1.9					
Fluoride	4	NA	NA	5.6	1.9	20				
Fluorine (soluble fluoride)		NA	NA	1.7	0.56					
Fluorotrichloro-methane		9.8	9.8	NA	NA					
Fonofos		0.03	0.01	0.03	0.01					FG
Formaldehyde		14	5	NA	NA	3				FG
GA [Tabun] (nerve agent)		0.012	0.004	NA	NA				0.61	70 ppm
GB [Sarin] (nerve agent)		0.012	0.004	NA	NA				0.6	70 ppm
GD [Soman] (nerve agent)		0.012	0.004	NA	NA					70 ppm
GF [Cyclosarin] (nerve		0.012	0.004	NA	NA					70 ppm
Glyphosate	0.7	25	8	1.4	0.47					
Haloacetic Acids	0.06	NA	NA	NA	NA					
Heptachlor	0.0004	0.01	0.005	0.007	0.002					FG
Heptachlor Epoxide	0.0002	0.01	0.005	2E-04	6E-05					FG
Heptane		NA	NA	NA	NA					
Hexachlorobenzene	0.001	0.08	0.03	0.004	0.001					FG
Hexachlorobutadiene		0.4	0.14	0.003	9E-04		0.001			FG
Hexachlorocyclopentadien	0.05	NA	NA	1.4	0.47					FG
Hexachlorodibenzodioxan		NA	NA	NA	NA					FG
Hexachloroethane		7	2.4	NA	NA					FG
Hexane (n-)		18	5	NA	NA					
Hexazinone		11	3	NA	NA					FG
HMX		7	2.3	NA	NA					
Hydrazine		NA	NA	NA	NA	4				
Hydrogen Cyanide		See	See	See	See					
Iodine		NA	NA	NA	NA	70				
Iron		NA	NA	4.2	1.4	10				
Isophorone		6	2	NA	NA					FG
Isopropyl Alcohol		NA	NA	NA	NA					FG
Isopropylbenzene		15	5.1	1.4	0.47		0.6			
Isopropyl Methyl-		120	40	NA	NA					
p-Isopropyl Toluene		NA	NA	NA	NA		0.6			
Lead	0.015	NA	NA	0.015	0.015	5				31-62
Lewisite *TB MED 577		0.08*	0.027	NA	NA					70 ppm
Lindane [gamma-BHC]	0.0002	0.6	0.2	0.004	0.001					FG
Magnesium (TB MED Std		100	30	100	30	1 as				
Malathion		0.3	0.1	0.3	0.1					FG
Maleic Hydrazide		14	5	NA	NA					
Manganese		NA	NA	2	0.65	7				

Chemical	EPA Stds-MCL mg/L	<7 Day Water MEGs (mg/L)		1-year Water MEGs (mg/L)		Hach 2400 (ppb)	HAPSITE [1]	PID (ppm 10.6 eV)	FID (ppm)	HazCat (ppm)
		5 L/day	15 L/day	5 L/day	15 L/day					Obvious Method*
MCPA		0.14	0.05	0.007	0.002					
MCPP		NA	NA	0.14	0.05					
Mercury (inorganic)	0.002	0.003	0.001	0.002	7E-04	0.1				250-500
Mercury (Methyl)		NA	NA	0.004	0.001					250-500
Methomyl		0.42	0.14	0.35	0.12					FG
Methoxychlor	0.04	0.08	0.03	0.07	0.02					FG
Methyl Chloroform [1,1,1-		140	47	0.49	0.16					FG
Methyl Chloride		NA	NA	NA	NA		0.001			
Methyl Ethyl Ketone		NA	NA	8.4	2.8				10	FG
Methyl Isobutyl Ketone		NA	NA	NA	NA					FG
Methyl Parathion		0.4	0.15	0.04	0.01					FG
Methyl Tert-butyl Ether		34	11	NA	NA		0.001			
Methylene Chloride		14	4.7	0.84	0.28		0.9			
Metolachlor		3	1	NA	NA	1				
Metribuzin		6.3	2	NA	NA					
Merex		NA	NA	0.01	0.004					
Molybdenum (Trioxide)		0.07	0.02	0.07	0.02	20				
Naphthalene		0.74	0.25	0.5	0.17		0.5			
Nickel (elemental/metal)		1	0.5	0.28	0.09	7				
Nicotine		0.4	0.13	NA	NA					
Nitrate/Nitrate-N	10	35	0.13	NA	NA	1#				
Nitrite (measured as	1	NA	NA	NA	NA	2				
Nitroguanidine		15	5	NA	NA					
Nitrophenol p-		1.2	0.4	NA	NA					
Nonane		NA	NA	NA	NA					
Octane		NA	NA	NA	NA					
Oxamyl [Vydate]	0.2	0.35	0.1	0.35	0.1					FG
Paraquat		0.14	0.05	0.06	0.02					
Pentachlorophenol	0.001	1.4	0.5	0.01	0.005					FG
Phenanthrene		NA	NA	4.2	1.4					
Phenol		8	3	NA	NA	2				
Phosphate-P		NA	NA	2	0.7	1.5#				
Phosphorous		NA	NA	NA	NA	50 as				
Phosponates		NA	NA	NA	NA	20				
Picloram	0.5	28	9.4	0.98	0.33					
PCBs (54% Cl)	0.0005	NA	NA	NA	NA	1				
Prometon		0.2	0.07	NA	NA					
Pronamide		1	0.4	NA	NA					
Propachlor		0.7	0.24	NA	NA					
Propazine		1.4	0.5	NA	NA					
Propham		7	2	NA	NA					
n-Propylbenzene		NA	NA	0.15	0.05		0.8			
Pyrene		NA	NA	4.2	1.4					
RDX		0.14	0.05	NA	NA					
Selenium	0.05	NA	NA	0.07	0.02	10				
Silica (as SiO2)		NA	NA	NA	NA	3				
Silver		0.07	0.02	0.07	0.02	5				1000 ppm
Simazine	0.004	0.7	0.23	0.07	0.02					
Sodium		60	60	60	60					
Strontium		36	12	8.4	2.8					
Styrene	0.1	30	10	2.8	0.93		0.5			
Sulfate		300	100	300	100	2#				
Sulfur Mustard [HD]		0.14	0.047	NA	NA				4.2	
2,4,5-T		1.1	0.37	0.14	0.05					

Chemical	EPA Stds-MCL mg/L	<7 Day Water MEGs (mg/L)		1-year Water MEGs (mg/L)		Hach 2400 (ppb)	HAPSITE [1]	PID (ppm 10.6 eV)	FID (ppm)	HazCat (ppm)
		5 L/day	15 L/day	5 L/day	15 L/day					Obvious Method*
T-2 Toxin		0.026	0.008	NA	NA					
2,3,7,8-TCDD		1 ppt	0.5ppt	10ppq	5ppq					FG
Tebuthiuron		3.5	1	NA	NA					
Terbacil		0.35	0.1	NA	NA					
Terbufos		0.007	0.002	4E-04	1E-04					FG
Tetrachloroethane (1,1,1,2-		3	1	0.42	0.14		0.4			FG
Tetrachloroethane (1,1,2,2-		0.06	0.02	7E-04	2E-04		0.4			FG
Tetrachloroethene		NA	NA	NA	NA		0.7			FG
Tetrachloroethylene	0.005	2.8	0.9	1.4	0.47					FG
Tetraflouroethane		NA	NA	NA	NA					
Tetrahydrofuran		NA	NA	NA	NA					FG
Thallium	0.002	0.01	0.003	0.001	3E-04					
Toluene	1	30	10	3	1		0.6		10	100-500
Total Disolved Solids		1000	1000	1000	NA					
Toxaphene	0.003	0.07	0.023	0.014	0.005					FG
TP (2,4,5-) {Silvex]	0.05	0.3	0.09	0.11	0.04					
Trichloroacetic Acid		5.6	1.9	NA	NA					
Trichloroacetonitrile		0.07	0.02	NA	NA					FG
1,2,3-Trichlorobenzene		NA	NA	NA	NA		0.8			FG
Trichlorobenzene (1,2,4-)	0.07	0.2	0.06	0.14	0.05		0.9			FG
Trichlorobenzene (1,3,5-)		0.8	0.3	NA	NA					FG
Trichloroethane (1,1,1-)	0.2	140	60				0.7			FG
Trichloroethane (1,1,2-)	0.005	0.8	0.3	0.5	0.02		0.4			FG
Trichloroethene	0.005	2.8	0.9	0.1	0.03		0.7			FG
Trichlorofluoromethane		9.8	3.3	9.8	3.3					FG
Trichlorophenoxyacetic		1	0.4	NA	NA					FG
Trichloropropane (1,2,3-)		0.8	0.3	0.8	0.28		0.6			FG
Triethylamine		NA	NA	NA	NA					FG
Trifluralin		0.1	0.04	0.1	0.03					
Trihalomethanes (TTHM)	0.08	NA	NA	NA	NA					
Trimethylbenzene (1,3,5-)		14	4.7	0.7	0.23		0.6			
Trimethylbenzene (1,2,4-)		NA	NA	0.7	0.23		0.5			
Trinitroglycerol		0.007	0.002	NA	NA					
Trinitrotoluene (2,4,6-)		0.03	0.008	NA	NA					
Vanadium		NA	NA	0.1	0.03					
Vinyl Acetate		NA	NA	NA	NA					FG
Vinyl Chloride	0.002	3.6	1.2	0.04	0.01		0.5			
VX (nerve agent)		0.02	0.005	NA	NA					
Xylenes (mixed), o, m, p)	10	60	20	40	13		1.4		10	100-500
Xylene (m) (p)(o)		60	20	40	13		1.4		10	100-500
Zinc Chloride		8	3	N	N	10				
Alpha particle	15 Ci/L	NA	NA	NA	NA					ADM300
Beta particles/photon emit	4 mrems/ yr		NA	NA	NA					ADM300
Radium 226/228	5	NA	NA	NA	NA					ADM300
Uranium	30	NA	NA	NA	NA					ADM300
TPH		NA	NA	NA	NA	2# as				
Toxicity		NA	NA	NA	NA	Inhibi				
Volatile acids		NA	NA	NA	NA	27#				
Tannin and Lignin		NA	NA	NA	NA	0.1#				
Surfactants (as LAS)		NA	NA	NA	NA	2#				
Quarternary Ammonia		NA	NA	NA	NA	0.2#				
Dissolved Oxygen		NA	NA	NA	NA					
COD		NA	NA	NA	NA	3#				
TOC		NA	NA	NA	NA	0.3#				

1. HAPSITE Tribed method (ug/l), HSS or air method (ppb)
2. FG: Family group – Hazcat can identify a family group such as chlorinated solvents or PCBs, but not the specific chemical.
#: designates mg/L; 1 mg/L = 1 ppm; 1μg/L = 1 ppb
* Obvious Method: The Hazcat kit relies on the user's ability to visually detect color changes and observe reactions. This capability assessment is based on the "obvious method" detection limit as noted by the manufacture since this is based on an average user. For personnel with advanced, wet chemistry lab experience, the detection limit for these analyses may be lower.

3.4.2.2. Non-potable water: A different table is used to characterize non-potable water since different standards are used for contact hazards than ingestion. Table 3-10 lists standards for bathing, washing, contact, etc. Again, sample results should be compared to these standards and entered into the DQO software to determine the characterization rating.

3.4.2.2.1. Bathing and Swimming. The Medical Group or EMEDS Commander shall approve all areas proposed for natural bathing and swimming facilities. The decision should be based on the following considerations:

- Site Location. Ensure the bathing areas are free of the effects of point and non-point pollution sources. Sources of potentially dangerous contamination include waste discharges from communities, industries, marine craft, local animal populations, and water fowl. The water must meet the source water quality standards outlined in Table 3-11.
- Type of Bottom. These areas should have bottoms which slope gently and uniformly toward deep water; have no holes or sudden step-offs; be free of hidden or submerged obstructions such as rocks, stumps, snags, and sunken logs; be composed of firm sand, small-sized gravel, or shale; have no silt, quicksand, shell patches, sharp and broken rock, or debris in depths of 5 ft (1.5 m) or less.
- Physical Water Quality. Consider the depth and turbidity of the water, presence of currents, rip tides, and dangerous marine or aquatic life.
- Natural bodies of water located in areas where schistosomiasis (bilharziasis), leptospirosis, or primary amoebic meningoencephalitis are endemic shall not be approved for recreational purposes without the concurrence of the public health or preventive medicine officer. Special consideration must be given to the prevalence of the disease in the immediate locale and to the presence of disease-causative agents in the body of water.

3.4.2.2.2. Water Quality. : Natural bathing areas present significantly more risks in terms of pathogenic organisms because the water is not chemically treated. Table 3-10 shows diseases of concern related to natural recreational waters. Fecal Coliform (FC) will be used as the indicator organism for evaluating the microbiological suitability of the water. Compare results of at least five samples taken over fewer than 30 days. The FC content should not exceed a log mean of 200/100 ml, nor should more than 10 percent of the total samples during any 30-day period exceed 400/100 ml.

3.4.2.2.3. Measurement. BE shall periodically take bacteriological samples for fecal coliform prior to season opening and for FC or other common pathogens based upon past

history at the natural swimming area. If a local health department, host nation, or other service routinely collects water quality samples, BE shall work with these agencies to share data to avoid duplication of sampling. BE shall collect samples and have them analyzed for the contaminants listed in Table 3-9 during the pre-season inspection. Periodically throughout the swimming season, BE should sample specifically for any contaminant with the potential to exceed acceptable limits based upon environmental conditions. These guidelines should assist in approving a site for use.

Table 3-10 - Diseases of Concern Associated With Natural Bathing Areas

DISEASE	Sources	Characteristics	Symptoms
Leptospirosis	Leptospira interrogan; water contaminated with urine from infected animals such as rats, swine, and cattle	Generally found in fresh water	Fever, chills, and headache
Giardiasis	Giardia Lamblia; in the intestinal tracts of mammals such as beavers and foxes living near bathing areas	Gastrointestinal illness; generally found in fresh water	Diarrhea, cramps
Shistosome dermatitis, known as "swimmers itch" or "water rash"	Larvae of certain trematode worms of birds and mammals penetrate the skin	Common to freshwater lakes in the north central U.S.; can be prevented by limiting exposure to water to less than 30 minutes, followed by vigorous towel drying between fingers and toes	Dermatitis characterized by skin eruptions
Primary amoebic meningoencephalitis (PAM)	Naegleria fowleri; a free-swimming amoeba associated with warm natural bodies of water	Common to southern U.S.; a parasitic disease untreatable with antiparasitic agents, antibiotics, and antimetabolites	Severe headache, fever, death
Schistosomiasis, also known as bilharziasis	Schistosoma mansoni (blood flukes); snails act as intermediate hosts for the cercariae, a larval form of the fluke; also found in parasite-infected drinking water, and other Schistosoma species	Serious public health disease found in fresh or mildly brackish water of tropical and semi-tropical areas such as Puerto Rico, the Philippines, the Middle East, Asia, and Africa (not found in marine environment)	Diarrhea, abdominal pain; liver and urinary disorders
Cryptosporidiosis	Cryptosporidium; a pathogenic intestinal protozoa found in man and animals that forms resistant oocysts; water contaminated through direct deposit of human and animal feces into receiving waters	Oocysts associated with turbid waters; ingestion causes gastrointestinal illness	Diarrhea

Table 3-11 Water Quality Standards for Swimming Pools.

Testing By Bathing Facility Manager				
Parameter	**Frequency**	**Min**	**Max**	**Comments**
pH	Every 2 Hours During Operation	7.2	7.8	
Free Chlorine Residual	Every 2 Hours During Operation	Table 1-15	2.0 ppm	Min depends on pH
Combined Chlorine	Every 2 Hours During Operation	None	0.2 ppm	
Cyanuric Acid	Biweekly	30 ppm	100 ppm	Used to stabilize free
Bromine	Daily	2.0 ppm	4.0 ppm	
Iodine	Daily	0.5 ppm	1.2 ppm	Not for outdoor pools
Temperature	Daily	none	82 ^{O}F	
Total Alkalinity	Weekly	60 ppm	180 ppm	
Testing By Civil Engineering Personnel				
Calcium Hardness	Monthly	None	500 ppm	
Total Dissolved Solids	Bimonthly	None	3000 ppm	
Turbidity	When Water is Cloudy	6" black disk must be visible on Bottom of deepest part of pool		

3.4.2.2.4. Inspections. Representatives from SV, BE, PH, and SEG shall conduct a pre-season survey of natural bathing areas. PH shall periodically conduct a general inspection of the area and operations, as necessary, to ensure safe and sanitary conditions are being maintained. The following elements are provided as minimum inspection criteria. A negative response to any question indicates the need for corrective action. Examine for potential sources of pollution such as agricultural drainage or waste water discharges.

- Evaluate the bacteriological and chemical effects of such discharges on the bathing area.
- Water depth and bottom slope safe?
- Free of dangerous reptiles, submerged objects, drop-offs, or other physical endangerments?
- General cleanliness satisfactory for safety?
- Proper first aid safety equipment present?
- Safety guidelines prominently displayed and being followed and enforced by lifeguards?

3.4.2.3. Other non-potable uses: Below is a list of considerations for each application.

- Firefighting:
  - No significant amount of flammable or other chemicals are present in water which may result in combustion by-products
  - Water cleanliness; solids may damage firefighting equipment over time
- Decontamination:
  - Water quality is consistent with bathing standards
  - Contaminants will not interfere with, clog, or disable decontamination equipment such as pumps, nozzles, hoses, heater, etc.
- Cooking/Food Preparation:
  - Water quality should be consistent with potable standards
  - Increasing FAC to 5-10 ppm for food preparation applications where water is not boiled; Increase FAC to 50-100 ppm for washing food preparation surfaces
- Showering Facilities:
  - Primary exposure route is contact with skin sensitizers (includes chemical and biological hazards)
  - Secondary exposure route is inhalation from chemicals volatilizing in a relatively confined space (i.e., HCN)
  - Water may also be used for shaving, teeth brushing, etc. This can lead to other exposure routes. FAC should be in the 1-2 range. Higher amounts may cause dermatitis or other adverse reactions. Biological hazards could enter the skin through cuts while shaving.
- Latrines:
  - Water is used to enhance the flow of human wastes
  - There are no water standards, but consider all of the uses for the water (i.e., will same water be used to clean the latrines, floors, etc.)
- Dust control:
  - Consider quantity of water available for this activity
  - Secondary release mechanism if volatile chemicals are present

Table 3-12 - Water Quality Standards for Non-consumptive Uses

Water Quality	Typical Uses
Disinfected non-potable fresh water	Decontamination of personnel
	Retrograde cargo washing
	Heat casualty body cooling
	Graves registration sanitation
	Well development
Non-potable fresh water	Vehicle coolant
	Aircraft washing
	Pest control
	Field laundry
	Concrete construction
	Well drilling
Sea water	Vehicle washing (may lead to corrosion)
	Electrical grounding
	Fire fighting
	NBC decontamination of material/equipment

For each water source/system, determine a quality risk rating using the matrix below which accounts for confidence in assessment (based on number of samples collected and variability in results) and characterization of hazard. Severity rating can be established by dividing the result for each analyte by the MEG; an overall average and highest severity rating should be used to determine the water quality risk rating. Use Table 3-13 to determine the overall water quality risk rating for the source.

Table: 3-13: Water Quality Risk Rating

Confidence	**Severity Rating <0.4 (Low)**	**Severity Rating 0.4 – 0.8 (Moderate)**	**Severity Rating >0.8 (High)**
0.80-0.99 – High	Low	Moderate	High
0.70-0.80 – Moderate	Low	Moderate	High
0.50-0.70 – Low	Moderate	High	Very High

3.5. Summary of Four Factors: After determining the risks associated with each factor (quantity, quality, threat, and vulnerability), compare with the risk ratings from other alternatives, including the risks associated with not drinking water (i.e., heat stress and dehydration). The water quality results and standards as determined from analyses and confidence in the characterization should be used to determine a go/no-go recommendation. This provides a recommendation based on a data quality objective process. The other factors are not as objective. However, information pertaining to threats and vulnerabilities should be provided to further stratify the recommendations.

	Risk Rating			
Factors	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Quantity				
Threat				
Vulnerability				
Quality - Qual Assess - Quant Assess				

3.6. Maintaining Safe Water

3.6.1. Quality Standards. While TG230 MEGs are used for the HRA, other water quality standards for potable water may apply based on the type of operating environment. These vary depending on force structure and duration of use. The DoD Tri-Service standards for field water quality are shown in Table 3-14 and 3-15. As a member nation of both NATO and the Quadripartite Armies (American, British, Canadian, Australian), the United States has agreed to accept and provide water meeting the standards of NATO STANAG 2136 and QSTAG 245 for short-term (1 - 7 days) and long-term (greater than 7 days) use. Table 3-14 shows the minimum acceptable potable water standards for short-term consumption. Table 3-15 shows the minimum acceptable potable water standards for long-term consumption. Table 3-16 shows U.S. drinking water standards that should be adopted as a goal for potable water in the field whenever possible.

Table 3-14: Short-term Potable Water Standards

	U.S. Tri-Service		QSTAG 245	STANAG 2136
CONSUMPTION RATE	**5L/Day**	**15 L/Day**	**5 L/Day**	**5 L/Day**
Physical Properties				
Color (Color Unit)	50	50	NA	50
Odor (Threshold Number)	3	3	NA	3
pH	5 - 9	5 - 9	5 - 9.2	5 - 9
Temperature (^{O}C)	4 - 35	4 - 35	4 - 35	4 - 35
TDS (mg/L)	1000	1000	1500	1000
Turbidity (NTU)	1	5	1	NA
Chemical Properties				
Arsenic (mg/L)	0.3	0.1	2	0.3
Cyanide (mg/L)	6	2	20	6
Chloride (mg/L)	600	600	NA	600
Lindane (mg/L)	0.6	0.2	NA	NA
Magnesium (mg/L)	100	30	NA	100
Sulfate (mg/L)	300	100	NA	300
Microbiological				
Coliform (#/100 mL)	1	1	1	1
Virus (#/100 mL)	NA	NA	1	1
Spores/Cyst (#/100 mL)	NA	NA	1	1
Chemical Agents				
Hydrogen Cyanide (ug/L)	6	2	NA	NA
BZ (Incapacitants) (ug/L)	7	2.3	NA	NA
Lewisite (arsenic fraction) (ug/L)	80	27	NA	NA
Sulfur Mustard (ug/L)	140	47	200	200
Nerve Agents (ug/L)	NA	NA	NA	2200
VX	15	5	NA	NA
GD	12	4	NA	NA
GB	28	9.3	NA	NA
GA	140	46	NA	NA
T-2 Toxins (ug/L)	26	8.7	NA	NA
Radiological				
Radiological	8 uCi/L	3 uCi/L	NA	NA

Table 3-15: Long-term Potable Water Standards

	U.S. Tri-Service		QSTAG 245	STANAG 2136
CONSUMPTION RATE	5L/Day	15 L/Day	5 L/Day	5 L/Day
Physical Properties				
Color (Color Unit)	15	15	15	15
Odor (Threshold Number)	3	3	NA	3
pH	5 - 9	5 - 9	5 - 9.2	5 - 9
Temperature (^{O}C)	15 - 22	15 - 22	15 - 22	15 - 22
TDS (mg/L)	1000	1000	1500	1000
Turbidity (NTU)1	1	1	1	1
Chemical Properties				
Arsenic (mg/L)	0.06	0.02	0.05	0.06
Cyanide (mg/L)	6	2	0.5	6
Chloride (mg/L)	600	600	600	600
Lindane (mg/L)	0.6	0.2	NA	NA
Magnesium (mg/L)	100	30	150	100
Sulfate (mg/L)	300	100	400	300
Microbiological				
Coliform (#/100 Ml)	1	1	1	1
Virus (#/100 Ml)	NA	NA	1	1
Spores/Cyst (#/100 Ml)	NA	NA	1	1
Chemical Agents				
Hydrogen Cyanide (ug/l)	6	2	NA	NA
Mustard (ug/l)	NA	NA	50	50
Nerve Agents (ug/l)	NA	NA	5	5
Radiological				
Radiological	0.1 uCi/L	0.05 uCi/L	0.06 uCi/L	2.2 Bq/mL

Table 3-16 - EPA Public Drinking Water Standards

Parameter	MCL	MCLG	units	Parameter	MCL	MCLG	units
Organics				Inorganics			
Benzene	0.005	0	mg/L	Arsenic	0.01	0	mg/L
Carbon tetrachloride	0.005	0	mg/L	Fluoride	4	4	mg/L
o-Dichlorobenzene	0.6	0.6	mg/L	Asbestos	7	7	mfl
para-Dichloroethane	0.075	0.075	mg/L	Barium	2	2	mg/L
1,2-Dichloroethane	0.005	0	mg/L	Cadmium	0.005	0.005	mg/L
cis-1,2-Dichloroethylene	0.07	0.07	mg/L	Chromium	0.1	0.1	mg/L
trans-1,2-Dichloroethylene	0.1	0.1	mg/L	Mercury	0.002	2	mg/L
1,1-Dichloroethylene	0.007	0.007	mg/L	Nitrate (as N)	10	10	mg/L
Dichloromethane	0.005	0	mg/L	Nitrite (as N)	1	1	mg/L
1,2-Dichloropropane	0.005	0	mg/L	Selenium	0.05	0.05	mg/L
Ethylbenzene	0.7	0.7	mg/L	Antimony	0.006	0.006	mg/L
Monochlorobenzene	0.1	0.1	mg/L	Beryllium	0.004	0.004	mg/L
Styrene	0.1	0.1	mg/L	Cyanide	0.2	0.2	mg/L
Tetrachloroethylene	0.005	0	mg/L	Nickel	0.1	0.1	mg/L
Toluene	1	1	mg/L	Thallium	0.002	0.0005	mg/L
1,2,4-Trichlorobenzene	0.07	0.07	mg/L	Lead	0.015	0	mg/L
1,1,1-Trichloroethane	0.2	0.2	mg/L	Copper	1.3	1.3	mg/L
1,1,2-Trichloroethane	0.005	0.003	mg/L	Radionuclides			
Trichloroethylene	0.005	0	mg/L	Gross alpha activity	15	0	pCi/L
Vinyl chloride	0.002	0	mg/L	Combined Radium 226/228	5	0	pCi/L
Xylenes (total)	10	10	mg/L	Beta activity, mrem	4		mrem
Benzo(a)pyrene	0.0002	0	mg/L	Strontium 90	8		pCi/L
Di(2-ethylhexyl)adipate	0.4	0.4	mg/L	Tritium	20000		pCi/L
Di(2-ethylhexl)phthalate	0.006	0	mg/L	Uranium	30	0	ug/L
Hexachlorobenzene	0.001	0	mg/L	Secondary Standards			
Hexachlorocyclopentadiene	0.05	0.05	mg/L	Aluminum	.05-.2		mg/L
2.3.7.8-TCDD (Dioxin)	3E(-8)	0	mg/L	Chloride	250		mg/L
Alachlor	0.002	0	mg/L	Color	15		C.U.
Atrazine	0.003	0.003	mg/L	Copper	1		mg/L
Carbofuran	0.04	0.04	mg/L	Corrosivity	>0		LSI
Chlordane	0.002	0	mg/L	Fluoride	2		mg/L
2,4-D	0.07	0.07	mg/L	Foaming Agents	0.5		mg/L
Dalapon	0.2	0.2	mg/L	Iron	0.3		mg/L
DBCP	0.0002	0	mg/L	Manganese	0.05		mg/L
Dinoseb	0.007	0.007	mg/L	Odor	3		TON
Diquat	0.02	0.02	mg/L	pH	6.5-8		
Endothall	0.1	0.1	mg/L	Silver	0.1		mg/L
Endrin	0.002	0.002	mg/L	Sulfate	250		mg/L
Ethylene dibromide (EDB)	0.00005	0	mg/L	Total dissolved solids	500		mg/L
Glyphosate	0.7	0.7	mg/L	Zinc	5		mg/L
Heptachlor epoxide	0.0002	0	mg/L	Disinfection/Byproducts			
Heptachlor	0.0004	0	mg/L	Bromate	0.01	0	mg/L
Lindane	0.0002	0.0002	mg/L	Chloramines (as Cl2)	4.0	4	MRDL
Methoxychlor	0.04	0.04	mg/L	Chlorine (as Cl2)	0.8	0.8	MRDL
Oxamyl (Vydate)	0.2	0.2	mg/L	Chlorite	1	0.8	mg/L
PCBs	0.0005	0	mg/L	Haloacetic acids	0.06	n/a	mg/L
Pentachlorophenol	0.001	0	mg/L	Total trihalomethanes	0.08		mg/L
Picloram	0.5	0.5	mg/L	Biological			
Simazine	0.004	0.004	mg/L	Cryptosporidium		0	mg/L
2,4,5-TP (Silvex)	0.05	0.05	mg/L	*Giardia lamblia*		0	mg/L
Toxaphene	0.003	0	mg/L	Total Coliforms (including fecal coliform and *E. coli*)	5.00%	0	mg/L
Acrylamide	8	0	mg/L	Viruses (enteric)		0	mg/L
Epichlorohydrin		0	mg/L	*Legionella*		0	mg/L

Notes:
MCL-Maximum Contaminant Level; MCLG-Maximum Contaminant Level goal

MRDLG -Maximum Residual Disinfectant Level Goal; MRDL -Maximum Residual Disinfectant Level (MRDL)

Cryptosporidium (as of 1/1/02 for systems serving >10,000 and 1/14/05 for systems serving <10,000) 99% removal; *Giardia lamblia*: 99.9% removal/inactivation; Viruses: 99.99% removal/inactivation

Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, for systems servicing >10,000, and January 14, 2005, for systems servicing <10,000, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.

HPC: No more than 500 bacterial colonies per milliliter

No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli* if two consecutive TC-positive samples, and one is also positive for *E. coli* fecal coliforms, system has an acute MCL violation.

Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps to reduce levels. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

National Secondary Drinking Water Standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards. These are shown in Table 3-17.

Table 3-17: National Secondary Drinking Water Standards

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	Non-corrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

3.6.2. Water Sources. Water may be obtained from a variety of sources in the field such as rivers, streams, ponds, lakes, wells, ice, snow, etc. However, all water sources should be considered unsafe until tested and approved for use. Use Table 3-18 below to determine the

hierarchy for source water. Perform this exercise even at established installations. Table 3-19 shows the acceptable use for various water sources.

Table 3-18: Water Source Alternatives

SOURCE	PROs	CONs
Surface water	1. Easy to determine quantity 2. Easy to extract 3. Lower start up cost 4. Probability of complete contamination due to sabotage is low (entire source may not be contaminated with a single attack, based on source, size, and configuration) 5. Can vary the area of extraction with mobile pumping trucks/tanks	1. Quality expected to be low 2. Easily affected by weather conditions (droughts, floods, etc.) 3. Easily contaminated by natural events 4. Easily contaminated by enemy 5. Higher maintenance cost (fencing, security personnel, etc) 6. Increase security personnel draws more attention and more interaction with locals (Increased force protection risk) 6. Probability of sabotage attempt is greater 7. More identifiable by enemy leading enhancing troop location pinpointing 8.Routine analysis is more extensive 9. More costly to treat 10.Weather and tide etc. can effect location and ease of extraction
Ground water	1. Quality expected to be high 2. Difficult to extract (requires wells, submersible pumps) 3. Lower maintenance cost 4. Less costly to secure 5. Harder for enemy to identify/pinpoint troop location 6. Monitoring is less extensive 7. Not effected by weather 8. Probability of sabotage attempt is less	1. Difficult to determine quantity 2. Expensive to withdraw 3. Higher startup cost 4. Higher degree of contamination IF sabotage is successful 5. Significant start up cost
Municipal water	1. Highly regulated in U.S. locations 2. Complete sabotage/contamination is difficult 3. Zero start up cost 4. Good water quality data available from approved local bottling companies (Coke, Sprite etc.)	1. Extreme gamble in deployed locations 2. Could be secretly contaminated by enemy 3. Requires advance recon and clearance to meet with local health agencies and municipality officials to conduct compliance inspections 4. Requires continued oversight of local agency analytical monitoring results and/or supplemental monitoring by BEE 5. Conflicting Intel – Example: Some local entities will give misleading Intel to downgrade local municipality water quality in hopes of selling bottle water.
Bottled water	1. Easy to determine quantity 2. Highly transportable 3. Preferred by military members 4. Easier to assess/monitor troop water consumption rate	1. Quality must be determined 2. Requires protected storage space 3. Requires Vet Com approval 4. Counter fitting 5. False sense of security by troops (All bottled water is safe mentality)

Table 3–19: Acceptable uses for Different Quality Water
(adapted from TB MED 577)

Water quality	Acceptable activities
Potable water	a. Drinking water b. Dining facility operations such as food washing c. Brushing teeth d. Medical treatment e. Ice production for food preservation and cooling f. Water hose and pipeline testing and flushing g. Photo-processing (for quality control, not health reasons—separate standards apply)
Disinfected fresh water (non-potable)	a. Centralized hygiene such as field showers b. Decontamination of personnel c. Retrograde cargo washing d. Heat casualty body cooling e. Graves registration personnel sanitation f. Well development
Fresh water (non-potable)	a. Vehicle coolant b. Aircraft washing c. Pest control d. Field laundry e. Concrete construction f. Well drilling
Brackish and Seawater	a. Vehicle washing b. Electrical grounding c. Fire fighting d. Chemical, biological, radiological, nuclear, and explosives (CBRNE) decontamination of material

Note: Brackish and seawater are minimally acceptable and may lead to significant corrosion if used; therefore, fresh water should be used if at all possible. It is acceptable to use water of higher quality for activities requiring lower quality water but not vice versa.

3.6.3. Public Water Systems. Existing public water systems are the easiest and, in most cases, the safest sources because this water has been treated to some extent. However, this does not preclude the requirement to test the quality of the water. All water from public water systems will be considered unsafe until tested and approved.

3.6.4. Surface Water. Surface waters such as lakes, rivers, streams, and ponds are usually more accessible than other sources and capable of supplying adequate quantities of water. However, this does not preclude the requirement to test the quality of the water. All water from surface sources will be considered unsafe until tested and approved. Water intakes must be placed as far from the bank as possible to minimize the effects of contamination sources along the edge of the water. Also, to avoid picking up mud and other debris, intakes must not be positioned at the surface or bottom of the source.

3.6.5. Ground Water. Ground water such as wells and springs is usually less susceptible to contamination than surface water. However, it is sometimes difficult to determine the adequacy of supplies. All water from ground sources will be considered unsafe until tested and approved. Ground water sources must be at least 100 yards from potential sources of contamination such as latrines, septic tanks, industrial run off, etc.

3.6.6. Source Water Testing. Regardless of the source, water quality tests must be performed to determine if the water is potable or can be made potable by purification. Under ideal situations, water samples should be analyzed by the nearest supporting lab shown in Appendix J. If supporting labs cannot be used, Bioenvironmental Engineering personnel must test the source water for the properties listed in the Table 3-9. Using one or more of the water test kits shown, BE personnel must contact supporting labs and coordinate requirements prior to shipping any samples.

3.6.7. Approved Water Sources: A list of approved water sources is available at the Army Veterinary Command website (http://vets.amedd.army.mil/vetcom/). Food and water sources are listed together on the website. To view CENTCOM locations registration is required. Registration approval and notification takes at least 14 days; therefore, register as soon as possible and especially before deployment.

3.6.8. Water Treatment: Table 3-20 shows the pros and cons of several treatment options. The Reverse Osmosis Water Purification Unit (ROWPU) treats water with physical and chemical processes effective in removing most microbiological organisms, inorganic chemicals, many organic chemicals, and radioisotopes. Its effectiveness in removing viruses has not been documented. It is not effective in removing cyanide and low molecular weight organic compounds such as aldehydes, alcohols, and some solvents. The ROWPU's filters, called reverse osmosis or RO elements, are critical to desalinization and purification of water. These filters have a lifecycle of 1,000 to 2,000 operational hours. Conceivably, a ROWPU will not operate continuously or indefinitely on one set of filters. The duration of the mission will dictate down time for the ROWPU and you should always have a back-up or second ROWPU unit installed. Additionally, potable water must be disinfected to remove disease-producing organisms. Chlorine is the disinfectant agent specified for military use throughout the Tactical Water Distribution System (TWDS). It is the only widely accepted agent that destroys organisms in water and leaves an easily detectable residual that serves as a tracer element. Disappearance of chlorine in potable water signals potential contamination in the system. Figure 3-C depicts potable water disinfection requirements throughout the TWDS. Sodium hypochlorite and calcium hypochlorite are the two chemicals used by the military to chlorinate water. Tables 3-21 and 3-22 provide estimated dosage quantities for both chemicals. The reverse osmosis portion of the ROWPU shall not be bypassed for any reason. A 5 ppm FAC dose should be applied to unfiltered water for 30 minutes, while a 2 ppm FAC dose should be applied to filtered water for 30 minutes.

3.6.8.1. Disinfection of Water Distribution System (WDS). Free-available chlorine (FAC) will be maintained at 2 ppm throughout the TWDS. The correct contact time prior to testing is 30 minutes at all points throughout the system. *Source: AFH 10-222v2(1996)*

3.6.9. Disinfection: Disinfection can be performed in many ways. Chlorination, Chloramines, and Ozonation are the primary forms of disinfection. Inactivation contact times are shown in table 3-21.

3.6.9.1. Chlorination -- This is the process of adding chlorine to water. Carefully balance the amount of chlorine to ensure there is only a residual amount of free available chlorine or FAC in the water once the bacteria have been destroyed. Too much FAC in the water (6 PPM or higher) can cause intestinal stress. Excess FAC also reacts with organic material in the water to form Disinfection Byproducts (DBPs), primarily Trihalomathanes (THMs), the most popular one being Chloroform. Water purified by means other than ROWPU or DE filtration will be disinfected by adding chlorine at the production site to maintain a 5 mg/L FAC after a 30-minute contact time. At the unit level, FAC will be maintained at 1 ppm in unit-level containers (400 gal trailers, lyster bags, collapsible pillow tanks, and 55 gal and 250 gal drums).

3.6.9.2. Chloramines -- These are created by the chemical reaction of ammonia and sodium hypochlorite under alkaline conditions to eliminate the presence of DBPs. Chloramines are much more stable and persist much longer in the water system. Water treated with chloramines lacks the distinct chlorine odor created by chlorination.

3.6.9.3. Ozonation -- Ozonation uses a four-step process. First, gas (air or oxygen) is cleaned, filtered, and dried. Then the dried gas is passed through electrodes to form ozone. When the ozone is injected into the water, the bubbles cause particles to coagulate. After bubbling, ozone off-gas is destroyed and the water flow is routed through filters to collect the particles. Ozonation is a clean and efficient alternative to chlorine-based water treatment. It is a powerful way to eradicate even the worst bacteria and viruses. However, ozonation does not leave residual disinfectant as with chlorine.

3.6.9.4. Emergency Disinfection. When away from supply lines and treated water is not available, individual service members must select the clearest, cleanest water with the least odor and treat the water using individual water purification means. These include:

- Iodine. Iodine tablets come in bottles of 50 tablets (NSN 6850-00-985-7166). The correct treatment is two tablets per quart of water. The treated water should be allowed to sit for 35 minutes before drinking.
- Boiling. To effectively kill most disease-producing organisms, water must be held at a rolling boil for 1 to 2 minutes. When cooled, it should be kept in a covered or capped uncontaminated container.
- Chlor-Floc. Chlor-Floc is an emergency disinfectant that also removes suspended particles from cloudy or discolored water. Individuals should follow the instructions printed on the Chlor-Floc kit.

3.6.10. Filtration: Slow sand filtration is a simple and reliable process and these filters provide excellent treated water quality. The process percolates untreated water slowly through a bed of porous sand, with the influent water introduced over the surface of the filter, and then drained from the bottom. Slow sand filters are less effective at removing microorganisms from cold water because as temperatures decrease, the biological activity within the filter bed declines.

3.6.10.1. Disinfection of Diatominaceous Earth (DE) Filtered Water. The FAC for DE filtered water depends on the temperature of the water. For water temperatures of less than

15 ^{O}C, DE filtered water will be disinfected by adding chlorine at the production site to maintain a 5 mg/L FAC after a 30-minute contact time. For water temperatures greater than 15 ^{O}C, DE filtered water will be disinfected by adding chlorine at the production site to maintain a 2 mg/L FAC after a 30-minute contact time.

Table 3-20: Advantages and Disadvantages of Treatment Processes

Process	Advantages	Disadvantages
Reverse Osmosis (ROWPU)	Various sizes Serve 1000's Can be re-located quickly Superb at removing salt Removes minerals, most heavy metals	Expensive Inefficient; wastes 3 gallons for every gallon of water produced Filters must be replaced every other month Must have two units on-line Cannot remove chlorine, other synthetic chemicals
Chlorination	Easy to apply Easy to measure amount in water as FAC Controls disease-causing organisms Controls nuisance organisms like iron bacteria	Readily produces disinfection byproducts (DBPs) Causes bad smell Causes bad taste
Chloramines	Remains active in the water for a longer time than Chlorine (days versus hours) Increases taste and smell of water; much easier to drink Does not produce DBPs	Not as effective as Chlorine in killing bacteria. Must be removed from the water once effectiveness is lost May cause corrosion; requires addition of orthophosphates
Ozonation	Non-toxic. Improves worker safety. Versatile. Treats wide range of temperatures and pH values Produces no odor or color. Highly effective against worst bacteria and viruses Low cost. Used by many industries	Expensive due to high electrical costs Difficult to apply; requires special training and certification Dissipates quickly; requires numerous applications Can create bromate, a carcinogen if bromide present in water
Slow Sand Filtration	Simple, reliable Minimal power and chemical requirements Reduces bacteria, cloudiness and organic levels – decreases need for disinfection and presence of DBPs No exotic building materials	Large in size Large amounts of media Labor-intensive; media must be kept clean Will not completely remove organics and dissolved inorganics Effectiveness reduced in cold climes

Figure 3-3: Disinfection of Field Water Supplies

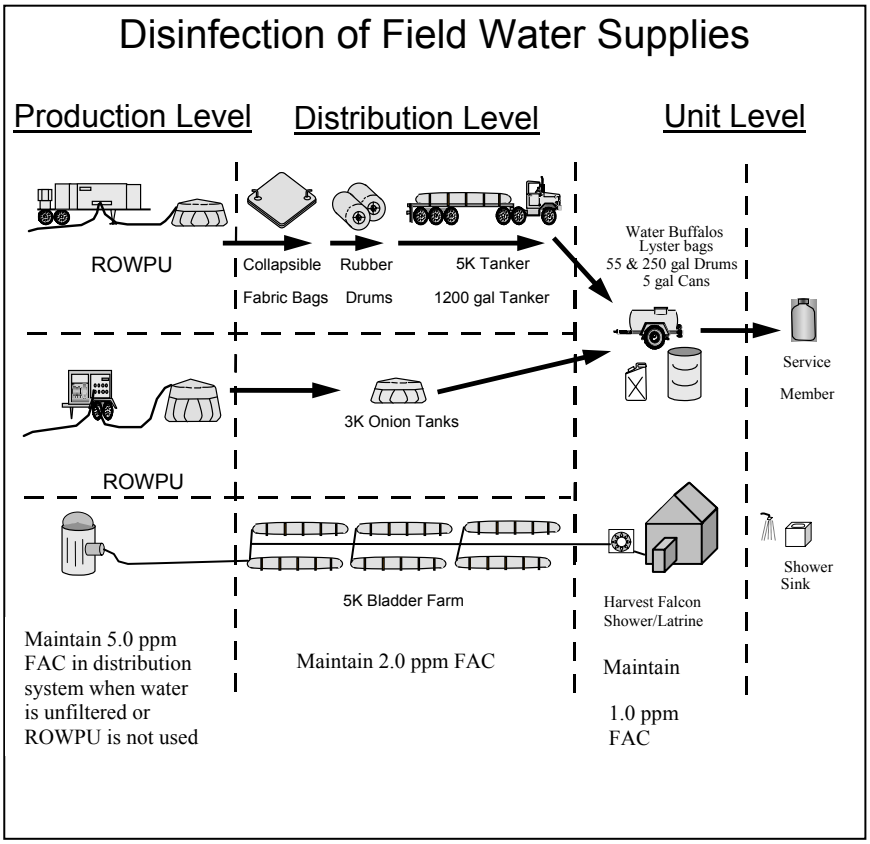


Table 3-21: Estimated Sodium Hypochlorite Dosage Quantities

Sodium Hypochlorite Dosage Calculator									
Desired Parts Per Million		**1**	**1**	**1**	**1**	**5**	**5**	**5**	**5**
Strength of Chlorine Solution		**5%**	**10%**	**15%**	**16%**	**5%**	**10%**	**15%**	**16%**
Gallons of Water to be Chlorinated	**50000**	1.0 gal 3785 cc	2.0 qt 1892 cc	42.7 oz 1262 cc	40.0 oz 1183 cc	5.0 gal 18925 cc	10.0 qt 9463 cc	213.3 oz 6308 cc	200.0 oz 946 cc
	25000	2.0 qt 1892 cc	1.00 qt 946 cc	21.33 oz 631 cc	20.00 oz 591 cc	10.0 qt 9463 cc	5.0 qt 4731 cc	106.7 oz 3154 cc	100.0 oz 2957 cc
	10000	25.6 oz 757.0 cc	12.80 oz 378.5 cc	8.53 oz 252.3 cc	8.00 oz 236.6 cc	128.0 oz 3785 cc	2.0 qt 1892 cc	42.67 oz 1262 cc	40.0 oz 1183 cc
	5000	12.8 oz 378.5 cc	6.40 oz 189.2 cc	4.27 oz 126.2 cc	4.00 oz 118.3 cc	2.0 qt 1892 cc	1.0 qt 946.0 cc	21.33 oz 630.8 cc	20.0 oz 591.4 cc
	2000	5.1 oz 151.4 cc	2.56 oz 75.7 cc	1.71 oz 50.5 cc	1.60 oz 47.3 cc	25.6 oz 757.0 cc	12.8 oz 378.5 cc	8.53 oz 252.3 cc	8.0 oz 236.6 cc
	1000	2.56 oz 75.70 cc	1.28 oz 37.85 cc	0.85 oz 25.23 cc	0.80 oz 23.66 cc	12.80 oz 378.5 cc	6.40 oz 189.2 cc	4.27 oz 126.2 cc	4.00 oz 118.3 cc
	500	1.28 oz 37.85 cc	0.64 oz 18.92 cc	0.43 oz 12.62 cc	0.40 oz 11.83 cc	6.40 oz 189.2 cc	3.20 oz 94.62 cc	2.13 oz 63.08 cc	2.00 oz 59.14 cc
	200	0.51 oz 15.14 cc	0.26 oz 7.57 cc	0.17 oz 5.05 cc	0.16 oz 4.73 cc	2.56 oz 75.70 cc	1.28 oz 37.85 cc	0.85 oz 25.23 cc	0.80 oz 23.66 cc
	100	0.26 oz 7.57 cc	0.13 oz 3.78 cc	0.09 oz 2.52 cc	0.08 oz 2.37 cc	1.28 oz 37.85 cc	0.64 oz 18.92 cc	0.43 oz 12.62 cc	0.40 oz 11.83 cc
	50	0.13 oz 3.78 cc	0.06 oz 1.89 cc	0.04 oz 1.26 cc	0.04 oz 1.18 cc	0.64 oz 18.92 cc	0.32 oz 9.46 cc	0.21 oz 6.31 cc	0.20 oz 5.91 cc
	25	0.06 oz 1.89 cc	0.03 oz 0.95 cc	0.02 oz 0.63 cc	0.02 oz 0.59 cc	0.32 oz 9.46 cc	0.16 oz 4.73 cc	0.11 oz 3.15 cc	0.10 oz 2.96 cc
	10	0.03 oz 0.76 cc	0.01 oz 0.38 cc	0.01 oz 0.25 cc	0.01 oz 0.24 cc	0.13 oz 3.78 cc	0.06 oz 1.89 cc	0.04 oz 1.26 cc	0.04 oz 1.18 cc

Conversion Factors:

1 gallon (gal) = 4 quarts (qt)
1 gallon = 8 pints (pt)
1 gallon = 128 Fluid Ounces (oz)
1 gallon = 3785.41 Cubic Centimeters (cc)
1 quart = 946.35 Cubic Centimeters
1 pint = 473.18 Cubic Centimeters
1 Fluid Ounce = 29.57 Cubic Centimeters

Note: Multiply strength of chlorine solution by 100 to convert percentage to decimal (5% = 0.05)

Table 3-22: Estimated Calcium Hypochlorite Dosage Quantities

Calcium Hypochlorite Dosage Calculator								
Desired Parts Per Million	**1**	**1**	**1**	**1**	**5**	**5**	**5**	**5**
Strength of Chlorine Solution	**55%**	**60%**	**65%**	**70%**	**55%**	**60%**	**65%**	**70%**
Gallons of Water to be Chlorinated								
50000	12 oz 344 grams	11.12 oz 315 grams	10.26 oz 291 grams	9.53 oz 270 grams	60.7 oz 1720 grams	55.60 oz 1576 grams	51.32 oz 1455 grams	47.66 oz 1351 grams
25000	6.07 oz 172 grams	5.56 oz 158 grams	5.13 oz 146 grams	4.77 oz 135 grams	30.3 oz 860 grams	27.80 oz 788 grams	25.66 oz 728 grams	23.83 oz 676 grams
10000	2.43 oz 69 grams	2.22 oz 63 grams	2.05 oz 58 grams	1.91 oz 54 grams	12.1 oz 344 grams	11.12 oz 315 grams	10.26 oz 291 grams	9.53 oz 270 grams
5000	1.21 oz 34 grams	1.11 oz 32 grams	1.03 oz 29 grams	0.95 oz 27 grams	6.07 oz 172 grams	5.56 oz 158 grams	5.13 oz 146 grams	4.77 oz 135 grams
2000	0.49 oz 13.8 grams	0.44 oz 12.61 grams	0.41 oz 11.64 grams	0.38 oz 10.81 grams	2.43 oz 68.8 grams	2.22 oz 63.05 grams	2.05 oz 58.20 grams	1.91 oz 54.04 grams
1000	0.24 oz 6.88 grams	0.22 oz 6.31 grams	0.21 oz 5.82 grams	0.19 oz 5.40 grams	1.21 oz 34.4 grams	1.11 oz 31.53 grams	1.03 oz 29.10 grams	0.95 oz 27.02 grams
500	0.12 oz 3.44 grams	0.11 oz 3.15 grams	0.10 oz 2.91 grams	0.10 oz 2.70 grams	0.61 oz 17.2 grams	0.56 oz 15.76 grams	0.51 oz 14.55 grams	0.48 oz 13.51 grams
200	0.05 oz 1.38 grams	0.04 oz 1.26 grams	0.04 oz 1.16 grams	0.04 oz 1.08 grams	0.24 oz 6.88 grams	0.22 oz 6.31 grams	0.21 oz 5.82 grams	0.19 oz 5.40 grams
100	0.02 oz 0.69 grams	0.02 oz 0.63 grams	0.02 oz 0.58 grams	0.02 oz 0.54 grams	0.12 oz 3.44 grams	0.11 oz 3.15 grams	0.10 oz 2.91 grams	0.10 oz 2.70 grams
50	0.01 oz 0.34 grams	0.01 oz 0.32 grams	0.010 oz 0.29 grams	0.010 oz 0.27 grams	0.06 oz 1.72 grams	0.06 oz 1.58 grams	0.05 oz 1.46 grams	0.05 oz 1.35 grams
25	0.01 oz 0.17 grams	0.006 oz 0.16 grams	0.005 oz 0.15 grams	0.005 oz 0.14 grams	0.03 oz 0.86 grams	0.03 oz 0.79 grams	0.026 oz 0.73 grams	0.024 oz 0.68 grams
10	0.00 oz 0.07 grams	0.002 oz 0.06 grams	0.002 oz 0.06 grams	0.002 oz 0.05 grams	0.01 oz 0.34 grams	0.01 oz 0.32 grams	0.010 oz 0.29 grams	0.010 oz 0.27 grams

Notes: Figures expressed in ounces are in dry ounces not fluid ounces. Where two figures are shown, use one or the other, not both.

$$\text{Ounces of Calcium Hypochlorite for 1 ppm solution} = \frac{1}{1{,}000{,}000} \times \frac{\text{gallons of water to be chlorinated}}{\text{Strength of chlorine solution}} \times \frac{16 \text{ ounces}}{\text{pound}} \times \frac{8.34 \text{ pounds}}{\text{gallon}}$$

Conversion Factors
1 ounce (oz) = 28.35 grams
1 pound (lb) = 453.59 grams
1 pound = 16 ounces
1 gallon of water weighs 8.34 pounds

Note: Multiply strength of chlorine solution by 100 to convert percentage to decimal (55% = 0.55)

Table 3-23: Disinfection Times To Reach Acceptable Inactivation of Bacteria, Virus and Giardia Lamblia Cysts

	pH < or =		
Free Residual < or = (mg/l)	**7.0**	**7.5**	**8.0**
0.4	88 min	105 min	125 min
0.6	60 min	72 min	85 min
0.8	47 min	55 min	67 min
1.0	37 min	45 min	54 min
1.2	32 min	39 min	46 min
1.4	28 min	34 min	41 min
1.6	25 min	30 min	37 min
1.8	23 min	28 min	34 min
2.0	22 min	25 min	31 min
2.2	20 min	24 min	29 min
2.4	18 min	22 min	27 min
2.6	17 min	21 min	25 min
2.8	16 min	20 min	24 min
3.0	16 min	19 min	23 min

3.6.11. Water Distribution System Inspection Criteria: The following criteria establishes safe and sanitary standards for the water system infrastructure. Where applicable, the health risk associated with each criterion is listed as a guide.

Table 3-24: Water Distribution System Inspection Criteria

Criteria	Compliant	Risk
Water Buffalo (400 gallon truck)		
Tank is level	Yes/No	Low
Manhole cover is closed and locked	Yes/No	High
Interior surface is clean/smooth and not rusting, chipping, cracking, or painted.	Yes/No	High
Outside container is labeled "Potable Water"	Yes/No	Moderate
Rubber gaskets are intact and do not have cracks, missing pieces, excessive dry rot, or improper fit.	Yes/No	Moderate
Spigots function properly	Yes/No	Low
The "T" handle for dispensing water from the tank opens and closes freely.	Yes/No	Low
Locking devices for spigot covers are functional and are not propped open. The cover should fall freely to cover the spigots.	Yes/No	High
Proper drain plug is present, hand tight, and easy to remove	Yes/No	Low
Other Tanks, Conduits, Containers		
Dispensing/Filling valves open and close freely without leaking	Yes/No	Moderate
Valves can be secured when not attended or in-transit	Yes/No	High
Threads on hose couplings are intact and not shredded	Yes/No	High
Dust caps must be secured to couplers, hose openings, and valve openings	Yes/No	High
Packaged water is stored in a clean, covered, well-ventilated area.	Yes/No	High
Packaged water is maintained at temperatures between 35 ^{O}F and 84 ^{O}F.	Yes/No	Moderate
Hose connections are secure and not leaking	Yes/No	Low

3.6.12. Sanitary Surveys: A sanitary survey is a periodic water system evaluation used to identify conditions presenting a sanitary or health risk. Below is some general information on conducting a sanitary survey.

3.6.12.1. Records Review: New systems will not have any records. Perform a record review on an existing system. The record review consists of:

- Review any available information on the water system including the population served, number of connections and storage capacity.
- Look at distribution system plans and maps to see locations of the lines, valves, tanks, sources, backflow preventors and treatment facility.
- Review routine operations and maintenance records. Review sampling results, disinfection residuals and monitoring frequency.

- Review the historical documents of the surrounding area. Historical evidence of industrial plants, landfills, hazardous operations, septic tanks, etc.

3.6.12.2. For New Water Systems: Draw a map of the water system to include distribution lines, valves, tanks, sources backflow preventors, and treatment facility. Review local area documentation if available on historical uses.

3.6.12.3. Visually Inspect Each Drinking Water Source: Sources include existing water distribution systems, ground water, surface water and bottle water facilities. Inspect the following areas:

- Water distribution system, tanks, and storage areas are secure and protected from possible chemical and biological contamination.
- Tour the entire distribution system to look for dead ends, pressure zones and/or high health-hazard facilities that need cross-connection protection.
- Are backflow preventors in-place for areas identified as having a possible cross-connection? Inspect the condition of the backflow preventor (i.e. rust, stains, leaks, dirt, etc.).
- Inspect the treatment equipment to include the type of chlorination. Are residual readings taken and recorded daily? Are residual readings adequate?
- Inspect the pumps, pumping facilities and controls to make sure they are clean and in good working order.
- Inspect the water storage tanks/bladders/etc. for structural soundness. Look for interior and exterior damage (i.e. rust, dirt, degradation, holes, etc.). Ensure the tanks are secure, vents and intakes are screened, etc.
- Is there any evidence of industry operations, landfills, hazardous storage areas, farming activities, septic tanks, etc? Air emissions, runoff and/or leachate from these operations may adversely affect water quality. Look for stressed or dead vegetation, fish kills, dead or sick animals, etc.
- Ensure potable water sources are labeled as such (i.e. water buffalo, specific spigots, etc.).

3.6.12.4. Documentation: Document the findings and results of the sanitary survey for future reference. Ultimately the information must be put in the ESOH-MIS (i.e., CCS, GEMS, or other surveillance system as approved for use by the supported combatant commander) for historical documentation.

3.6.13. Monitoring Frequency Determination (based on quality, threat, and vulnerabilities): Once the base is established, the BE must devise a routine surveillance plan. The population of the base and distribution system size determines the number of sampling sites. The sampling plan should be based on the initial risk assessment and any changing conditions. The following Table 3-25 correlates sampling frequency with risk. However, in some cases, an increase in risk/threat increases the frequency of the monitoring specific to the threat. The table also recommends an increase in number of samples collected to increase resolution of the system. This is shown as a normalization. For example, a base that normally collects 5 bacti samples has a change in risk from Low to High. Therefore, they should start collecting 10 samples daily (5*2.00=10).

Table 3-25: Frequency of Routine Monitoring Based on Risk

	Low (frequency/ #sample multiplier)	Medium (frequency/ #sample multiplier)	High (frequency/ #sample multiplier)	Imminently High (frequency/ #sample multiplier)
Bacteriological	Monthly/1.00	Weekly/1.50	Daily/2.00	Daily/2.00+
Chlorine/pH	Weekly/1.00	Daily/2.00	Hourly/2.5	Hourly/2.5+
TOC	Annually/1.00	Monthly/1.50	Daily/2.0	Hourly/3.0+
VOCs	Annually/1.00	Monthly/1.50	Daily/2.0	Hourly/3.0+

3.6.14. Deployment Water Sampling Kit and Instruction: The deployment potable water sampling kit is capable of testing for all regulated environmental contaminants (organic, inorganic, and radiological). The kit is not designed to analyze for bacterial analysis, bacterial analysis should be conducted on site. CHPPM recommends ordering the kit at least 3-4 weeks in advance. To order the water sampling kits, submit a request via email or telephone. The CHPPM website for contact information is http://chppm-www.apgea.army.mil/desp/POC.aspx. Send email requests to chppm-desprequests@amedd.army.mil. The phone numbers for each Command are as follows:

Table 3-26 CHPPM Contacts for Water Sampling Kit

Command	Phone Number
CENTCOM Operation Iraqi Freedom	410-436-5211
CENTCOM CJTF-76 & HOA	410-436-8125
CENTCOM CJTF-180	410-436-7282
CENTCOM OIF	410-436-8135
EUCOM	410-436-8153
CHPPM Europe	314-486-7049
NORTHCOM	410-436-8106
PACOM	410-436-7282
SOCOM	410-436-7712
SOUTHCOM	410-436-8106

Samples can be collected from potable water sources, sources of potential potable water or sources of water used for personal hygiene or cooking. In addition, the kit provides instruction to medical personnel on the collection of potable water samples. The kit contains pre-preserved containers, blanks, preservatives, and administrative items. Table 3-27 and Figure 3-4 outline the contents of the deployable sampling kit. All containers and items are new, and should be used only once. The kit will either be contained in a cooler or bag. Once samples are collected for analysis and administrative forms are complete, personnel seal and reship the cooler to a reach back laboratory for analysis. Table 3-28 outlines required sample volume, preservative, and holding time for laboratory analysis. Although standard EPA methods are used to analyze the samples, the limited sample volume size may result in detection limits higher than EPA MCLs. Pay close attention to the laboratory detection limits on the results.

Table 3-27: Inventory of Equipment in Deployment Potable Water Sampling Kit

ITEM #	ITEM DESCRIPTION	QUANTITY
1	Water Sampling Instructions	1
2	40 ml glass containers (MBAS, Tritium, Chloride, Fluoride, Sulfate, TOC, Nitrate/Nitrite, SVOC, VOC, Cyanide, Ammonia, total phosphate, Diquat/Paraquat, Glyphosate/Carbamates, Herbicides, Insecticides, EDB/DBCP and Endothall	1
3	125 ml glass containers (Metals, Gross Alpha/Beta, Alkalinity, pH, Color, Conductivity, TDS)	3
4	Blanks - 40 ml glass containers (SVOC, VOC, Diquat\Paraquat, EDB\DBCP)	4
5	Sample vial configuration chart	1
6	Water Sampling Bag (Blue)	1
7	Foam Insert with cover	1
8	Nitrile Gloves and towelettes	2 each
9	Pipettes	2
10	Dropper bottle or ampoule of hydrochloric acid (HCl)	1
11	Permanent Marker	1 package
12	pH Paper	1
13	Sample pitcher (100 ml)	1
14	Water Sampling Field Data Sheet	1

Figure 3-4: Disinfection of Field Water Supplies

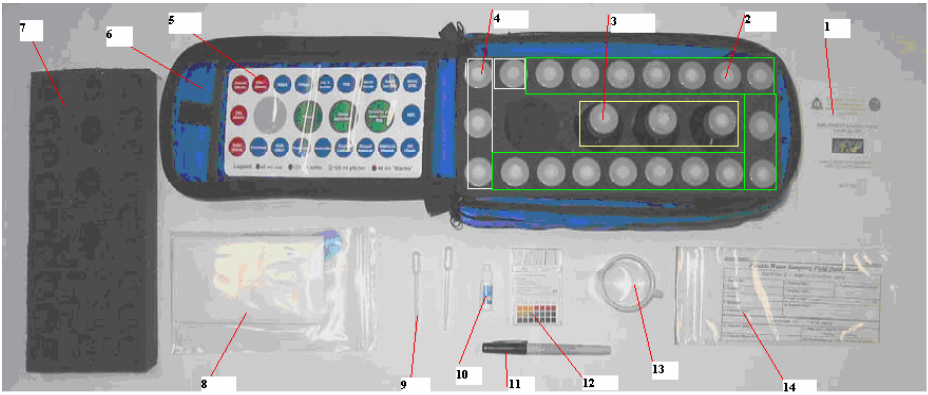


Table 3-28: Container Description and Preservative Requirements

ID	Sampling Group	Preservative for pH	Amount	Preservative Residual CL	Amount	(ml)	Holding Time
1	MBAS					40	48 hours
2	Tritium					40	NA
3	Chloride, Fluoride, Sulfate					40	48 hours
4	TOC	pH<2 Sulfuric acid	5 drops			40	28 days
5	Nitrite/Nitrate	pH<2 Sulfuric acid	5 drops			40	28 days
6	SVOC (Un-Chlorinated)	pH<2 , 1:1 HCl	3 drops			40	14 days
7	SVOC (Chlorinated)	pH<2 , 1:1 HCl	3 drops	Na_2SO_3	25 mg	40	14 days
8	VOCs - THMs	pH<2 , 1:1 HCl	3 drops	Ascorbic acid ($C_6H_8O_6$)	25 mg	40	14 days
9	Cyanide (Total)	pH>12, NaOH	3 drops	Ascorbic acid ($C_6H_8O_6$)	24 mg	40	14 days
10	Ammonia and Total Phosphate	pH<2 Sulfuric acid	5 drops			40	14 days
11	Diquat/Paraquat	pH<2 Sulfuric acid	3 drops	$Na_2S_20_3$	3 mg	40	7 days
12	Glyphosate/Carbamates	pH<3, monochloracetic acid	1.2 ml	$Na_2S_20_3$	3 mg	40	14 days
13	Herbicides			$Na_2S_20_3$	3 mg	40	14 days
14	Pesticides			$Na_2S_20_3$	3 mg	40	7 days
15	EDB/DBCP			$Na_2S_20_3$	3 mg	40	14 days
16	Endothall			$Na_2S_20_3$	3 mg	40	7 days
17	Alkalinity, pH, color, conductivity,					125	48 hours
18	Metals, Turbidity, Hardness	pH<2, Nitric acid (HNO3)	15 drops			125	28 days
19	Gross alpha/beta	pH<2, Nitric acid (HNO_3)	15 drops			125	na
20	Blank (SVOC)	pH<2 , 1:1 HCl	3 drops	Na_2SO_3	25 mg	40	
21	Blank (VOC)	pH<2 , 1:1 HCl	3 drops	Ascorbic acid ($C_6H_8O_6$)	25 mg	40	
22	Blank Diquat/Paraquat	pH<2 Sulfuric acid	3 drops	$Na_2S_20_3$	3 mg	40	
23	Blank (EDB\DBCP)			$Na_2S_20_3$	3 mg	40	

3.6.15. Camelback maintenance: Camelbaks® have become extremely popular among troops. These devices offer a convenient means of staying hydrated. However, maintenance and cleaning of these devices is often overlooked. The checklist below outlines some practical ways to properly maintain/clean the camelback. This information should be shared with other airmen to ensure a healthful environment.

Cleaning and Disinfection of Camelbak®

1. Inspect Camelbak for serviceability before and after each use
2. Remove/inspect reservoir assembly, delivery tube, and bite valve for signs of leakage and overall serviceability; replace if unserviceable
3. Inspect interior of reservoir assembly, delivery tube, and bite valve for evidence of mold/bacteria growth.
4. Inspect pack carrier for serviceability and cleanliness; replace if damaged
5. Soak heavily soiled pack carrier in warm/cold soapy water, rinse, and air dry only
6. Clean Camelbak reservoir assembly, delivery tube, and bite valve after every use to prevent mold/bacteria build-up
7. Fill reservoir half-full with warm water and mild soap, shake vigorously!
8. Drain reservoir contents through delivery tube, bite valve, and filler cap (ensure spillage over reservoir/filler cap threads)
9. Refill reservoir adding 2 TBSP (30 ml) of liquid household bleach (unscented/non-additive). **CAUTION:** Bleach solution will irritate skin and damage clothing; thoroughly rinse hands with water to remove any spilled solution
10. Vigorously shake/knead reservoir assembly and delivery tube for 1 minute, venting off excess air by pinching bite valve.
11. Let reservoir contents stand for 15 minutes, drain contents through delivery tube, bite valve, and filler cap (ensure spillage over reservoir/filler cap threads).
12. Using warm potable water, thoroughly rinse/inspect reservoir, delivery tube and bite valve for evidence of residual mold (material staining from mold growth can not be removed)
13. Refill for use, using approved potable water source. Ensure reservoir filler cap is sealed tightly.

3.6.16. Cross-Connections: Cross-connections may appear in many subtle forms and in unsuspected places. A cross-connection is the link or channel connecting a source of pollution with a potable water supply. The polluting substance, in most cases a liquid, tends to enter the potable supply if the net force acting upon the liquid acts in the direction of the potable water supply.

Rule: Two factors are necessary for backflow.

1.) There must be a link between the two systems: good water and bad liquid.
2.) The resultant force must be toward the potable supply.

IMPORTANT NOTE: Backsiphonage is a form of backflow but we distinguish between the two because the corrective actions are often different. There are a number of BPDs that will mitigate backsiphonage but have no effect on backflow.

3.6.17. Backflow Prevention: The selection of the proper device to use is based upon the degree of hazard posed by the cross-connection. With the deletion of the 19-Series Plumbing Regulation in the early 90's, specific guidance on assigning degrees of hazard was lost. However, the previous categories of Low, Moderate, and High were replaced by Low or High degree of hazard. Table 3-29 lists several factors when cross connections may become a high risk. Table 3-30 list several types of backflow prevention devices, their applicability, and risk rating.

Table 3-29: Factors Making a Cross-Connection a High Risk Hazard

Factors	Examples	Exercise
Locations where the contaminant, if introduced into the potable water system, could have dire health consequences	• Plating plants • Industrial metal finishing • Fabrication • Vehicle washes • Funeral parlors • Hospital autopsy rooms	Determine locations that could present a dire health hazard in your deployed location. Examples might include medical waste operations and artillery & humvee wash racks. Can you find any others?
Locations where highly susceptible members of the population could be exposed if the potable water supply were compromised. Include locations where high numbers of the population could be exposed. Expand this to include small numbers of highly critical personnel.	• Tent city • Air Force Bases • Dining facilities • Flightline operations • Patient care areas	Determine locations where members of the population whose health is already minimized could be exposed. Also determine where large numbers could be exposed

Everything else is a low hazard. Remember to refer to the data in your health risk assessments to determine when highly hazardous operations may be utilizing the plumbing system. Ask questions like: "Is the liquid transported in its own dedicated system or is it using the base's water system?

- If transmitted via base water system, evaluate the potential for a cross-connection.
- Next, evaluate the degree of hazard.
- Lastly, ensure the BPD is rated for that degree of hazard.

Table 3-30: Backflow Prevention Devices

Complexity Level	Risk Control Device	PROs	Used for Back-siphonage?	Used for Backflow	CONs	Health Risk Protection
LOW	Air Gap	Simple to create; non-mechanical	YES	YES	Interrupts piping flow; can be easily defeated; exposes water to surrounding air; loses free available chlorine to surrounding air	LOW
LOW	Barometric Loop	Simple to create; non-mechanical	YES	NO	Requires location for 35-foot tower of piping	MODERATE
LOW	Atmospheric Vacuum Breaker	Simple, inexpensive mechanical device; excellent application on hose bibs	YES	NO	Application limited; stops water flow when activated	LOW
MEDIUM	Pressure Vacuum Breaker	Works under constant pressure and can be tested in-line	YES	NO	Installation must be 6-12 inches higher than the existing outlet	MODERATE
MEDIUM	Double Check Valve	Usage of two separate check valves allows in-line testing: easily modified to include atmospheric vent or bypass check valve	YES	YES		MODERATE
HIGH	Reduced Pressure Principle Backflow Preventer	Provides maximum protection	YES	YES	Expensive; Difficult to install; Requires complex testing procedure	HIGH

Section 4.0: Waste Management

4.1. General: This section provides information and guidance on identifying, assessing and analyzing control measures for the health risks associated with waste hazards. These hazards may consist of human, solid (both hazardous and non-hazardous), and special wastes (medical and radiological). BE typically focuses on health risks resulting from waste handling, accumulation, storage, and disposition. In some cases, this risk assessment is supported with sampling and analysis. Failure to adequately anticipate and address waste issues may result in increases in disease incidence, vector-related problems, and corresponding adverse impacts on operations. BE must work with the Civil Engineer Environmental Flight (CEV) component to ensure the applicable waste management requirements align with infrastructure conditions. Where Final Governing Standards (FGS), additional Host Nation requirements, or United States codes are in effect, BE works with CEV, Services (SVS) and Contracting (CS), components to ensure wastes are managed properly, ultimately mitigating any related hazards.

4.2. Planning: This chapter is organized around BE support for operational decision-making that pertains to several types of waste: wastewater, solid (non-hazardous), solid (hazardous), and special wastes. The negative operational impacts from each of these potential hazards can increase if waste management planning is not done effectively. Potential effects include disease incidence, vector bites, and other physiological effects. Proper planning begins with anticipating issues during the "beddown" phase and continues to be important throughout the "establish the base" and "sustainment operations" phases. The Conceptual Site Model (CSM) is a summary of conditions at a site that identifies the type and location of most potential sources of contamination and how and where people, plants or animals may be exposed to the contamination. Use the examples below to help develop a CSM for the deployed location. Consider all of the potential sources, pathways, and potential exposure routes of hazards associated with waste.

Table 4-1: Examples for Waste Conceptual Site Model

CSM Fields	Examples
Area of Concern	Individual Waste, Construction, Industrial Ops, Landfill, Incinerator, Compost Area, Sewer, Latrines, Waste Disposal Areas
Primary Release	Air Emissions, Spills, Industrial Processes, Inadequate Disposal, Water Runoff
Secondary Release	Leachate, Off gassing, Resuspension, Revaporization, Combustion
Media Pathway	Air, Surface Water Runoff, Groundwater
Activity or Point of Exposure	Dining Facility, Burn pit, Swimming, Showers, Flightline Operations, Ground Maintenance, Landfill, Tent City
Exposure Route	Inhalation, Ingestion, Contact, Sub-dermal Absorption
SEG Effected	All personnel, CE Personnel, Flightline Personnel, Tent City, Waste collectors/operators

4.3. Solid Waste (Non-hazardous) Generation: Solid wastes accumulate from several sources – office refuse, industrial (non-hazardous) refuse, personal refuse, and food wastes.

The Air Force planning factor for generation of refuse is 4 lbs/person/day (AFPAM 10-219 v5); approximately 0.5-1 lbs/person/day of this total is assumed to come from dining operations (AFPAM 10-219 v5 para 3.6.6.6). The total includes garbage (waste from preparation and serving of food), rubbish (paper, cartons, boxes, cans, etc.), and industrial wastes. Additionally, the EMEDS facility will generate the following amount of solid waste per day, which is not included in the planning factor above. According to the AFTTP 3-42.71, *EMEDS*, the following waste generation rates apply.

- EMEDS Basic (serves base population of 500-2000): 180 lbs/day
- EMEDS+10 (serves base population of 2000-3000): 610 lbs/day
- EMEDS+25 (serves base population of 3000-5000): 1100 lbs/day

4.3.1. Solid Waste Collection and Storage: Waste will be generated upon arrival at a bare base from a variety of sources, e.g., packing materials, MRE packaging, etc. If not properly handled, these waste streams can attract vectors for disease that spread to the base population. Each tent, unit, and building should have a solid waste collection point. All trash containers should utilize bags to collect waste; trash containers should be covered and emptied daily or when full. All units should have a posted solid waste disposal plan, especially around living quarters.

4.3.2. Intermediate Storage: There are several options for intermediate collection devices. Waste may be consolidated into plastic containers, which range from 32 to 80 gallons. Also, the base may use larger trash collection points such as roll-offs, dumpsters, etc., in several locations around the base. Siting for these containers should be done in consultation with security forces (SFS) since they may also present a potential target for delivering or storing explosive devices. These containers must have covers to prevent wind from blowing the waste around the base and to discourage disease vectors. Standard sizes for roll-off containers are 14, 20, 30, and 40 cubic yard. At a minimum 2-3 dumpsters should be located on a bare base near the flightline operations, living quarters, and medical/dining facilities. Finally, there may be some combination of these systems employed. To determine the number of containers and appropriate sizes, calculate the total solid waste generation rate. Note that the density of uncompacted solid waste is approximately 200 lbs per cubic yard (Corbitt 8.28). Use Equation 4-1 or Table 4-2 to determine the optimal number of required waste collection containers.

Equation 4-1:

$$\text{Number of containers} = \frac{(\text{base population}) * (4 \text{ lbs/pers/day}) * (\text{\# days waste accumulates b/w collections})}{(200 \text{ lbs/cu yd}) * (\text{volume of each container})}$$

Table 4-2: Number of Containers Required for the Base*

Size	500 troops		1,000 troops		2,000 troops		5,000 troops		10,000 troops	
Collection Frequency	3 days	7 days	3 days	7 days	2 days	3 days	2 days	3 days	1 days	2 days
14 CY**	2	5	5	10	6	9	15	22	15	30
20 CY	2	4	3	7	4	6	10	15	10	20
30 CY	1	3	2	5	3	4	7	10	7	14
40 CY	1	2	2	4	2	3	5	8	5	10

* Data in table 4-2 was calculated using equation 4-1
** CY: Cubic Yards

Use Equation 4-2 or Table 4-2 to determine the frequency of collection based on a pre-determined volume of containers. Use Equation 4-2 for point collection.

Equation 4-2

$$\text{Frequency of collection (days)} = \frac{(200 \text{ lbs/cu yd}) * (\text{total volume of containers in cu yds})}{(\text{base population}) * (4 \text{ lbs/person/day})}$$

4.3.3. Collection: Municipal solid waste collection may be done at the points of generation, similar to residential collection, with rear/side loaders, or at intermediate points such as dumpsters or roll-off containers. Rear-loaders and side-loaders have the capacity of transporting between 9 and 32 cubic yards of wastes compacted at about 750 lbs/cu yd (3 times that of loose waste). Anti-terrorism Force Protection (ATFP) considerations must be made in coordination with SFS:

- Compacting loaders should enter the base empty.
- Roll-offs may be more secure (i.e., exchange an empty for a full container).
- Locate intermediate collection points farther away from populated areas.
- Conduct more frequent inspections of the containers at higher FPCONs.
- Decrease the frequency of waste collection and increase the size or number of containers during higher FPCON.
- Balance security risks with health risks.

4.3.4. Solid Waste Disposition: Solid waste may be disposed of in several ways – landfills, incineration, composting, or open burning. The following table lists the pros and cons for each option.

Table 4-3: Pros/Cons of Solid Waste Disposal Options

Disposal Option	Pros	Cons
Landfill	Reduced exposure risk Generally acceptable option	Requires site evaluation before digging Can only accept solid wastes Long-term risks of sinking, leaching, and off-gassing Possibility of scavengers recovering operational information
Incineration	Minimizes solid waste volume and air hazards	Complicated to design effectively Requires air pollution controls Creates additional route of exposure (air)
Composting	Ecologically sound, secondary use	Time-consuming Requires management of a reactor Requires controlled or fenced area
Open Burning	Easy means to destroy waste and reduce volume	Creates air hazard Requires full-time operator Backlighting of perimeter watch towers may create ATFP concern

4.3.3.1. Landfilling or Burying Waste: The typical sanitary landfill in the field is constructed using the trench method (Figure 4-1). Normally, a bulldozer digs a trench into which refuse is dumped. The bulldozer spreads and compacts the refuse, and covers it with a minimum of six inches of earth at the end of the day. When each trench is filled, it is covered with two feet of compacted soil and marked with a sign reading "Abandoned Land Fill". The following rules must be followed when siting a landfill to minimize contamination and prevent associated disease:

- keep a minimum of 30 feet of clay between strata and refuse
- site the landfill at least 500 feet from wells/water sources
- do not use mines for disposal of refuse
- locate the landfill in an area of stable soil
- locate the landfill downwind from the installation/encampment

To determine landfill size requirements, use the following formula which is based on unit conversions and the assumption that waste is generated at 4 lbs/person/day as stated in AFPAM 10-219 v5.

V = 120 lbs/person/month * P * T / W

Where:

W is the waste density (lbs/cu yd) based on the collection mechanism shown in Table 4-5

T is the expected life (in months) of the landfill based on the operation;

P is the average population of the base during the operation;

V is the total volume (cubic yards) required for the life of the landfill.

When determining the required landfill size, space limitations may require a shorter landfill life. This will drive a planning process to determine a long-term waste disposition strategy.

Table 4-4: Typical Unit Weights for Various Collection Vehicles (adapted from Corbitt 8.111)

Type of Collection Vehicle	Waste Density (W)
Car/pickup	200 lbs/cu yd
Rear-loading packer	750 lbs/cu yd
Compacted roll-off container	500 lbs/cu yd
Open top roll-off container	300 lbs/cu yd

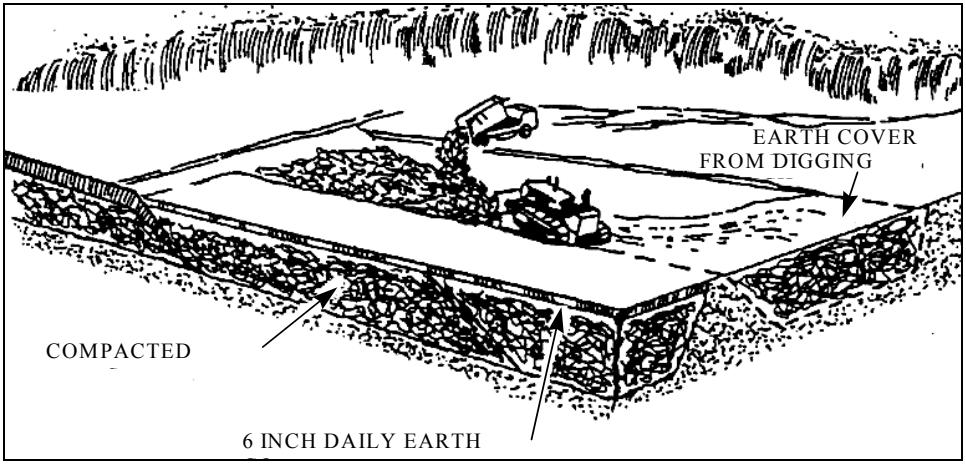


Figure 4-1 - Trench Method - Sanitary Landfill (AFPAM 10-219 v5)

According to the CSM (Table 4-1), personnel may be exposed to a number of hazards from a landfill. Identify, assess and communicate the risks using the Health Risk Assessment (HRA). Table 4-6 lists several methods to help identify and assess potential hazards from different types of wastes in support of the HRA. Use the tool below to develop sampling strategies related to landfills, incinerators, burning, and hazardous wastes.

Table 4-5: Health Risk Assessment Approach

Identify Hazards	Assess Hazards	Analyze Hazards
Inhalation from: - container/landfill off-gassing - burning/incineration by-products - re-entrainment/vaporization from spills	1. Estimate the likelihood of the exposure 2. Estimate the severity of the exposure 3. Prioritize special surveillance with other requirements	- Survey immediate area around source for volatile compounds using TVA-1000B and/or HAPSITE - Conduct downwind/upwind monitoring with portable analyzers and air sampling trains
Water Ingestion from leachate contaminating surface/ground water		- Survey groundwater and sub-surface soils around source - Monitor water system
Sub-dermal absorption		- Monitor airborne vector count - Analyze airborne vector for diseases using RAPID/M1M - Track patient visits resulting from or exhibiting symptoms associated with airborne vectors
Contact with hazardous/special wastes - routine handling - spill response		- Characterize hazard and controls qualitatively - Analyze sample when hazard is unknown, otherwise use toxicological references

4.3.3.2. Incineration: Incineration involves the controlled burning of solid waste usually to maximize the energy output and minimize the hazardous by-products. This is done by controlling the temperature, air intake, and type of fuel. BE evaluates the waste content, incinerator process controls, pollution controls, and monitors stack output or measures downwind emissions when monitoring data is not available.

4.3.3.2.1. Two types of incinerators are typically used in the field. The first type, the barrel incinerator (Figure 4-2), is constructed from a 55-gallon drum. The top is removed and scrap pipes are inserted through holes that are bored near the bottom of the drum to create an improvised grate. Holes are bored in the bottom of the drum. The drum is elevated on rocks, bricks, or cans to allow an updraft that will keep the fire supplied with oxygen. The second type, the inclined-plane incinerator (Figure 4-3) is suitable for burning combustible and liquid waste as well as wet garbage. Gasoline flows from the drum and is ignited at a vapor burner under the lower grate. Waste is placed into the incinerator at the top of the

incline. Heat passes above and below the inclined plane. This dries and incinerates the waste as it flows down the incline.

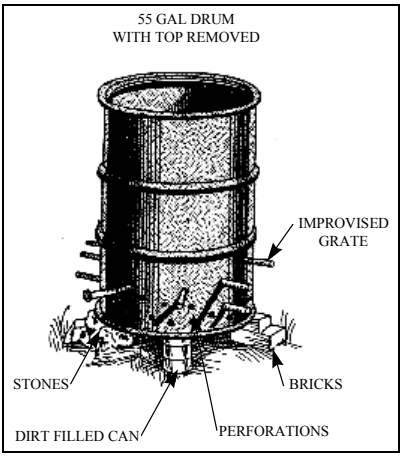


Figure 4-2 - Barrel Incinerator (BE FM, 2000)

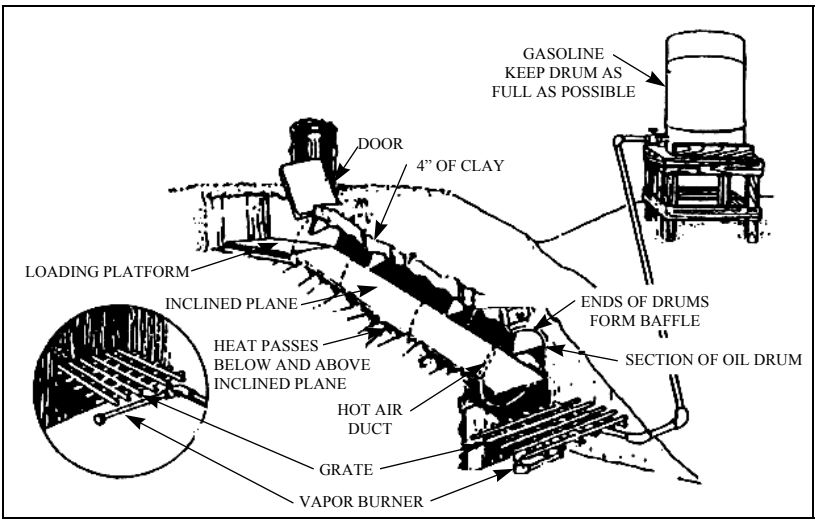


Figure 4-3 - Inclined-Plane Incinerator (BE FM, 2000)

4.3.3.2.2. Incineration may result in hazardous combustion by-products depending on the efficiency of the burn, fuel-to-air ratio, air pollution controls, and composition of the waste. BE identifies and assesses hazards associated with incineration and burning. Based on the CSM, Table 4-5 outlines several methods to identify and assess the hazards associated with incineration and open burning.

4.3.3.3. Composting: Composting is a process by which organic materials are converted from an unstable product, which decomposes and creates objectionable odors, to an

increasingly more stable product that will store well without being offensive. Composting requires a balance of waste fuel, nutrients, and microbes to decompose wastes. Another benefit of this process is it can be effective in reducing the overall volume of waste. The composition of the input waste stream has a significant impact on the process efficiency.

4.3.3.4. Burning: Open burning may be used in some deployed environments as an expeditious means of waste disposal. This process can result in several high risk exposure scenarios and should be used as a final option. Hazardous and other special wastes should be segregated from the waste stream prior to burning. This will reduce hazardous by-products. Other items or types of wastes (i.e., tires, plastics, etc.) should also be excluded when complete combustion is not being achieved. BE should assess and document exposures from combustion by-products (i.e., HCN, NO_2, and other VOCs), and recommends controls such as restricting burn periods to favorable weather conditions and segregating different waste streams. BE must engage with the contracting officer when these operations are contractor operated. Special consideration should be given to ATFP issues such as blackout conditions which could be defeated by backlighting from nighttime burn operations.

4.4. Wastewater: Wastewater consists of by-products from latrines, showers, food preparation activities, medical operations, industrial operations, and laundry wastes. Typical liquid waste generation rates are shown below in Table 4-6.

Table 4-6: Wastewater Generation Rates

Source	Amount (gallons/person/day)
Latrine	7.7
Shower	1.3-4.5
Food Preparation	2.0
Hospital*	1.0 (based on base population)
Laundry	2.0

Source: *AFPAM 10-219v5*

The EMEDS TTP lists wastewater generation rates in gallons per day (gpd):

- EMEDS Basic: 700 gpd
- EMEDS+10: 1400 gpd
- EMEDS+25: 2500 gpd
- EMEDS+50: 4950 gpd

The EMEDS also has a significant laundry requirement that is not considered in the above wastewater generation rates. These estimates refer to the weight of laundry generated per day by the EMEDS (EMEDS ECS Requirements):

- EMEDS Basic: 1000 lbs/day
- EMEDS+10: 2000 lbs/day
- EMEDS+25: 3600 lbs/day
- EMEDS+50: 9000 lbs/day

4.4.1. Wastewater Collection Devices Wastes must be disposed of in such a way as to preclude contamination of surface or subsurface waters, attraction of rodents and insects, creation of a nuisance, or violation of federal, state, or local (to include host nation) pollution abatement laws or regulations. It is estimated that human solid and liquid wastes are generated at a rate of 1 lb/person/day and 7.7 gallons/person/day, respectively. The Air Force (AF) has bare base housekeeping equipment (Harvest Falcon) consisting of tents, kitchens, showers, latrines, etc. The Harvest Falcon latrine is the system used for collecting human waste products during the "beddown" and "sustainment" phases of operations. The Harvest Falcon and other options devised by U.S. Forces to meet the criteria of simple construction and adequate sanitation are shown in Table 4-7.

4.4.1.1. Latrine Facilities. For temporary camps, 1-3 days, straddle trench latrines can be constructed. For longer encampments, deep pit latrines, bored hole latrines, pail latrines, etc., and urine soakage pits should be constructed. Some considerations for establishing latrine facilities are listed below.

4.4.1.1.1. Sizing. For planning purposes, one toilet will serve 17.5 personnel (AFPAM 10-219 v5). Ultimately, the final numbers of latrine facilities are 30 toilets and 15 urinals for males, and 12 toilets for females.

Table 4-7: Comparison of Latrines

Solutions	Capacity (gallons)	Troops/unit/day	Pros	Cons
Harvest Falcon (6 toilets and trough/set)	180	23	Easy to clean and maintain	Requires pump-out schedule; Limited capacity
Port-a-pottie/ Chemical Latrines	25	10-20	Easy to maintain Convenient	Requires pump-out schedule; Limited capacity; Limited availability; Not fixed to ground
Permanent toilets	Check sewer design and size	Check design assumptions Double the daily average flow (Corbitt 6.22)	Ideal, may not have sufficient quantity Easy to maintain	Prone to clogging sewer/overflowing when system is not designed for large number of personnel
Cat Hole	8	10 (estimate)	Easy to make	Short useful life Provision for toilet paper
Straddle Trench	80	250 (estimate)	Relatively easy to make; Easy to maintain and close	1-3 day useful life; Provision for toilet paper; Requires boards for better footing

Solutions	Capacity (gallons)	Troops/unit/day	Pros	Cons
Deep Pit Latrine	112-337	250-500 (estimate)	Suitable for 3 days – 2 weeks; Comfort	Requires preventive maintenance
Bored Hole Latrine	200	300 (estimate)	Suitable for 1 week+	Requires bore hole construction
Mound Latrine	Varies	Varies (similar to trench)	Some comfort	Requires mound construction and stabilization
Burn out Latrine	55	50-75 (estimate)	Permanent disposal	Requires 2 gal fuel/ can/day Useful life is 90 days
Pail or Bucket Latrine	5-10	5-10 (estimate	Simple	Requires permanent disposition

4.4.1.1.2. Location. To ensure that food and water are protected from contamination, latrines must be located at least 100 yards from the unit dining facilities and 100 feet from the nearest water source or supplies. Latrines must always be dug above the natural water table and on level ground. Waste must not be allowed to drain into any water source. Normally, latrines are located at least 30 yards from the end of the unit area and always downhill from the encampment.

4.4.1.1.3. Screening. Canvas or brush screening should be placed around each facility, or the latrine can be enclosed within a tent. In cold climates, the shelter should be heated. A drainage ditch should be dug around the facility to prevent surface water from running off into the latrine. Shelters should be sprayed periodically with an approved insecticide to control flies.

4.4.1.1.4. Hand Washing Devices. A simple hand-washing device must be installed near the latrine enclosure. It must be easy to operate and supplied with fresh water and soap. A soakage pit must be constructed to accept the rinsate. BE, PH, and unit commanders must aggressively emphasize washing hands as a means of controlling transmission of diseases.

4.4.1.1.5. Policing. An established base will likely have a cleaning contract established using Third Country Nationals (TCNs). In lieu of such support, commanders must assign personnel to clean and maintain the latrines on a daily basis. Improper sanitation could lead to dysentery and diarrhea among other diseases that can render personnel ineffective for combat operations.

4.4.1.1.6. Cleaning. Latrines should be cleaned daily with soap, water, and a disinfectant on contact surfaces. Regardless of the source of labor, BE and PH must coordinate with contracting to ensure a QAE is assigned to guarantee proper work practices. Additionally, cleaning materials should be procured or authorized through the hazmart pharmacy. BE

evaluates the storage and use of cleaning products to ensure compatibility and safe use. Chlorine and ammonia based products should never be mixed or applied to the same surface.

4.4.1.1.7. Closing. When a latrine pit becomes filled to within one foot of the surface or when it is to be abandoned, remove the latrine box and close as follows.

- Fill the pit to the ground level with successive 3-inch layers of earth. Pack each layer thoroughly to prevent fly pupa from hatching and escaping from the closed latrine.
- Place a sign on top of the covered pit that reads "Closed Latrine" and the date it was closed.

4.4.2. Other Wastewater Facilities. Every device or facility that is used for washing or drinking in the field must have some kind of soakage area under it to prevent pooling and mud from forming as these will encourage vector growth. The area around hand washing devices, wash racks, lyster bags, water buffaloes, etc., should be excavated to a depth of a few inches and filled with stones to form a soakage pit. Wastewater from wash racks should be run through a grease trap before it flows into a soakage pit/trench. Water from field showers must also be drained into a soakage pit/trench. However, a grease trap is not required.

4.4.2.1. Soakage Pit Design. For larger wastewater flows, proper design of the soakage pit is more important. The following information will help ensure proper design and reduce the risk of wastewater overflows which can result in potential health risks and adverse operating conditions.

- Determine expected flow. This can be done through observations, measurements, or estimates based on sources of wastewater. The system should be designed for peak flow.
- Determine the percolation rate. This can be done by digging a 6 or 12 inch diameter hole in the ground down to 18 inches or more depending on the results of the percolation test – if the required percolation rate is not achieved, then the test can be conducted at lower depths. The test is accomplished through the following steps:
  (1) presoak the pit for 4-24 hours prior to testing (24 hrs for >15% clay);
  (2) line the bottom 2 inches of the pit with gravel or sand;
  (3) fill the hole with 6-12 inches of clean water and measure the percolation rate in minutes/inch noting the rate every 10-15 minutes – continue adding water until the rate equilibrates within 10% of the previous rate;
  (4) at least 6 tests should be conducted and the percolation rate average should be calculated. Compare to the table below to determine the loading rate.

Percolation rate (minutes/inch)	Max Sewage Loading rate (gal/sq ft/day)
< 1	Prohibited
3	1.2
10	0.8
24	0.6

Percolation rate (minutes/inch)	Max Sewage Loading rate (gal/sq ft/day)
30	0.56
45	0.45
60	0.35
90-120	0.2
>120	Prohibited

- Calculate the size of the drainage field. Divide the peak flow by the design loading rate to determine the surface size. The length should be less than 100 feet. Use three to four inch diameter perforated pipes; they should have a grade of at least 3 inches/100 ft, and be covered with at least 12 inches of surface covering. The depth should be at least 12 inches and be filled with clean drain rock.

4.4.2.2. Retention Basin Design. Retention basins are used when soakage pits are not practical and there is a means to periodically pump out the basins. These may also be effective in hot, dry environments where the evaporation rate is high. The following process is used to design evaporation/retention basins.

- Determine the design flow just as above.
- Determine the loss rate. This may include the evaporation rate and the percolation rate when a liner is not used.
- Determine the size. Often surface area restrictions will drive the design and the frequency of the pump out.

4.4.3. Wastewater Discharges. Wastewater discharge falls into three categories -- direct, indirect, and industrial.

4.4.3.1. Direct discharge is the introduction of pollutants directly to surface waters or soil. These discharges may be subject to host nation regulations, permits, and other considerations. From a health risk perspective, direct discharges should always be down stream of base camps, drinking water sources, and other operations. It is recommended that direct discharges be located at least 1,000 feet beyond personnel and operations. Prior to establishing a new direct discharge, BE should consider the impact of the flow on the receiving stream. This analysis should consider how the receiving stream may overflow its banks changing the water flow, the impact on groundwater and underground flow, and the impact on upstream water levels. Other considerations may include impact on the environment and downstream populations.

4.4.3.2. Indirect discharge is any introduction of pollutants in process wastewater that flows to a domestic wastewater treatment plant (DWTP) or other collection systems such as retention ponds and stabilization lagoons. Indirect discharges may also be subject to host nation regulation, permits, and other considerations. Most importantly, BE evaluates the condition and capacity of the receiving system. Often, the USAF sets up operations at an existing air base or airport. The existing infrastructure may be fragile and designed for a much smaller population – travelers and a few permanent workers. Factors to consider include pipe sizes, layout, receiving treatment plant (which could become overwhelmed),

and pumping stations. In many third world countries, open ditches may be utilized for wastewater discharge. A vulnerability assessment should be conducted to identify critical components and limits. The same process used for the water vulnerability assessment can be applied to wastewater.

> During Operation Enduring Freedom, the USAF bed-down troops at a coalition air base with a small population. The lack of adequate latrine facilities resulted in about 300 people using 2 restrooms and an already overflowing Harvest Falcon Latrine unit. Within a few days, the wastewater system was overwhelmed. In particular, a lift station was working constantly to keep up with the increased flow; the system failed resulting in sewage overflow which happened to be at the entry control point to tent city. This incident had a negative impact on support operations and resulted in immediate evacuation and relocation of several support activities. USAF troops were at the mercy of the host nation to fix the problem which took several days. Proactive evaluations as described in the above sections are essential in preventing scenarios like this one from ever occurring again.

4.4.3.3. Industrial discharge is a wastewater leaving specific industrial operations (electroplating, anodizing, metal coating, chemical etching and milling, electrolysis plating, printed circuit board manufacturing) or an industrial wastewater treatment plant (IWTP). Wastewater standards apply to regulated facilities. Regulated facilities include DWTP, IWTP, and an industrial discharger. A DWTP is a DoD or host nation facility designed to treat wastewater (primarily domestic sewage) prior to discharge to a nation's waters. An IWTP is a DoD facility designed to treat process wastewater prior to discharging to a nation's waters. An industrial discharger is any installation that discharges wastewater from one of the previously mentioned industrial processes.

4.4.4. Kitchen Waste Facilities. Liquid waste from kitchen facilities contains particles of food, grease, and soap and must be treated before it is disposed of. Treatment methods include the following.

4.4.4.1. Soakage Pits. In temporary camps or before Harvest Eagle equipment arrives, a unit must construct soakage pits to treat liquid waste from kitchen operations. A unit of approximately 200 people would need two soakage pits. Each pit would be used on alternate days. This allows for evaporation and reduces the possibility of the pits becoming clogged. Soakage pits should be close to the edge of the unit area but at least 30 yards away from the nearest water source.

4.4.4.2. Soakage Trench. Where the water table or rock formations will not allow construction of the standard four-foot deep soakage pit, a soakage trench can be employed. A soakage trench encompasses more area to allow for slower overall percolation into the ground.

4.4.4.3. Grease Traps. A grease trap must be used with each kitchen liquid waste soakage pit or trench. All kitchen liquid waste must pass through a grease trap to remove as much grease and food particles as possible to prevent clogging soakage pits and trenches.

4.4.4.4. Evaporation Beds. In places where clay soil or rock formations preclude using standard soakage pits or trenches, evaporation beds can be employed to handle liquid waste from field kitchens. These beds work best in hot dry climates. As with soakage pits, grease should be removed from the liquid waste before it is allowed to enter the beds.

4.4.5. Grey Water. Any water used in the home, except water from toilets, is called grey water. Dish, shower, sink, and laundry water comprise 50-80% of residential "waste" water. This may be reused for other purposes, especially landscape irrigation. The benefits of grey water recycling include:

- Lower fresh water use
- Less strain on failing septic tank or treatment plant
- Grey water treatment in topsoil is highly effective
- Ability to build in areas unsuitable for conventional treatment
- Less energy and chemical use
- Groundwater recharge

4.4.5.1. Laundry Facilities. Established locations may have personal use laundry facilities in either tents or modular buildings. The wastewater from these operations can be diverted to retention ponds for evaporation and/or percolation. Grey water is purified to a spectacularly high degree in the upper, most biologically active region of the soil. This protects the quality of natural surface and ground waters.

4.4.5.2. Commercial Laundry Facilities. Commercial laundries typically apply chemicals in the cleaning operations. Evaluate these as potential industrial waste operations.

4.5. Hazardous Waste (HW). HW management under field conditions can be influenced by a variety of regulations/activities, such as, the U.S. EPA, individual states, Final Governing Standards (FGS), host nation requirements, etc. BE should coordinate with the installation CEV to determine specific HW requirements that may be in effect at the deployed location. CEV manages the installation hazardous waste program. Hazardous wastes present potential health hazards to those operating around these substances. Additionally, an enemy attack could release these hazards into the environment causing additional casualties and possibly complicating the identification of CBRN agents that may have been used. BE coordinates with CEV to ensure that all hazardous wastes are sampled and characterized. Characterization data are required to assess and manage health risks associated with hazardous waste.

4.6. Special Wastes. Special wastes consist of radiological, medical, infectious, or other wastes that require special handling.

4.6.1. Radiological. Radiological waste characterization involves detecting the presence of individual radionuclides and quantifying their inventories in the waste. This can be done by a variety of techniques, depending on the waste form, radionuclides involved and level of detail/accuracy required. For example, a simple radiation dose rate measurement will give

an indication of the total quantity of gamma emitting radionuclides in a waste package, but will not identify individual radionuclides or their concentrations.

4.6.1.1. Radiological waste characterization can also be inferred from process knowledge. Use the SAM-935 to identify the radioisoptope.

4.6.1.2. Radiological disposition should be coordinated with the Air Force Radioactive and Mixed Waste Office (AFRMWO) as laid out in Air Force Instruction 40-201, paragraph 1.10.4, *Managing Radioactive Materials in the USAF*. It is costly to dispose of radioactive material and against DOT regulation to declare an item hazardous when it is not. Several options include:

- **Disposal by Transfer for Land Burial:** Radioactive material may be transferred to a licensed low level radioactive waste disposal facility for land burial. Requirements for the transfer of materials are outlined in Technical Order (T.O.) 00-110N-2, *Radioactive Waste Disposal*, and 10 CFR 20.2006, *Transfer for Disposal and Manifests*.

- **Disposal by Release to Sanitary Sewer:** Dispose of radioactive material by release to a publicly owned treatment works (POTW) sanitary sewer system only when authorized by the permit and allowed by local, state, and Federal regulations. Federal regulations limit disposal via this route to readily soluble material or readily dispersible biological material in water and the quantity does not exceed limits referenced in 10 CFR 20.2003, *Disposal by Release into Sanitary Sewerage*. Release to a federally owned treatment works (FOTW) must be authorized by the Radioisotope Committee (RIC).

- **Decay in storage:** If the half-life is less than 65 days; decay in storage for isotopes having a half-life less than 120 days with authorization from the RIC.

Table 4-8: Common Items Containing Radioactive Materials

Isotope	Form	Recyclable Types	Recyclable NSN	Excluded Types/NSN
Krypton 85	Gas	Any source type	Any	Wave Guides, Ignition Exciters
Tritium	Gas Only	Compasses	6605-00-151-5337 6605-01-196-6971	Compass, Oxide (6605-00-846-7618)
Tritium	Gas Only	Watches	Any	Oxides
Tritium	Gas Only	Luminescent Safety Devices (i.e. Exit Signs)	Any	None Known
Depleted Uranium	Solid	Counterweights; Non-explosive Munitions; Armament	Any	Extraneous Metal (i.e. nuts, bolts, airframe parts, casings, aluminum)

Isotope	Form	Recyclable Types	Recyclable NSN	Excluded Types/NSN
Cesium 137	Solid	Exempt Quantity Check Sources	Any	Check sources issued as general or specifically licensed devices
Polonium 210	Solid	Any device distributed under 10 CFR 31.3	Any	3M distributed devices
Americium 241	Solid	Smoke Detectors (CASE BY CASE)	Any	

- **Recycle:** The Wright-Patterson Radiation Safety Branch (88 ABW/EMB) established a contract for the recycling of radioactive material. A list of common items containing radioactive materials is shown below in table 4-8. Complete a request for Department of Defense operations. This request may be a letter, facsimile, or electronic mail message. The request should be sent to: Wright-Patterson Radiation Safety Office, Radiation Safety Branch, 88 ABW/EMB, Building 30089, 5490 Pearson Road, Wright-Patterson AFB, OH 45433-5332, attention: Chris Anthony. Do not ship any radioactive materials unless specifically authorized by 88 ABW/EMB. If additional assistance is required to facilitate your recycling request, call DSN 787-2010 extension 205, (937) 257-2010, or facsimile DSN 986-1534, (937) 656-1534, or electronic mail anthonc@wrigem.wpafb.af.mil. After authorization is granted, the 88 ABW/EMB will provide the necessary instruction to satisfy all regulatory requirements, provide notification to the Nuclear Regulatory Commission (if required), and provide a verification of material receipt.

- **Disposal by Transfer:** Radioactive material can be transferred to an authorized recipient following the procedures in AFI 40-201.

- **Disposal of Specific Wastes:** A licensee may dispose of the following licensed material as if it were not radioactive according the requirements of 10 CFR 20.2005, *Disposal of Specific Wastes*:

- 0.05 microcuries, or less, of hydrogen-3 or carbon-14 per gram of medium used for liquid scintillation counting; and
- 0.05 microcuries, or less, of hydrogen-3 or carbon-14 per gram of animal tissue, averaged over the weight of the entire animal.

For additional information, see Sections 3.9, 3.10, and Attachments 9 and 10 of AFI 40-201, *Managing Radioactive Materials in the US Air Force*.

4.6.2. Medical. Medical waste (MW) consists of sputum, surgical dressings, swabs, disposable diapers, culture media, pathological tissues, blood clots and blood, live vaccine containers, syringes, and other materials from infectious patients. The standard methods of disposing of infectious waste are burying and incineration. If waste is buried, it must be

mounded with compacted soil and marked with a sign reading, “Medical Waste”. However, controlled incineration is the preferred method for disposal of infectious waste. The inclined-plane incinerator (Figure 4-C) is an approved means for incineration of MW in the field. Do not dispose of MW in a barrel incinerator or by open burning.

In the US, most states do not define the specific requirements for MW disposal. They allow incineration, decontamination/sterilization followed by packaging to prevent a health hazard and disposal in an authorized landfill. However, not all landfills accept sterilized MW and pathological waste. It is critical you learn and follow the requirements of your beddown location. Your first stop should be your legal office either at your beddown location or your supporting MAJCOM. See Section 4.20 of AFI 41-201, *Managing Clinical Engineering Programs* for additional information.

Section 5.0: OEHSA – Occupational

5.1. Routine Assessment: The principal purposes of routine assessment are to:

- Identify OEH support requirements
- Identify potential OEH hazards related to a process/processes
- OEH hazard risk determination based on confidence in exposure characterization, confidence in existing hazard controls, probability, and severity
- Assign a qualitative risk to each hazard

A routine OEH assessment report should be written to the workplace supervisor and should include:

- Recommendations and required follow-up actions, including suspense dates
- Compliance Assessment Checklist summarizing OEH program areas evaluated, including summary of compliance status for each area
- Certified PPE listing that links PPE to work center processes
- Cover letter directing the workplace supervisor to make the report and attachments available to all employees

5.2. Special OEH Assessment: It is the responsibility of BE to periodically review the list of special assessment requirements and adjust priority based on risk, or as required by local conditions.

5.2.1. Quantify Potential Exposures Identified During Routine Assessment

- Perform periodic control evaluations (i.e., quarterly ventilation surveys to maintain confidence in the effectiveness of established controls)
- Evaluate unscheduled requests (e.g., pregnancy evaluations, OEH illness investigations, etc)
- Sustain compliance with regulatory requirements

5.2.2. Other Special Assessments: Special assessment requirements are generally identified during routine assessment but may also be identified by other means, e.g., illness or injury reports.

- Prioritize and perform Special Assessment IAW AFMAN 48-146.
- Periodically review the list of Special Assessment requirements and adjust priority based on risk, or as required by local conditions.

5.3. Ionizing Radiation: The most commonly encountered types of ionizing radiation are alpha, beta, neutron particles, and x-rays or gamma electromagnetic radiation. All types of radiation can be absorbed and they will transfer energy to the absorbing body. Radiation surveys and radioactive material management are accomplished in accordance with AFI 48-148 (www.e-publishing.af.mil/pubfiles/af/48/afi48-148/afi48-148.pdf). Basic radiation information for conducting radiation surveys are below. Additional information can be found in the AFI and 10 CFR Part 20--Standards for Protection Against Radiation.

5.3.1. Curie and Becquerel: The curie (Ci) is the unit associated with how many atoms are disintegrating in a given period of time. A curie (Ci) is defined as the amount of

radioactive material in which the number of atoms disintegrating each second is equal to 3.7 x 10^{10}(37 billion), or 1 Ci = 37 billion disintegrations per second (dps). The SI unit of activity is the becquerel (Bq). It represents the quantity of radioactive material which undergoes one disintegration per second (dps).

5.3.2. Absorbed Dose: Absorbed dose is the amount of radiation energy absorbed or deposited per unit of mass. There are both conventional and SI units of measurement for absorbed dose.

The conventional unit of absorbed dose is the radiation absorbed dose (rad)**.** The SI-derived unit of absorbed dose is the gray (Gy), equivalent to the deposition of one joule of energy per kilogram (1 J/kg) of mass; 1 Gy = 100 rad.

Dose-rate conversion factors can be used to derive dose from activity measurements. These are specific to the type of detector. A dose-rate conversion factor for a side-window GM detector with the window open is 2000. A dose-rate conversion factor for a pancake GM detector is 2400. Simply multiply the dps reading by the conversion factor to get mrem/hr. Source: hps.org/publicinformation/ate/q82.html.

5.3.3. Quality Factor: The quality factor converts the absorbed dose (in rads or grays) to a unit of dose equivalence. A quality factor is necessary to relate the effects of radiation because the same amounts absorbed (energy per kilogram of tissue) of different kinds of radiation cause different degrees of damage. Each specific type and energy of radiation has its respective quality factor. Table 5-1 lists the quality factors for different types of radiation.

$$Q = H/D$$

Where:

Q = quality factor
H = dose equivalent
D = absorbed dose

Table 5-1: Quality Factors

Radiation Type	Quality Factor (Q)
X-rays, gamma rays, positrons, electrons (including beta particles)	1
Neutrons ≤ 10 keV	3
Neutrons ≥ 10 keV	10
Protons and singly-charged particles of unknown energy with rest mass > 1 amu	10
Alpha particles and multiple charged particles (and particles of unknown charge) of unknown energy	20

Source*: Extracted from Table 4-1, IOH-SD-BR-SR-2005-0004)*

5.3.4. Dose Equivalent: Once the quality factor has been applied, the measure is called the dose equivalent and is listed in units of either rem or sievert. The rem and sievert are measures of rad or gray corrected (using the quality factor, Q) to account for the biological effects caused by a given type of radiation.

rem = rad x Q
sievert = gray x Q

5.3.5. Industrial Radiography: The three types of industrial radiography are protective, enclosed and unshielded installations. Unshielded are considered the most hazardous. An unshielded facility or area must be cordoned off to limit the exposure rate at the rope barrier to 2 milliroentgens (mR) in any single hour or 10 mR in any seven consecutive days. The rope barrier must be posted with radiation signs to prevent accidental exposure to unauthorized personnel.

5.3.6. Medical/Dental X-Ray Scatter Radiation Surveys: These surveys are preformed to verify occupied adjacent rooms are shielded properly from scatter radiation and exposures remain below 10 mR per week. To convert measurements from mR/hr to mR/wk use the following calculation:

$$Dose(mR/wk) = dose\frac{mR}{hr} \times \frac{1hr}{3600\sec} \times t_{avg/film}(\sec) \times f_{films/wk}$$

Source*: USAF OEHL Report 85-144RI111HXA, Ionizing Radiation Guidebook for Bioenvironmental Engineers*

5.3.7. EOD/OSI Surveys: The kVp and mA are fixed. Initial measurements are usually taken at the individual's normal operating position. If measurements are higher than 2 mR/hr at the operating position, move back and continue taking measurements until exposures are below 2 mR in an hr. Move the operators position to the 2 mR/hr line. This is not the same as the 2 mR/hr dose rate, but rather based on the actual dose the operator receives in an hour.

5.3.8. Radioactive Material Storage Areas

- Unrestricted Area – Radiation intensity does not exceed 2 mR/hr at one foot from any one container and the container is labeled with AFTO Form 9B. An AFTO Form 9C must be posted in the storage area and the area must be surveyed once a year.
- Controlled Area – Surveys are conducted quarterly or annually for areas designated as a controlled area for radioactive storage.
- Restricted Area – Radioactive material exhibiting radiation intensities in excess of 2mR/hr at one foot from any single storage container. Area is restricted to prevent entry by unauthorized personnel.
- IAW AFI 48-148, www.e-publishing.af.mil/pubfiles/af/48/afi48-148/afi48-148.pdf

5.3.9. Abnormal Exposures: An abnormal exposure is considered any exposure received in a single monitoring period that (if continued at the same rate) would exceed the limits specified in 10 CFR 20 - http://www.nrc.gov/reading-rm/doc-collections/cfr/part020.

Table 5-2: Abnormal Radiation Doses

The More Restrictive of	Monthly Dosimeter	Quarterly Dosimeter
Total Effective Dose Equivalent	≥ 417 mrem	≥ 1250 mrem
Sum of deep dose equivalent and committed dose equivalent to any individual organ or tissue other than the lens of the eye	≥ 4170 mrem	≥ 12500 mrem
Eye dose equivalent	≥ 1250 mrem	≥ 3750 mrem
Shallow dose equivalent to skin or extremity	≥ 4160 mrem	≥ 12500 mrem
Internal deposition of any radionuclide	≥ 10% of ALI	≥ 25% of ALI
ALARA constraint	≥ 2 SD above mean for all with same AFSC	

Source: *Table 1, AFI 48-125 Personnel Ionizing Radiation Dosimetry*

In addition, internal deposition of any radionuclide exceeding 10% of the applicable annual limit on intake (ALI) in one month or 25% of the applicable ALI in one calendar quarter is considered to be an abnormal exposure.

Table 5-3: Physiological Effects of Radiation Exposure

Radiation Exposure	Biological Effects
1 rem	No acute affects, very small chance of cancer
5 rem	No noticeable changes
25 rem	Blood changes
50 rem	No observed effects
75-100 rem	Nausea and vomiting on day of exposure in 10% of exposed personnel
200 rem	Nausea, vomiting, malaise, fatigue, fever, blood changes several hours after exposure; hair loss within weeks after exposure
200 - 300 rem	Anorexia, fatigue, weakness, fever, infection in 50% of exposed personnel
400-600 rem	Reversible bone marrow destruction: bleeding and ulceration in most personnel; 50% death in 2-4 weeks
700 rem	Irreversible bone marrow destruction
1000 rem	Severe nausea, vomiting and diarrhea immediately after exposure; 100% death 1-2 weeks after exposure

Source: *EPA Radiation Safety Superfund Sites (165.1), Environmental Response Training Program with additional information*

5.3.10. Ionizing Radiation Protection – Controls

5.3.10.1. Time –There is a direct relationship between exposure dose and duration of exposure; reducing the exposure time by one-half reduces the dose received by one-half.

5.3.10.2. Distance – For gamma and x-ray point sources, and to some extent neutrons, the inverse square law can be applied to determine the change in radiation exposure with change in distance from a radiation source. The inverse square law is an approximation; it applies only to a point in free space where there is no scattering of radiation.

$$\mathbf{I_1 d_1^2 = I_2 d_2^2}$$

Where:

I_1 and d_1 = original intensity and distance

I_2 and d_2= new intensity and distance

To estimate gamma or x-ray intensities from radioactive materials at distance of interest:

$$I = \frac{6CEn}{d^2}$$

Where:

C = source activity in curies from I (R/hr); use mCi for I in mR/hr

E = energy of the emitted photons in MeV.

n = fraction of decays resulting in photons with an energy of E.

d = distance from source in feet

Table 5-4: Gamma Emission Energy and Frequency for Isotopes

Isotope	Energy (keV)	Frequency	Isotope	Energy (keV)	Frequency	Isotope	Energy (keV)	Frequency
P-32	None		I-131	284	0.06	Ra-226*	242	0.08
Co-60	1173	1.0		364	0.81		295	0.19
	1333	1.0		640	0.07		352	0.36
Se-75	121	0.17	Cs-137	662	0.90		609	0.47
	136	0.59	Yb-169	57	2.3		1120	0.17
	264	0.60		120	0.30	DU	63	0.04
	280	0.25		308	0.11		93	0.05
	400	0.11	Tm-170	52	0.03	HEU**	143	0.004
Sr-90/ Y-90	None			81	0.02		185	0.02
			Ir-192	308	1.4	Pu-238	Low-energy x-rays	
Mo-99	181	0.06		468	0.48	Pu-239	Low-energy x-rays	
	740	0.13		607	0.13	Am-241	59.5	0.36
I-125	27	1.12	Po-210	Negligible		Cf-252	Low-energy x-rays	
	31	0.25						

Source: BEE Guide to Ionizing Radiation (2005)

5.3.10.3. Shielding – The amount of mass placed between a source and a person is exponentially proportional to radiation attenuation. Shielding must be properly selected so

that it will absorb the specific type of radiation emitted by the source. Attenuation, not total absorption is the objective. Attenuation of photon energy is determined by using the following equation:

$$\mathbf{I = I_0 e^{-\mu x}}$$

Where:

I = attenuated radiation exposure rate
I_0 = original radiation exposure rate
e = base of natural logarithms
μ = linear absorption coefficient (cm^{-1}) (Table 4-X in Chapter 4, Radiological has typical μ values for common isotopes and materials)
x = absorber thickness

Rearranging the equation and solving for thickness (x):

$$x = -\frac{Ln(\frac{I}{I_o})}{\mu}$$

Half-value layers (HVL) and tenth-value layers (TVL) are used in the calculation of the thickness of various materials to reduce exposure rate from gamma or x-ray source to one-half or one-tenth the original value. HVLs and TVLs for different materials and photon energies can be found in the Handbook of Health Physics and Radiological Health (3^{rd} Ed). To determine the number of HVL:

$$\#HVLs = \frac{Ln(\frac{I}{I_o})}{Ln(0.5)}$$

Equations obtained from the Brooks AFB Ionizing Radiation Management Course

Tables 8-15 and 8-16 in Chapter 8 Radiological offer guidelines for the amount of shielding required to reduce the radiation level to one-half its original value for photons and one-tenth its original value for nuclear accidents respectively.

5.4 Radiofrequency Radiation: The most common categories of radiofrequency (RF) radiation encountered during Air Force activities are:

- Radio Detection and Ranging (RADAR) and Electronic Counter Measures (ECM), these are the most hazardous
- Communication air-to-ground, air-to-air and ground mobile
- Navigational aides
- Repair and maintenance facilities (i.e., test stands in workplaces – dummy loads)
- Medical equipment and industrial devices

Radiofrequency radiation emitters are classified as either continuous wave or pulsed. For continuous wave emitters, the RF signal is transmitted continuously without any breaks. For pulsed emitters the signal is turned on/off repeatedly in a cyclic pattern at a high rate. Refer to AFOSH STD 48-9 (www.e-publishing.af.mil/pubfiles/af/48/afoshstd48-9/afoshstd48-9.pdf) for additional information and program requirements.

5.4.1. Permissible Exposure Limit (PEL) Of RF Radiation Emitters: The permissible exposure limit (PEL) is based on a six minute exposure for frequencies less than 15 GHz and reduced for higher frequencies (i.e., 10 seconds at 300 GHz). The basis for the PEL is the frequency and whether the exposure is in a controlled or uncontrolled environment. For exposures less than six minutes in controlled environments, the 6 minute equivalent is calculated with:

$$6\,\text{min}\,equivalent = \frac{Exposure(mW/cm^2) \times t_{\text{min}}}{6\,\text{min}}$$

5.4.2. Multiple Frequency Exposure: Calculate the compliance factor (CF) for simultaneous exposure to more than one frequency range and compare to unity (i.e., 1).

$$CF = \frac{TWA_1}{PEL_1} + \frac{TWA_2}{PEL_2} + \ldots \frac{TWA_n}{PEL_n}$$

Once the summation of these ratios has been determined, the exposures can be classified as:

CF $\leq$ 1 – no overexposure from multiple frequencies
CF > 1 – overexposure from multiple frequencies

5.4.3. Hazard Distance Calculations: The hazard distance (D_{PEL}) of an RF system is equal to the distance (in meters) from the antenna to the point where the power density level is equal to the permissible exposure limit. There are two calculations depending on if the system has stationary or rotating antennas.

Stationary System: In the event you are surveying a system with a stationary antenna, you will use the following hazard distance (D_{pel}) calculation:

$$D_{pel} = \sqrt{\frac{P_{ave} \times G_{abs}}{40\pi PEL}}$$

Where:
P_{ave}=Average power
G_{abs}=Absolute gain

Rotating System: Use the following equation to calculate the hazard distance for rotating systems.

$$D_{pel} = \sqrt{\frac{P_{ave} \times G_{abs} \times RRF}{40\pi PEL}}$$

Where:

P_{ave}= Average power
G_{abs}= Absolute gain
RRF= Rotational Reduction Factor

To convert the D_{pel} in meters to feet, multiply the D_{pel} in meters by 3.28.

Hazard Distance Calculation: Begin the hazard distance calculation by calculating the average power. The peak power and average power are the same for continuous wave emitters.

$$P_{avg} = P_p \times PW \times PRF$$

Where:
P_{avg} = average power
P_p = peak power
PW = pulse width
PRF = pulse repetition frequency

Or:

$$P_{avg} = P_p \times DF$$

Where:
DF = duty factor = PW x PRF

Absolute Gain:
Aperture antenna: In the event the system uses an aperture antenna, the following formula is used to calculate the absolute gain:

$$G_{abs} = \frac{4\pi A}{\lambda^2}$$

Where:
A = area of the aperture antenna
λ = signal wavelength

Other antenna types: If there is any other type of antenna besides an aperture antenna, the absolute gain will be calculated using the following formula:

$$G_{abs} = 10^{\frac{Gain}{10}}$$

Rotational Reduction Factor: The rotational reduction factor (RRF) pertains to rotating or scanning systems only. The antenna must be put into a stationary mode to perform measurements. If the system cannot emit in a stationary position it is best to calculate the hazard distance with RRF, perform a risk assessment and then make recommendations rather than try to take measurements.

$$RRF = \frac{BeamWidth}{SectorSize}$$

5.4.4. Inspecting RFR Emitter Sites: The primary reasons for inspecting the emitter site is to determine if it is accessible to personnel and to determine if power density measurements will be required.

RFR emitters defined as low-power devices, may be considered non-hazardous equipment, and are excluded from the PELs as long as the radiating structure is not maintained within 2.5 cm of the body. The criteria for low-power devices are based on a combination of frequency range and radiated power of the system. No further evaluation or data collections are required for non-hazardous emitters. Hand-held radios, cellular telephones, etc., usually fall into the non-hazardous category.

5.4.5. RFR Overexposures: To predict if an RFR exposure could have exceeded the PEL, it is necessary to setup a reenactment of the incident. Quantify the power density at the location where the person was allegedly exposed and combine this with the length of exposure to determine the power density time-weighted average (TWA); document and report all findings.

$$PowerDensity_{TWA} = \frac{S_1 \times T_1}{T_{avg}}$$

Where:
S = calculated maximum power density from specific antenna region
T_1= exposure time
T_{avg}= averaging time as a function of frequency (See Table 2.1 and 2.2 in AFOSH 48-9 for appropriate times)

5.4.6. Risk Rating Assignment: After the survey work is complete the next step is for BE to evaluate existing control measures. Table 5-5 lists examples of the controls required based on different risk levels.

5.4.7. RFR Protection: The basic protections for RFR exposures are time and distance.

5.4.7.1.Time – The longer the exposure, the greater the chance for radiation injury. Reducing the exposure time by one-half reduces the dose received by one-half.

5.4.7.2. Distance – The inverse square law can be applied to determine the change in radiation exposure with change in distance from a radiation source. By doubling the distance from the source of the radiation, the exposure decreases to one-fourth the original amount.

Table 5-5: RFR Risk Ratings and Controls

Risk	Risk Definition	Controls	Examples
Low Risk	• RF system is not capable of producing levels at or above the PEL • Transmission time is too short to exceed the average power density	Built in controls	• Low-power excluded devices • Auto mounted or hand held radar guns used for traffic control
Moderate Risk	RF system is capable of producing power densities in excess of PEL, but physical controls are in place to preclude exposure under normal operating conditions, test or maintenance procedures	• Azimuth blanking • Dummy loads • Flashing lights • Interlocks	• Radar test stands • B-52 ECM Pods • Ground radar unit • PAVE PAWS early warning
High Risk	RF systems that can and do produced average power densities at or above the PEL and are accessible to personnel during normal operating procedures	• Signs, ropes, barriers, cones fences • Constant observation • Interlocks • Flashing lights • Audible signals • Brief visitors before entering controlled environment	Nose mounted radar on small aircraft where the beam is accessible from the ground and routinely operated in a stationary mode for maintenance

5.5. LASERS: The laser program is managed and maintained IAW AFOSH STD 48-139 (ww.e-publishing.af.mil/pubfiles/af/48/afoshstd48-139/afoshstd48-139.pdf).

5.5.1. LASER Hazards: Laser hazards are categorized based on frequency, power, and concentration of the beam. The power or intensity of the beam determines the amount of damage that can occur to the eyes or skin. The frequency determines the type of injury that occurs based on the depth of penetration of the beam into the organ. Table 5-6 correlates various wavelengths of light with parts of the eye that can be affected. Other hazards associated with lasers include chemical lasing media, targets, exhaust discharge products, high voltage radiation, noise, electrical, fire, and explosion.

Table 5-6: LASER Eye Effects

Spectrum Region	Wavelength (nm)	Site of Damage
Far UV	200-315	Cornea burns
Near UV	315-400	Mostly lens, some cornea
Visible Light	400-700	Retina burns
Near IR	700-1400	Retina burns
Far IR	1400-10^6	Cornea burns

5.5.2. Laser Protection and Controls: Engineering controls for lasers are listed in Table 5-7. Administrative controls include warning signs and training. PPE mainly consists of laser eye protection (LEP), and is used when engineering controls are not feasible or enough to protect the worker from overexposure. LEP must be matched to the specific

wavelength of the laser and have an optical density (OD) (discussed below) sufficient to protect the worker against the power or that particular laser. These properties are usually stamped somewhere on the LEP. To evaluate the LEP for adequacy, compare the laser wavelength and the LHaz-calculated OD to the specifications of the LEP. If the LEP does not protect at the same wavelength and the OD is not dark enough, alternate LEP must be recommended.

Table 5-7: LASER Control Measures per ANSI Z136.1-2000

ANSI Table
Control Measures for the Four Laser Classes

Control Measures	Classification				
Engineering Controls	1	2	3a	3b	4
Protective Housing (4.3.1)	x	x	x	x	x
Without Protective Housing (4.3.1.1)	LSO shall establish Alternative Controls				
Interlocks on Protective Housing (4.3.2)	▽	▽	▽	x	x
Service Access Panel (4.3.3)	▽	▽	▽	x	x
Key Control (4..3.4)	–	–	–	•	x
Viewing Portals(4.3..5.1)	–	MPE	MPE	MPE	MPE
Collecting Optics (4.3.5.2)	MPE	MPE	MPE	MPE	MPE
Totally Open Beam Path (4.3.6.1)	–	–	–	x NHZ	x NHZ
Limited Open Beam Path (4.3.6.2)	–	–	–	x NHZ	x NHZ
Enclosed Beam Path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled				
Remote Interlock Connector (4.3.7)	–	–	–	•	x
Beam Stop or Attenuator (4.3.8)	–	–	–	•	x
Activation Warning Systems (4.3.9.4)	–	–	–	•	x
Emission Delay (4.3.9.1)	–	–	–	–	x
Indoor Laser Controlled Area (4.3.10)	–	–	–	x NHZ	x NHZ
Class 3b Indoor Laser Controlled Area (4.3.10.1)	–	–	–	x	–
Class 4 Laser Controlled Area (4.3.10.2)	–	–	–	–	x
Laser Outdoor Controls (4.3.11)	–	–	–	x NHZ	x NHZ
Laser in Navigable Airspace (4.3.11.2)	–	–	•	•	•
Temporary Laser Controlled Area (4.3.12)	▽ MPE	▽ MPE	▽ MPE	–	–
Remote Firing and Monitoring (4.3.13)	–	–	–	–	•
Labels (4.3.14 and 4.7)	x	x	x	x	x
Area Posting (4.3.9)	–	–	•	x NHZ	x NHZ

LEGEND
x - Shall
• - Should
– - No requirement
▽ - Shall if enclosed Class 3b or Class 4
MPE - Shall if MPE is exceeded
NHZ - Nominal Hazard Zone analysis required

5.6. Chemicals

5.6.1. Hazardous Materials Acquisition: During deployments, the contracting officer will most likely be responsible for all chemical acquisition; a HazMat Pharmacy may not exist. In these cases, BE should establish a process by which the contracting office will not purchase products containing hazardous materials without BE coordination/approval.

5.6.2. Exposure Routes: Hazards and Controls

5.6.2.1. Absorption/Contact Hazards: Chemical absorption through the skin can be a significant contributor to the overall dose a person receives. Published instructions for the control of health hazards relating to chemical exposures, such as the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs)/Biological Exposure Indices (BEIs), will provide guidelines to prevent absorption hazards. The ACGIH TLVs/BEIs booklet provides the designation of "Skin" in its "Notations" column, to designate substances which have high risk of cutaneous exposure.

5.6.2.2. Absorption/Contact Controls: Information on the types of protective material suitable for certain chemicals are listed below.

Table 5-8: Chemical Protective Materials

Chemical	Protective Material
i) Formaldehyde, Glutaraldehyde	Butyl Rubber
HMDI	Saranex, Barricade, Responder
TDI	Butyl Rubber, Nitrile Rubber, Viton, Polyvinyl Alcohol, Polyvinyl Chloride, Saranex, Barricade, Responder
1,1, Dichloroethane	Viton (1-4 hours)
Methylene Chloride	Polyvinyl Alcohol, Barricade, Responder
1,1,1, & 1,1,2 Trichloroethane	Viton, Polyvinyl Alcohol
Trichloroethylene	Polyvinyl Alcohol, Viton
Vinyl Chloride	Nitrile (> 4 hr), Viton (> 4 hr)
Polychlorinated Biphenyls	Butyl Rubber, Neoprene Rubber, Viton
n Hexane	Nitrile Rubber, Polyvinyl Alcohol, Viton, Barricade, Responder
Naphtha (<3% - 20%)	Nitrile Rubber, Polyvinyl Alcohol, Viton
Naphtha (<30%)	Nitrile Rubber, Polyvinyl Alcohol, Viton (all > 4 hr)
Gasoline 40-55% aromatics	Nitrile Rubber, Viton
Gasoline unleaded	Viton, Nitrile Rubber (> 4 hr)
Toluene, Xylene	Polyvinyl Alcohol, Viton, Barricade, Responder
Ethyl Benzene	Viton, Barricade
Jet Fuel <30% aromatics	Nitrile Rubber, Viton, Saranex (all > 4hr)
Chlorine gas	Butyl Rubber, Neoprene, Viton
Ammonia	Butyl Rubber, Neoprene, Viton
Chromic Acid	Butyl Rubber, Viton
Hydrochloric Acid 37%	Butyl Rubber, Nitrile (> 4 hr), Neoprene (> 4hr)
Nitric Acid 30-70%	Butyl Rubber, Neoprene (> 4 hr)
Alcohols	Butyl Rubber, Viton
Sulfuric Acid 30-70%	Butyl Rubber, Neoprene, Nitrile Rubber, Viton
MEK	Butyl Rubber, Polyvinyl Alcohol,
MIBK	Butyl Rubber (> 4 hr)

Sources: *http://www.allsafetyproducts.biz/site/323655/page/74172*
http://www.hazmat.msu.edu:591/glove_guide

5.6.2.3. Inhalation:

5.6.2.3.1. Calculating TWA: The Time Weighted Average (TWA) is the average of all the samples in the sample set applied over a period of time, usually 8 hours. This average is compared to the 8-hour TWA-OEL. The formula to calculate an 8-hour TWA is:

$$TWA = \frac{C_1T_1 + C_2T_2 + \ldots C_nT_n}{\sum_{1}^{n} T_n}$$

Where:
C_1 = Concentration of sample one
T_1 = Time of sample one
C_2 = Concentration of sample two
T_2 = Time of sample two
C_n = Concentration of next consecutive sample
T_n = Time of next consecutive sample
Time = Total sample time

5.6.2.3.2. Calculating Confidence in Results: For laboratory methods use parameters provided by the laboratory to determine the 95% upper confidence limit. For field methods, use the DQO tables provided in chapter 1. Refer to the technical guide for more information.

5.6.2.3.3. Determining Sampling Requirements Based on Desired Confidence: Using the tables below, one can estimate the number of samples required to achieve the desired confidence. Based on historical data, hazards associated with USAF operations have shown a variation that corresponds to a geometric standard deviation (GSD) of 2 (Source AFMAN 48-146; NIOSH pub 77-173). However, for processes where the hazards are more consistent and stable, this can be lowered. Additionally, this sampling strategy can be applied to other types of occupational hazards.

Table 5-9: Sampling Requirements

Confidence in Characterization (Consistency in hazard levels throughout the process)		High	Moderate	Low	Very Low
Confidence result will yield correct decision	Decision error (p)	GSD= 1.0	GSD=1.3	GSD=2	GSD=54
99%	1%	5	25	59	350
95%	5%	3	13	30	175
90%	10%	2	8	18	106
80%	20%	1	4	8	46
70%	30%	1	2	3	18

If time constraints only allow one sample to be collected, use table 5-10 to determine confidence based on ratio of result to the OEL. GSD equal to 1.3 approximates general environmental conditions. GSD equal to 1.5 approximates industrial operations; GSD equal to 2.0 is typical for most USAF operations.

Table 5-10: One-sample Confidence Determination

Probability of exceeding AL	Confidence	GSD	Result/OEL
0.05	95%	1.3	0.4
0.2	80%	1.3	0.5
0.4	60%	1.3	0.6
0.6	40%	1.3	0.7
0.05	95%	1.5	0.25
0.1	90%	1.5	0.3
0.3	70%	1.5	0.4
0.5	50%	1.5	0.5
0.05	95%	2	0.1
0.25	75%	2	0.2
0.4	60%	2	0.3

Source: *NIOSH Pub 77-173*

5.6.2.3.4. Compliance Factor: Always do a compliance factor calculation when two or more chemicals have additive effects even if the individual TWAs do not exceed the OELs. The compliance factor (CF) is a unit-less number that will be compared to unity, or 1, and is the sum of the ratio of the TWA and the OEL for each additive chemical.

$$CF = \frac{TWA_1}{OEL_1} + \frac{TWA_2}{OEL_2} + \ldots \frac{TWA_n}{OEL_n}$$

CF $\leq$1; no overexposure from multiple chemicals
CF > 1; overexposure from multiple chemicals

5.6.2.3.5. Screening Samples: The screening samples are intended to give an initial understanding of the activity hazards. As a Rule of Thumb, 3 screening sample sets should be taken to get an initial understanding. Evaluate and interpret the screening sample results in accordance with AFMAN 48-146, *Occupational Health Management Information System* using the following criteria:

If any of the 3day exposure UCL is:	Then you:
<AL	Can be 95% confident that no more than 5% of the daily exposures will exceed the OEL.
> OEL	May enact a detailed analysis plan to better describe the exposure distribution; consider controls
> AL but < OEL	Are uncertain: Should prepare and enact a detailed analysis plan

5.6.2.3.6. Detailed Analysis: During the detailed analysis collect 6-10 sample sets spread out over a period of time. As the results are obtained, compile descriptive statistics to describe the underlying distribution of the daily exposures. Descriptive statistics are used to summarize data, typically their mean, median, and geometric mean (central tendencies) and their range, minimum and maximum, standard deviation, and geometric standard deviation (spreads). These will help determine the accuracy and precision of your data, and ultimately confidence in characterization.

5.6.2.4. Controls for Inhalation Hazards

5.6.2.4.1. Ventilation: Industrial ventilation guidelines and equations are found in the *Industrial Ventilation: A Manual of Recommended Practice* book. The equations below can be used to estimate airflow requirements for dilution ventilation. When observing the location of the dilution ventilation system, be aware of the worker(s) position and the airflow direction. The airflow path should flow in the following direction:

Supply > Worker > Contaminant > Exhaust

The "theoretical" mixing equations assume that complete mixing takes place in the room. This means that all of the air introduced into the room helps to dilute the contaminant to acceptable levels before worker exposure, or if considering fire/explosion hazards, before the vapors reach a source level for possible ignition. Rarely will complete mixing in work environment situations exist. The equations will provide ample airflow needed to keep air contaminants at prescribed levels. Also a safety factor (K) is applied to maintain exposures at acceptable levels based on the work environment makeup.

5.6.2.4.2. Steady-State Condition: The airflow required to dilute a workplace or the environment depends on the physical properties of the contaminant, (i.e., molecular weight, specific gravity, rate of chemical release, the acceptable airborne concentration, and the overall safety factor "K" as mentioned earlier).

The basic equation for the steady-state dilution airflow rate to toxic or irritating contaminants is:

$$Q = \frac{403 \times spgr \times W \times K \times 1{,}000{,}000}{M \times L}$$

Where:
Q = dilution airflow, cubic feet/minute
403 is a constant (if not otherwise noted)
spgr =specific gravity of liquid (water = 1.0)
W =amount of liquid used (evaporated), pints per minute
K = safety factor to increase the calculated airflow rate over the minimum, in order to take non-routine conditions into account. K factors normally range from 3-10 depending on the overall effectiveness of the ventilation system and uniformity of contaminant evolution. A higher K value is associated with poor airflow conditions and other unknown conditions or circumstances, which could increase exposures to workers.
M= molecular weight of contaminant
L = target airborne concentration of contaminant to be maintained in the work environment (usually based on OSHA standards or Threshold Limit Values (TLVs) or Occupational Exposure Limit (OEL) list with an appropriate safety factor), in parts per million (ppm)

5.6.2.4.3. Dilution Ventilation for Health, Concentration-Buildup Control: Some additional terms include:

$$Q' = \frac{Q}{K}$$

Q'= effective ventilation airflow, ft^3/minute
Q = actual ventilation airflow, ft^3/minute
K = dimensionless safety factor that accounts for an airflow that is not effective in dilution contaminants before it's able to reach the employee's breathing zone

$$G = \frac{403 \times spgr \times ER}{MW}$$

Where:
G = vapor generation rate, ft^3/minute
403= This is a constant. It is the volume that 1 pint of liquid, when vaporized, will occupy at STP, cubic feet/pint, if not otherwise noted
spgr = specific gravity of liquid (water = 1.0)
ER = amount of liquid used per time interval (pints/minute)
MW = molecular weight of contaminant

In order to calculate the concentration at any time when the original contaminant concentration is zero, use this equation:

$$C_t = \frac{G\left[1 - e\left(\frac{-Q \times t}{V_r}\right)\right] \times 1{,}000{,}000}{Q}$$

where:

C_t= concentration at any elapsed time t, ppm
G = vapor generation rate
e = base of natural logarithms
Q = effective ventilation airflow
t = time since contaminant release began, minutes
V_r= room volume, ft^3

5.6.2.4.4. Dilution Ventilation for Health, Purging Control: This equation yields the expected concentration at a given time based on airflow and room size. It assumes that the source of the emission has ceased.

$$C_t = C_{original}\left[e\left(\frac{-Q't}{V_r}\right)\right]$$

where:

C_t= concentration at any time t, ppm
$C_{original}$=concentration when generation ceased, ppm
Q = effective ventilation airflow
t =time since contaminant release ceased, minutes
V_r= room volume, ft^3

5.6.2.4.5. Dilution Ventilation for Fire/Explosion Hazards: It is imperative that the dilution process occurs before the contaminant air reaches any ignition sources. Situations involving the accumulation of flammable or explosive mixtures may be found in pits, basements, and other confined spaces. The equation for fire and explosion prevention is:

$$Q = \frac{F \times spgr \times W \times S_f \times 100}{MW \times LEL \times B}$$

Where:

Q = dilution airflow, ft^3/min
spgr = specific gravity of liquid
W = amount of flammable liquid used or released per time interval
S_f= Safety factor depending on percent of LEL to be maintained, usually 4 - 10 (i.e., ¼ to 1/10 of LEL)
100 = Constant for this equation (see note below)
MW = Molecular weight of contaminant
LEL = Lower explosive limit of contaminant, percent
B = Constant reflecting that the LEL decreases at evaluated temperatures. 1 for temperatures up to 250°F and 0.7 for temperatures above 250°F

Note, this equation is based on the assumption that 100% of the dilution air is effectively diluting the contaminant (explosive vapor level) before it can reach any source of ignition. Equations found in the Fundamentals of Industrial Hygiene 5th Edition.

5.6.2.4.6. Contaminant and Volume in a Given Environment: It is common practice to regard the entire mixture as consisting of the components requiring the highest amount of dilution per unit liquid volume. This means the largest percentage of the mixture containing the highest values of specific gravity, molecular weight, and lower explosive level, will dictate the variables.

Some situations or operations require adjustments for air density. Factors affecting density are altitude, humidity, and temperature. For dilution systems, the most common influencing factor is high temperatures such as drying operations in ovens or environments of this nature.

For high temperature applications (drying ovens, etc.), calculate the actual air flow using this conversion based on temperature and pressure since air density is reduced:

$$Q_{actual} = Q_{calculated}\left(\frac{460^{o}F + T}{530^{o}F}\right)$$

Where:

Q_{actual} =dilution airflow at actual temperature in ft^3/min

$Q_{calculated}$ = dilution air flow calculated in ft^3/min

T = actual dilution air temperature in °F

Equations found in the Fundamentals of Industrial Hygiene 5th Edition

5.6.3. Respiratory Protection Program: The Respiratory Protection Program is accomplished IAW AFOSH STD 48-137 (www.e-publishing.af.mil/pubfiles/af/48/afoshstd48-137/afoshstd48-137.pdf). Acceptable Fit-Testing Methods, Assigned Protection Factors and cartridge change-out schedule information can be found on the OSHA website at www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=2275 . Additional information on change-out schedules is located at www.osha.gov/SLTC/etools/respiratory/index.html. Table 5-11 contains some recommended cartridge change-out schedules for Expanded Standard Chemicals.

5.6.3.1. Change-out Schedule: Table 5-12 contains guidance that can be used when information on the manufacturer's respirator and cartridge are unavailable.

Table 5-11: OSHA Expanded Standard Cartridge Change-out Schedule

a.	Acrylonitrile 1910.1045(h)(2)(ii)	end-of-service life or end of shift (whichever occurs first)
b.	Benzene 1910.1028(g)(2)(ii)	end-of-service life or beginning of shift (whichever occurs first)
c.	Butadiene 1910.1051 (h)(2)(ii)	every 1, 2 or 4 hours dependent on concentration according to Table 1 and at beginning of each shift
d.	Formaldehyde 1910.1048 (g)(2)(ii) -	for cartridges every three hours or end of shift (whichever is sooner); for canisters, every 2 or 4 hours according to the schedule in (g)(3)(iv)
e.	Vinyl chloride 1910.1017(g)(3)(ii)	end-of-service life or end of shift in which they are first used (whichever occurs first)
f.	Methylene chloride - 1910.1052 (g)(2)(ii)	canisters may only be used for emergency escape and must be replaced after use.

Table 5-12: Common Chemical Cartridge Change-Out Schedule

Chemical Name	Contaminant Concentration (ppm)				
	50	100	200	500	1000
	Breakthrough Times (minutes)				
Toluene	1018	562	307	135	72
Ethylbenzene	1133	604	319	135	70
m-Xylene	1143	608	321	136	70
Isopropanol	425	286	186	101	61
Ethanol	123	105	85	60	43
1,1, Dichloroethane	234	157	103	57	35
Trichloroethylene	749	441	256	122	68
Methyl Chloroform	618	366	214	102	57
1,1,2 Trichloroethane	976	558	314	143	77
Chloroform	409	263	166	87	52
Carbon Tetrachloride	677	398	231	109	61
Perchloroethylene	1106	609	331	145	77
Butyl Acetate	935	508	273	118	62
Acetone	118	92	69	44	30
2-Butanone (MEK)	423	271	170	88	52
Pentane	332	205	124	63	37
Hexane	585	334	189	87	48
Triethylamine	747	412	225	100	53

Source: *American Industrial Hygiene Association Journal 35:391-410, 1974.*

5.6.3.2. Change Schedules For Mixtures: Where the individual compounds in the mixture have similar breakthrough times (i.e., within one order of magnitude), service life of the cartridge should be established assuming the mixture stream behaves as a pure system of the most rapidly migrating component or compound with the shortest breakthrough time (i.e., sum up the concentration of the components). Where the individual compounds in the

mixture vary by two orders of magnitude or greater, the service life may be based on the contaminant with the shortest breakthrough time.

5.6.3.3. Chemical Contaminant Migration: Where contaminant migration is possible, respirator cartridges should be changed after every work shift where exposure occurs unless the employer has specific objective data to the contrary (desorption studies).

5.6.3.4. Rules of Thumb: This information can be found in Chapter 36 of the American Industrial Hygiene Association "*The Occupational Environment – Its Evaluation and Control.*" publication.

- If a chemical's boiling point is >70 C and the concentration is less than 200 ppm you can expect a service life of 8 hours at a normal work rate
- Service life is inversely proportional to work rate
- Reducing concentration by a factor of ten will increase service life by a factor of five
- Humidity above 85% will reduce service life by 50%

5.7. Physical Hazards

5.7.1. Noise

5.7.1.1. Point-Source Noise Hazards: Sound levels for noise sources may be used in conjunction with the estimated exposure times to calculate the representative equivalent sound level for a given time period, L_{eqT}. The mathematical formulas used for this purpose are the L_{eqT} and the Compliance Factor calculation. The L_{eqT} calculation yields a time weighted average (TWA) in decibels, dB(A) that is compared to the criterion level of 85 dB(A).

$$L_{eqT} = 10\log\left[\frac{1}{T}\sum t_i 10^{0.1L_i}\right]$$

The LeqT formula is somewhat simplified as:

$$L_{eqT} = 10\log\left[\frac{t\times 10^{\left(\frac{dBA_1}{10}\right)} + t\times 10^{\left(\frac{dBA_2}{10}\right)} + \ldots t\times 10^{\left(\frac{dBA_n}{10}\right)}}{480}\right]$$

The second indirect method used to calculate worker exposure is the Compliance Factor (CF) calculation. Results of the CF calculation are a unit-less number to be compared to unity (1). If the sum of the fractions exceeds unity (1) the mixed exposure should be considered to exceed the limit value.

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \ldots \frac{C_n}{T_n} \rangle 1.0$$

Where:
C is the noise level reading obtained from the noise meter in dBA

T is the limiting value in minutes for unprotected noise exposure. It is based on the 85dBA criterion level with a 3 dB exchange rate using the following equation.

$$T = 480x2^{\frac{(85-L_\lambda)}{3}}$$

Where: L_λ = A-weighted sound level

CF $\leq$ 1; no overexposure from multiple frequencies
CF > 1; overexposure from multiple frequencies
Equations found in the AFOSH Std 48-19, *Hazardous Noise Program*

Rule of Thumb: **two identical sources (each with the same number of decibels) produce 3 dB more than a single such source.**

The following formula provides a method of adding noise levels ***when more than two sources are identical***:

$$\boldsymbol{dB_{total} = 10 \log n + dB_1}$$

n = number of identical sources
dB_1 = The dB level for one source

For the three sources of 100 dB each, the total sound level is:
DB_{total} = 10 log 3 + 100
= 10 x 0.477 + 100
= 4.77 + 100
= 104.77 dB (round to 105 dB)

5.7.1.2. (Ambient) Noise Hazards: Air Force bases are required to have noise zone maps that show the estimated aircraft noise levels on and around each base as a part of the Air Installation Compatible Use Zone (AICUZ) Program. AICUZ maps will probably not be established at many deployed areas. Therefore, noise exposure estimates will be conducted by BE. In garrison, CE maintains the AICUZ program but BE should be familiar with the program and provide guidance as needed for proper facility locations during deployments. The information assists in the future siting of noise activities such as engine test stands and aircraft run-up areas. It also helps in determining the position of hospitals, sleeping areas such as tents or barracks, etc. The noise exposure units typically used are L_{eq} and L_{dn}. L_{eq} stands for the equivalent sound level that is the A-weighted level of time-varying noise over a certain period that would contain the same acoustic energy as a continuous level over the same period. L_{dn} (also know as DNL) is the day-night average sound level that is the 24-hour average A-weighted sound level with a 10-dB penalty added to the nighttime period. Table 5-13 shows the recommended outdoor noise environment levels for L_{dn} and L_{eq}. Table 5-14 lists interior noise levels for L_{eq}.

Table 5-13: Acceptable Outdoor Day-Night Noise Levels

	Article II. Outdoor Noise Environment - L_{dn} (DNL)				
Facility	**65-69**	**70-74**	**75-79**	**80-84**	**85-89**
Housing	NR 25	NR 30	NR 35	No	No
Medical Facilities	NR 25	NR 30	No	No	No
	Outdoor Noise Environment - L_{eq}				
Facility	**65-69**	**70-74**	**75-79**	**80-84**	**85-89**
Offices and Administration Bldgs	Yes	NR 25	NR 30	NR 35	NR 40
Medical Facilities	Yes	NR 25	NR 30	No	No

NR: Noise reduction (difference between indoor and outdoor levels)

Table 5-14: Acceptable Indoor Day-Night Noise Levels

Activity	All Noise Sources in Leq (dBA)	Continuous Interior Sources (dBA)
Sleeping	45	40
Hospitals and Churches	50	40
Private Offices and Conference Rooms	50	40
Offices and other Work Spaces	55	40

Source*: Information extracted from EPA's document Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety (EPA, 1974).*

The L_{dn} is calculated by using the following equation:

$$L_{dn} = SEL + 10 \, Log \, (N_d + 10N_n) - 49.4$$

Where: SEL = Sound Exposure Level
N_d = Number of day operations
N_n = Number of night operations

The table below lists the SEL levels for several aircraft. The SEL levels below can be used to calculate the L_{dn} which will determine the average noise levels in areas around the flightline. The L_{dn} levels will than aid in determining appropriate locations for offices, clinics, barracks, etc. This is particularly useful in bed-down situations.

Table 5-15: Aircraft Sound Exposure Levels

Slant Distance (ft)	A-10A Takeoff dB SEL	B-1 Approach dB SEL	B-2A Take off dB SEL	B-52H Take off dB SEL	C-17 Approach dB SEL	C-130H Takeoff dB SEL	C-5A Take off dB SEL	C-141A Take off dB SEL	F-15E Take off dB SEL	F-16 Take off dB SEL	F-22 Approach dB SEL	U-2 Take off dB SEL
100	109.8	113.9	125.8	130.3	115.1	107.2	131.3	123.3	129.8	124.5	126.1	124
250	103.5	108	119.6	123.9	108.6	101.2	125	117	123.7	118.3	119.9	117.8
500	98.2	103.3	114.6	118.5	103	96.5	119.6	111.7	118.8	113.2	114.9	112.8
1000	91.8	98.2	109	112.2	96.5	91.4	113.5	105.8	113.5	107.6	109.3	107.2
1250	89.3	96.4	107	109.9	94	89.6	111.2	103.6	111.6	105.6	107.3	105.2
1600	86.6	94.5	104.9	107.4	91.4	87.7	108.8	101.4	109.7	103.5	105.3	103
2000	83.5	92.5	102.7	104.8	88.7	85.8	106.2	99	107.6	101.4	103.1	100.8
4000	71.9	85.8	95.4	97	80.4	79.6	97.2	91.7	100.9	94.3	96.1	93.4
5000	67.2	83.3	92.7	94.4	77.7	77.3	93.8	89.2	98.5	91.7	93.5	90.7
6300	62.6	80.5	89.9	91.8	74.8	74.9	90.3	86.5	95.8	88.9	90.7	87.8
8000	58.5	77.5	86.9	89.1	71.9	72.3	86.7	83.8	93	86	87.7	84.8
10000	55.3	74.2	83.8	86.4	69	69.7	83	80.9	89.9	82.9	84.5	81.7
12500	52.4	70.7	80.5	83.5	65.9	67	79.3	77.9	86.6	79.7	81.2	78.4
16000	49.6	66.8	77.2	80.4	62.8	64.2	75.4	74.7	83.1	76.2	77.6	74.9
20000	46.6	62.7	73.6	77.2	59.6	61.4	71.5	71.4	79.3	72.4	73.8	71.3

Source: *Extracted from the Flyover Noise Calculator.*

Afterburner and thrust powers are worst case; however, these exposures are in short duration and infrequent. Temperature parameters for the table were set at 70° F and 59%. Noise levels typically increase slightly (usually less than one) in warmer weather with a high humidity than colder weather with a lower humidity.

5.7.1.3. Controlling Noise Exposure: Noise exposures are decreased by process elimination, substitution of material, process changes, and design changes (tools, workstations and equipment). Other engineering controls such as shielding, enclosing the source, mufflers or controlling the vibration of the noise source decrease noise exposures also. Proper maintenance such as replacement or adjustment of worn or loose parts and lubrication of machine parts and use of cutting oils plays a part in controlling noise as well. If the above controls are not feasible, distance the noise source away from the work or sleep area. Finally, hearing protection can be implemented IAW AFOSH Std 48-19. Ear plugs and muffs do nothing to reduce or eliminate the hazard and their failure means immediate exposure to the hazard. The proper attenuation of a particular hearing protector must be considered before it is used during the hazardous noise exposure.

5.7.2. Thermal Stress

5.7.2.1. Heat Stress: BE will begin monitoring when the forecast exceeds 85°F. At that time, a minimum of 4 measurements, evenly-spaced in time will be taken during the hottest part of the day. The results will then be compared to the tables listed below and in AFPAM 48-151 (www.e-publishing.af.mil/pubfiles/af/48/afpam48-151/afpam48-151.pdf) and reported throughout the base.

The first step in performing a base wide evaluation is to calculate an accurate heat stress index. There are two ways to collect a WBGT measurement; (1) with a solar load and (2) without a solar load. In order to calculate a heat stress index using the WBGT wet bulb, black globe, and dry bulb reading must be obtained and plugged into the calculation.

1. Outdoors With Solar Load: ***WBGT = 0.7Tnwb + 0.2Tbg + 0.1Tdb***
2. Absent Solar Load or Indoors: ***WBGT = 0.7Tnwb + 0.3Tbg***

Where:
Tnwb = natural wet bulb
Tbg = black globe
Tdb = dry bulb temperatures

Table 5-16: Wet Bulb Globe Thermometer (WBGT) Index Reference Values

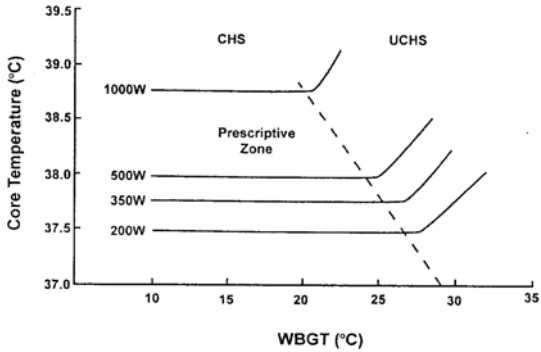
Metabolic Rate Class	Metabolic Rate (M)		*Reference Value of WBGT*			
	Related to a unit skin surface area W/m2	Total (for a mean skin surface area of 1.8 m2) W	Person acclimatized to heat (F)		Person NOT acclimatized to heat (F)	
0 Resting	M<65	M<117	91.4		89.6	
1	65<M<130	117<M<234	86		842	
2	130<M<200	234<M<360	82.4		79	
3	200<M<260	360<M<468	No sensible air movement 77	Sensible air movement 79	No sensible air movement 72	Sensible air movement 73.4
4	M>260	M>468	73.4	77	64.4	68

Table 5-17: Wet Bulb Globe Thermometer (WBGT) Stages, Temperature Ranges and Flag Colors

Stage	Temperature Range	Flag Color
1	78 –81.9F WBGT	No Flag Required
2	82 – 84.9F WBGT	Green
3	85 – 87.9F WBGT	Yellow
4	88 – 89.9F WBGT	Red
5	90F WBGT & Higher	Black

Heat stress can be divided into compensated heat stress (CHS) and uncompensated heat stress (UCHS). CHS and UCHS are primarily determined by biophysical factors (environment, clothing, work rate) and are modestly affected by biological status (heat acclimatization and hydration status). The CHS exists when heat loss occurs at a rate in balance with heat production so that a steady-state core temperature can be achieved at a sustainable level for a requisite activity. CHS occurs in normal daily routines with a work schedule allowing WBGT work rest cycles. The UCHS occurs when the individual's evaporative cooling requirements exceed the environment's evaporative cooling capacity. During UCHS, personnel cannot achieve steady-state core temperature, and core temperature rises until exhaustion occurs at physiological limits. UCHS examples include performing intense exercise in oppressive heat, wearing NBC protective clothing in hot weather (MOPP Levels and Level A), or performing strenuous work in a hot environment. The table below illustrates the steady-state core temperature responses (acclimatized, fully hydrated, lightly clothed person) that might be expected at several metabolic rates and environmental (WBGT) conditions. The metabolic rate is proportional to the amount of body heat that must be dissipated to the environment. Metabolic rates of 250 watt (W), 425 W and 600 W represent easy, moderate and hard military tasks respectively, while 1,000 W represents an activity like competitive running.

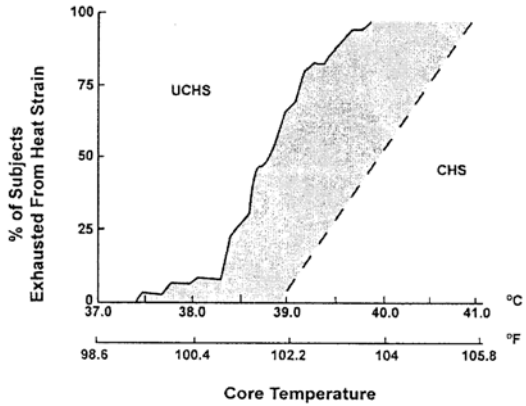
Table 5-18: Core Temperature Responses and Metabolic Rates during CHS and CHS Heat Stress



Source: *TB MED 507/AFPAM 48-152*

Table 5-19 below represents the relationships between core temperature and expected incidence of exhaustion from heat strain. During CHS personnel can tolerate high core temperatures for extended durations and exhaustion is often associated with dehydration or physical fatigue. During UCHS, personnel incur heat exhaustion at relatively low core temperatures due to cardiovascular strain. Most hot-weather military situations fall between these two extremes. The WBGT can be correlated to heat stress incidence using tables 5-18 and 5-19. This is most relevant during emergency response or MOPP operations. The risks of heat stress incapacitation should be compared with incapacitation caused by competing hazards.

Table 5-19: Relationship between Core Temperatures and Exhaustion from Heat Strain during Physical Work in UCHS and CHS



Source: *TB MED 507/AFPAM 48-152*

5.7.2.2. Fighter Index of Thermal Stress (FITS)

The Fighter Index of Thermal Stress is based upon the following formula:

(F) = 0.83Twb + 0.35Tdb + 5.08

FITS is usually calculated by the base meteorological staff and evaluated jointly with the base BE. The calculated FITS index is generally used by aircrew/flyers (not for ground crew). Once the FITS is established, and it's compared to the tables in AFPAM 48-151 (www.e-publishing.af.mil/pubfiles/af/48/afpam48-151/afpam48-151.pdf) recommendations are made to the Squadron Operations Flights. The Squadron Operation Flights then determine the zone applicability within the aircrew working environment and display the appropriate warning color and recommendations for aircrew personnel.

Table 5-20: Fighter Index of Thermal Stress (FITS) Reference Values and Flag Colors

Dry Bulb Temperature	Zone	Dew Point Temperature								
(F)		30	40	50	60	70	80	90	100	>110
70		70	73	76	81	86	X	X	X	X
75		74	77	80	84	89	X	X	X	X
80	NORMAL	77	80	83	87	92	98	X	X	X
85		81	83	86	90	95	101	X	X	X
90		84	87	90	93	98	104	110	X	X
95		88	90	93	96	101	108	112	X	X
100		91	93	96	99	104	109	115	122	X
105	CAUTION	94	96	99	102	107	112	118	124	X
110		97	99	102	105	109	114	120	126	133
115		100	102	105	109	112	117	123	129	136
120	DANGER	104	105	108	111	115	120	125	131	138

5.7.2.3. Activity-Based Heat Stress Evaluation: When evaluating activity-based heat stress there are many more factors one must consider. Between the ACGIH-TLVs and AFPAM 48-151, a number of charts can be found including information on type of clothing, work/rest cycles, metabolic rate categories, fluid intake, acclimatization, and time. All of these factors will play a role in your recommendations. During the screening phase you will utilize the flow chart provided in the ACGIH-TLVs. It will serve as a tool to aid in deciding whether or not a more detailed analysis is required.

Table 5-21: Permissible Heat Exposures –Guidelines for Average Acclimatized Airmen Wearing BDUs, Hot Weather

Heat Cat/Flag Color	WBGT (F)	Easy Work		Moderate Work		Hard Work	
		Work Rest Cycle	Water Intake Qt/hr	Work Rest Cycle	Water Intake Qt/hr	Work Rest Cycle	Water Intake Qt/hr
1	78.1 – 81.9	No Limit	0.5	No Limit	0.75	40/20 min	0.75
2	82 – 84.9	No Limit	0.5	50/10 min	0.75	30/30 min	1.0
3	85 – 87.9	No Limit	0.75	40/20 min	0.75	30/30 min	1.0
4	88 – 89.9	No Limit	0.75	30/30 min	0.75	20/40 min	1.0
5	> 90	50/10 min	1.0	20/40 min	1.0	10/50 min	1.0

Table 5-22: Permissible Heat Exposures –Guidelines for Average Unacclimatized Airmen Wearing BDUs, Hot Weather

Heat Cat/Flag Color	WBGT (F)	Easy Work		Moderate Work		Hard Work	
		Work Rest Cycle	Water Intake Qt/hr[1]	Work[2] Rest[3] Cycle	Water Intake Qt/hr	Work Rest Cycle	Water Intake Qt/hr
1	78.1 – 81.9	No Limit	0.75	50/10 min	0.75	30/30 min	0.75
2	82 – 84.9	No Limit	0.75	40/20 min	0.75	30/30 min	1.0
3	85 – 87.9	No Limit	0.75	30/30 min	0.75	20/40 min	1.0
4	88 – 89.9	50/10 min	0.75	20/40 min	0.75	10/50 min	1.0
5	> 90	40/20 min	1.0	10/50 min	1.0	Not allowed	NA

[1]For all three work rates, individual water requirements may vary by ± 0.25 qt/hr.
[2]When performing work/exercise with ground crew ensemble, fire-fighting gear, MOPP Level 4 or other similar restrictive or impermeable clothing arrangements should be made for remote site measurement of the WBGT and 10ºF added to the measurement. Add 15° WBGT if also wearing combat armor; if combat armor is worn alone in humid climates add only °5 WBGT.
[3]Rest means minimal physical activity (i.e., sitting or standing, accomplished in the shade if possible).

Table 5-23: Guide to Determination of Workload

EASY WORK	MODERATE WORK	HARD WORK
▪ Walking on hard surface @ 2.5 mph with ≤ 30 lb load ▪ Weapon Maintenance ▪ Manual of Arms ▪ Marksmanship Training ▪ Drill and Ceremony	▪ Walking on a hard surface @ 3.5 mph with < 40 lb load ▪ Walking loose sand @ 2.5 mph with no load ▪ Patrolling ▪ Low crawl, high crawl ▪ Defensive position construction ▪ Field Assaults	▪ Walking on hard surface @ 3.5 mph with ≥ 40 load ▪ Walking on loose sand @ 25 mph with load

5.7.2.4. Time: To determine the WBGT for an exposure group that works in different environments (i.e., outdoors with indoor breaks, on the flight line and in a hangar, etc.), use the following TWA equation.

$$WBGT = \frac{WBGT_1 \times T_1 + WBGT_2 \times T_2}{T}$$

Where:
T = Total Time

5.7.2.5. Thermal Stress Controls: Increasing air movement and reducing radiant heat control thermal stress. Administrative controls include acclimation and rotating workers. Personal protective equipment includes ice garments, cooling vests, and reflective clothing.

5.7.2.6. Cold Stress: Most textbook discussions of thermal stress include the problems associated with both heat and cold. However, protection from cold environments is generally much easier, and people do not usually allow themselves to be exposed to the cold for very long without protection. Cold Stress tables are located in AFPAM 48-151 (www.e-publishing.af.mil/pubfiles/af/48/afpam48-151/afpam48-151.pdf). Use Table 5-24 to determine equivalent wind chill factors. Table 5-25 lists several controls measures.

Table 5-24: Wind Chill Temperature Index Reference Values and Advisory Flag Colors

WINDSPEED		TEMPERATURE (F)								
CALM	CALM	40	35	30	25	20	15	10	5	0
KNOTS	MPH	EQUIVALENT CHILL TEMPERATURE								
3 to 6	5	35	30	25	20	15	10	5	0	-5
7 to 10	10	30	20	15	10	5	0	-10	-15	-20
11 to 15	15	25	15	10	0	-5	-10	-20	-25	-30
16 to 19	20	20	10	5	0	-10	-15	-25	-30	-35
20 to 23	25	15	10	0	-5	-15	-20	-30	-35	-45
24 to 28	30	10	5	0	-10	-20	-25	-30	-40	-50
29 to 32	35	10	5	-5	-10	-20	-30	-35	-40	-50
33 to 36	40	10	0	-5	-15	-20	-30	-35	-45	-55
		CAUTION					NO FLY			

Table 5-25: Working Practice Guidance in Cold Environment

Wind Chill Condition	Required Precautions and Hourly Work/Warming Cycle
Standard	Wear gloves, do not perform work for more than 10 minutes, and cover metal handles and bars with thermal insulation
Moderate	Follow Standard precautions, no outdoor activities with water (vehicle/aircraft washing), wear gloves and total body protection, avoid heavy sweating, change wet clothes immediately, implement the "buddy" system 50 MINUTES WORK/20 MINUTES WARMING
Caution	Follow both Standard and Moderate precautions, wear mitten not gloves. 40 MINUTES WORK/20 MINUTES WARMING
Danger	Follow Standard through Caution actions 30 MINUTES WORK/30 MINUTES WARMING
Extreme	MISSION CRITICAL WORK ONLY

a. Warming must be in an indoor, heated environment
b. The unit commander will determine which tasks are mission critical

5.7.2.7. Cold Stress Controls: Controls include increasing air temperature and decreasing air speed in the work zone and providing re-warming areas. Administrative controls include work/rest cycles, move work to warmer areas, schedule work to warmest times and extra breaks if needed. Personal protective equipment includes properly selected insulated clothing, wind barriers, mittens versus gloves in really cold environments and water barriers to external liquids.

5.7.3. Ergonomic hazards: The goal is to generate tolerable working conditions that do not pose safety concerns and is acceptable to the worker. Identify ergonomic issues by talking with employees and walking through the work center to observe employees performing their jobs. The signal risk factors below provide a set of criteria that can be used for recognizing potential problem jobs resulting from routine exposure:

- Repetitive motions for >2 hours at a time or >4 hours/day
- Fixed or awkward postures for >2 hours/day
- Forceful hand exertions for >2 hours/day
- Vibration from tools (or equipment) for >2 hours/day
- Manual material handling >2 hours/day
- Unassisted lifting of loads >25 lb.

5.7.3.1. Evaluation and Control of Ergonomic Hazards: Use the following table to evaluate and determine controls for ergonomic hazards.

Table 5-26: Evaluating and Controlling Ergonomic Hazards

Item	Yes	No
1. Repetitive motions for >2 hours at a time or >4 hours/day. If yes, can you recommend any of the following: o Mechanical aids such as arm rests, power tools, etc o Adjust workload o Rotate workers o Reduce weight of tools o Attach balancers and hoists to support tools o Apply leverage to assist with force		
2. Fixed or awkward postures for >2 hours/day **If yes, can you recommend any of the following:** o Adjust work and work piece so the body, limb, or body part can remain in a comfortable position o Reorient the direction of force in line with the natural movements of the limbs/body o Select tools that allow the wrist to remain straight during use o Provide creepers, rollers, stools, or other support for work underneath aircraft or vehicles so arms and shoulders can remain in a comfortable position		
3. Forceful hand exertions for >2 hours/day If yes, can you recommend any of the following: o Use tools with long handles and handles with rounded edges o Use materials that yield to pressure at contact points (rubber, etc.) o Cushion hard, sharp table edges o Wear soft gloves to reduce pressure o Select gloves or handles that improve grip		
4. Vibration from tools (or equipment) for >2 hours/day If yes, can you recommend any of the following: o Isolate the hand and wrist from the vibration o Select tools with less vibration o Wear gloves that reduce the vibration transmitted from the tool to the hand and arm		
5. Manual material handling >2 hours/day If yes, can you recommend any of the following: o Provide handles on objects to be lifted and carried o Make sure walking and working surfaces are not slippery		
6. Unassisted lifting of loads >25 lb. If yes, can you recommend any of the following: o Use mechanical devices such as rollers, conveyors, and hoists o Use gravity to move objects o Store objects to be lifted at heights between the knees and the shoulders o Store heaviest objects to be lifted at waist height from the floor		

A Level II Work Analysis is used for more complex situations where Level I solutions are not available or do not apply. A Level II Work Analysis quantifies exposure to the extent practical and results in recommended control measures to minimize or eliminate the exposure. A Level II Work Analysis should be performed by someone who has trained on Ergonomics.

Section 6.0: Chemical Threats

6.1. Introduction: Chemical threats are typically characterized as Chemical Warfare Agents (CWA), Toxic Industrial Chemicals (TIC), or other chemical hazards. CWAs are typically synthesized by developed nations, however, proliferation of knowledge and technology have enabled terrorists to synthesize some CWAs. Additionally, industrial accidents have highlighted the need to plan for response to TICs. This chapter covers the broad spectrum of chemical hazards under the emergency response umbrella, however several elements are specific to implementation of the Counter Chemical Warfare Concept of Operations since more information is available on this CONOP.

6.1.1. Threats to Air Bases and Critical Missions: Chemical agents pose a threat to a base's critical assets and missions through denied access of contaminated land, facilities, and assets. CWA also threatens personnel directly. TICs pose a threat to installations through the potential for accidental or intentional releases. BE supports an installation's ability to survive and operate through CCW planning, TIC vulnerability assessments and planning, and emergency response operations.

Planning or Pre-Attack Conditions: BE should partner with other functional areas to conduct a threat assessment from enemies, nation states, industry, and on-base hazards. Vulnerabilities should be identified and countered through preparation and planning. This includes organizing, training, and equipping properly to respond to chemical incidents. Also, BE should identify critical assets and essential missions based on the operational context (i.e, daily in-garrison operations, deployed warfighting, emergency response, etc.) Below are several potential critical assets and missions that should be considered.

Critical Assets	Critical Missions	
• Water sources	• Sortie generation	• Munitions
• Munitions	• C2 element	• Air operations
• Aircraft	• Runway repair	• Space/missile ops
• Personnel	• Combat Air Patrol	• Security
• Weapons	• Aerial port ops	• Strategic airlift
• Hospital	• COCOM tenants	• Air traffic control

Response or Post-Attack Conditions: During response or post-attack, the key objective is mission optimization. BE should work with commanders and decision makers to understand and define essential tasks and functions. In some cases, the response and recovery will be the primary mission. In other cases, launching sorties or a counter-attack will be the primary mission. Sampling and analysis may be conducted to confirm and quantify health risks to support operational risk management. In some cases, other sources of information such as intelligence and physiological effects may be used to support risk management actions.

6.1.2. Operational Effects: Understanding the operational context is key to assessing the impact of a CBRNE event on operations. When determining the impact on mission operations, evaluate chemical threats for their potential to cause incapacitation, lethality, and disruption of operations. BE must be able to provide the Incident Commander (IC) and

Medical Group Commander (MDG/CC) with a clear picture of the consequences of the hazards associated with various chemical threats (i.e., heat stress from PPE, exposure, etc.) as well as the countermeasures under consideration (i.e., de-MOPP, antidotes, etc.). The commander will balance the importance of the current mission with the level of acceptable risk in order to determine the best course of action with optimizes the mission.

6.2. Categories, Characteristics and Symptoms of Chemical Threats

The following information is adapted from: *A Review of the Scientific Literature as it Pertains to Gulf War Illnesses,Volume 5: Chemical and Biological Warfare Agents (5 Dec 00); www.gulflink.osd.mil/library/randrep/bw_paper*

6.2.1. Nerve Agents: Nerve agents are a group of very toxic chemical warfare agents. In their pure state they are colorless and mobile liquids. In an impure state, they may be encountered as yellowish to brown liquids. Some nerve agents have a faint fruity odor. Additional details about the physical properties of the agents listed below can be found in Appendix M. The principle agents include:

- GA – Tabun
- GB – Sarin
- GD – Soman
- GF – Cyclosarin
- VX – Methylphosphonothioic acid

Symptoms vary with the route of exposure.

Minimal Inhalation Exposure

- Watery nasal discharge, nasal hyperaemia, sensation of tightness in the chest and occasionally prolonged wheezing

Slightly Above Minimal Symptomatic Dose

- Miosis, redness of the eyes, pain in and behind the eyes and frontal headache; some twitching of the eyelids may occur; occasional nausea and vomiting
- Systemic manifestations of nerve agent poisoning usually includes tension, anxiety, jitteriness, restlessness, emotional instability, and giddiness
- There may be insomnia or excessive dreaming, occasionally with nightmares

Moderate Inhalation and Skin Exposure

- Symptoms may be evident: headache, tremor, drowsiness, difficulty in concentration, impairment of memory with slow recall of recent events, and slowing of reactions
- In some casualties there is apathy, withdrawal and depression
- Increased fatigability and mild generalized weakness which is increased by exertion followed by involuntary muscular twitching, and occasional muscle cramps
- Pale skin due to vasoconstriction and blood pressure moderately elevated

Severe Inhalation Exposure

- Cardiovascular symptoms will dominate and twitching (which usually appear first in the eyelids and in the facial and calf muscles) becomes generalized

- Extensive rippling movements under the skin; twitching movements in all body parts followed by severe, generalized muscular weakness, including respiratory muscles
- Respirations become more labored, shallow, rapid; then slow and finally intermittent

6.2.2. Blister or Vesicant Agents: Blister or vesicant agents are likely used to both produce casualties and to force opposing troops to increase their MOPP level. These agents degrade fighting efficiency rather than kill, although some doses can be fatal. Additional details about the physical properties of the agents listed below can be found in Appendix M. Blister and vesicant agents include:

- HD – Sulfur mustard or yperite
- HN – Nitrogen mustard
- L – Lewisite (arsenical vesicants may be used in a mixture with HD)
- CX – Phosgene oxime (properties and effects are very different from other vesicants)

Eye Exposure: Conjunctivitis follows exposure of about one hour to concentrations barely perceptible by odor. A latent period of 4 - 12 hours follows mild exposure, after which there is tearing and a sensation of grit in the eyes. The conjunctival and the lids become red. Heavy exposures irritate the eyes producing severe lesions.

Skin Exposure: Small doses to the skin cause redness and intense itching. At higher doses, blister formation starts, generally between 4 - 24 hours after contact lasting for several days before reaching its maximum. The fragile blisters usually rupture spontaneously giving way to a wound characterized by puss and dead tissue.

Inhalation Exposure: Mustard attacks all the mucous membranes of the respiratory tract. Symptoms start with burning pain in the throat and hoarseness of the voice. A dry cough gives way to a lot of expectoration and secretions and dying tissue may obstruct the lungs. The damaged lower airways become infected easily, predisposing to pneumonia after approximately 48 hours. If the inhaled dose has been sufficiently high, the victim dies in a few days.

6.2.3. Choking Agents: These agents attack lung tissue, primarily causing pulmonary edema. This group includes:

- CG – Phosgene
- DP – Diphosgene
- Cl – Chlorine
- PS – Chloropicrin

Inhalation Exposure

- In most fatal cases, pulmonary edema peaks in 12 hours followed by death in 24 - 48 hours. If the casualty survives, resolution commences within 48 hours and, in the absence of complicating infection, there may be little or no residual damage.
- During and immediately after exposure, coughing, choking, a feeling of tightness in the chest, nausea, occasional vomiting, headache and tearing of the eyes occurs.
- Post-exposure, the patient might show no abnormal chest signs and the patient may be symptom-free. This interval commonly lasts 2 - 24 hours but may be shorter. Then, the

onset of pulmonary edema begins. These signs and symptoms include cough dyspnea, rapid shallow breathing, occasional nausea/vomiting and cyanosis.
- As the edema progresses, discomfort, apprehension and dyspnea increase; frothy sputum develops.
- The patient may develop shock-like symptoms, with pale, clammy skin, low blood pressure and feeble, rapid heartbeat.

6.2.4. Pulmonary Agents (Blood): These agents prevent cell respiration and the normal transfer of oxygen from the blood to body tissues. These agents include:
- AC – Hydrogen Cyanide
- CK – Cyanogen Chloride

Skin and Eye Exposure: Causes redness of the eyes and flushing of the skin.

Inhalation Exposure:
- Irritates the respiratory tract, causes shortness of breath, confusion, headaches, nausea, coughing and possible confusion
- At high concentrations, causes effects within seconds and death within minutes

6.2.5. Vomiting Agents/Respiratory Irritants: These agents irritate the respiratory tract several minutes after exposure, cause great discomfort and force personnel to remove their protective masks. These agents include:
- DM – Adamsite
- DA – Diphenylchlorarsine
- DC - Diphenylcyanarsine

Eye Exposure: Irritant
Inhalation Exposure: Causes irritation of the mucous membranes, nasal discharge, sneezing, coughing, severe headache, nausea and vomiting.

6.2.6. Irritant Agents: Irritant agents are riot control agents that rapidly produce sensory irritation or disabling physical effects that disappear within a short time following termination of exposure. These agents include:
- CN – Chloroacetophenone
- CA – Bromobenzylcyanide
- CS – O-Chlorobenzylidene Malonitrile
- CR – Cibenzoxazepine

Eye and Skin Exposure:
- Causes tearing of the eyes
- Skin irritant and some agents cause blisters at high concentrations

Inhalation Exposure: Causes respiratory tract irritation and burning, difficulty breathing, coughing, headache and nasal drip

6.2.7. Incapacitating Agents: Classified as non-lethal and temporarily immobilizes personnel by interfering with the higher functions of the brain such as attention, orientation, memory, conceptual thinking, planning and judgment. These agents include:

- BZ – 3 quinuclidinyl benzilate
- LSD – Lysergic acid diethylamide

Skin Exposure: Causes redness

Inhalation Exposure: Causes fast heartbeat, dry skin, blurred vision and at high concentrations causes extreme delusions, hallucinations, and excitement

6.2.8 Toxic Industrial Chemicals and Toxic Industrial Materials (TIC/TIM): These compounds generally have a lethal dose 10 to 100 times less toxic than nerve agents, but are more widely available. Below are the top 25 ranked chemicals identified as potential TIC/TIM threats according to the NATO International Task Force:

Ammonia	Arsine	Boron trichloride
Boron trifluoride	Carbon Disulfide	Chlorine
Diborane	Ethylene oxide	Fluorine
Formaldehyde	Hydrogen bromide	Hydrogen chloride
Hydrogen cyanide	Hydrogen fluoride	Hydrogen sulfide
Nitric acid, fuming	Phosgene	Phosphorus trichloride
Sulfur dioxide	Sulfuric acid	Tungsten hexafluoride

The signs and symptoms of chemical agent exposure depend upon the concentration, route of exposure, and duration of exposure.

Table 6-1: Time Onset of Symptoms

Symbol and Name of Chemical Agents	Time of Onset of Symptoms (Inhalation)	Time of Onset of Symptoms (skin)
Nerve Agents		
GA=Tabun	Seconds to minutes	2 hours
GB=Sarin	Seconds to minutes	2 hours
GD=Soman	Seconds to minutes	2 hours
GF=Cyclosarin	Seconds to minutes	Up to 2 hours
VX	Seconds to minutes	Up to 18 hours
Vesicants and Blister Agents		
H and HD=Sulfur Mustard	4 - 6 hours	2 - 48 hours
HT=Sulfur Mustard-T mixture	Delayed	Delayed
HN=Nitrogen Mustard	4 -6 hours	4 - 12 hours+
L=Lewisite and other arsenical vesicants	Immediate	Immediate
HL=Mustard/lewisite mixture	Immediate to delayed	Immediate

Symbol and Name of Chemical Agents	Time of Onset of Symptoms (Inhalation)	Time of Onset of Symptoms (skin)
CX=Phosgene oxime	Immediate	Immediate
Choking Agents		
CG=Phosgene	Immediate to delayed	Immediate to delayed
DP=Diphosgene	Immediate to delayed	Immediate to delayed
PS = Chloropicrin	Immediate	Immediate
Cl = Chlorine	Immediate	Immediate
Blood Agents		
AC=Hydrogen cyanide	Seconds	Immediate to delayed
CK=Cyanogen Chloride	Immediate	Immediate
Vomiting Agents/Respiratory Irritants		
DM=Adamsite	One minute	N/A
DA=Diphenylchlorarsine	Several minutes	N/A
DC=Diphenylcyanarsine	Seconds to minutes	N/A
Irritant Agents		
CN=Chloroacetophenone	Immediate	Immediate
CA=Bromobenzylcyanide	Immediate	Immediate
CS=O-Chlorobenzyllidene Malonitrile	Immediate	Immediate
CR=Dibenzoxazepine	Immediate	Immediate
Incapacitating Agents		
BZ=3-quinuclidinyl benzilate	1 - 4 hours	N/A
LSD-Lysergic acid diethylamide	Few minutes	N/A

6.2.9. Nontraditional Agents

6.2.9.1. Dusty Compounds: Dusty compounds use a carrier particle such as talc or diatomaceous earth in order to form a particulate aerosol out of liquid chemical agents. Chemical agents impregnated on a carrier agent such as a fine dust, enter the body via skin contact or inhalation. Both nerve and mustard agents can be made into dusty agents. Dusty agents increase the amount of agent spread across an area, and they frustrate and defeat many chemical detectors and protection measures. The finely milled toxic material penetrates the fabrics of protective coverings and the seals of gas masks presenting localized percutaneous vapor and contact hazards. The inhalation hazard is minimal compared with liquid and vapor releases. Dusty agents may be released in a variety of climatic conditions and maintain persistency for many weeks. Because small amounts of agent are adsorbed onto widely dispersed aerosols which create localized vapor hazards around each aerosol, detection limits increase by a factor of several hundred. This means that detectors must be much more sensitive to detect these agents. The HAPSITE tenax concentrator SIM method is capable of detecting about 0.1 mg/m^3 of dusty nerve agent.

6.2.9.2. Thickened Agents: A number of chemical compounds can make some agents thicker and thus more persistent. Thickened agents increase the length of time a chemical agent poses a health hazard via increased persistence and penetration of the intact skin. Thickened agents form large droplets that concentrate the agent reaching the ground and making the contact hazard greater. Since nerve agents are not gases, rather viscous liquids, they spread in the form of liquid drops.

G-Agent: G-agents vaporize easily and for the most part are a vapor hazard. Unthickened "G" series nerve agent liquids can be clear to dark in color and have the viscosity of fine machine oil and thickened agents may have the appearance of motor oil.

VX Agents: VX hardly vaporizes making it primarily a liquid contact hazard. The V-agents are oily liquids with high boiling points. Nevertheless, the limited amount of vapor they do produce is enough to pose a heath hazard if inhaled.

6.2.9.3. Other NTAs: As the threats on the battlefield and in-garrison change and adversaries innovate novel threats and methods to employ those threats, BE must continue to be aware of these changes. It is imperative that BE review intelligence resources, identify the capabilities and limitation of their detectors and surveillance technology, and understand the applicability of the threat in a giving operational context.

6.3. Health Threat Assessment

6.3.1. Risk Evaluation: BE along with CEX should perform the risk evaluation to determine both the likelihood of an attack from various chemical agents as well as to evaluate the outcome if an attack were to occur. Based on the possible outcomes, BE will need to prepare multiple recommendations to mitigate or minimize the health threat and present them to the MDG Commander and/or IC. In some cases, the commander will require a "no effects" level be achieved; this is typical of an in-garrison environment and is governed by standards such as OSHA PELs and ACGIH-TLVs. In deployed locations, if the current mission requires minimizing effects to personnel in order to accomplish the operation, the US Army TG 230 provides military exposure guidelines (MEG's) for chemical risk assessment. The MEG tables for many of the chemicals found in TG-230 are located in the chapter 2. If the commander's risk tolerance is unknown, assume moderate risk as the baseline for recommendations.

6.3.2. Planning and Pre-Attack Phase: During this phase, the key objective is contamination avoidance. Identify critical assets such as water storage, aircraft and munitions and identify critical missions (listed under Section 6.1). Ascertain the commander's risk tolerance to critical assets and missions, and integrate this into base chemical detection planning and execution. CEX is responsible for detection planning and execution with BE providing input on advanced detection, identification, and quantification through follow on sampling and analysis.

Conduct the following pre-attack, chemical countermeasures:

- Review reports from other installations in the theater of operations
- Review all CBRN threat assessments for likely agents and available delivery systems

- Discuss the proposed COA with wing leadership to determine the priority taskings
- Consult with Mission Director to understand Air Tasking Order and timelines, work level associated with tasks, specific infrastructure and clean sectors requirements
- Conduct TIC vulnerability assessments of mobile and stationary sources

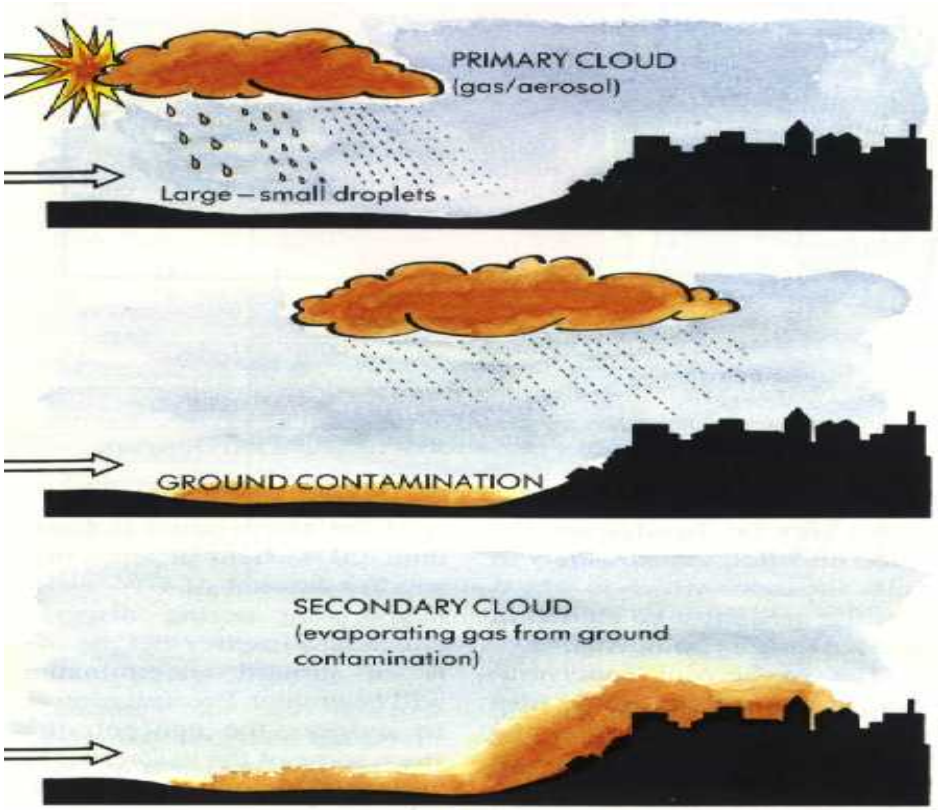
6.3.2.1. Base Detection Plan: CEX with BE input establishes a base detection plan capable of identifying the potential risk pre-attack as well as post attack using available chemical monitoring equipment. The plan evaluates the full spectrum of environmental media that can be used to transport chemical agents and matches the media to the capability of the chemical monitoring equipment available. The spectrum of media include air, gas, vapor, liquid vapors/droplets (air & surfaces), solids, and particulates/dusty agents.

Additional considerations in the development of a base detector plan are:
- Align base chemical detector plan with base sectors and transitional areas and establish ability to verify both positive and negative results in all sectors post attack.
- Coordinate with CEX to determine location of M-8 paper and M-22 alarms; consider value of and proximity to critical assets.
- Lay out M-8 paper in sufficient quantity over large homogeneous areas to support data quality objectives and confidence levels in a post attack situation. For example a positive readings on M-8 placed on multiple buildings within an area provide much more confidence in characterization than would a single sheet of M-8 paper from one building within a sector.
- Detectors and alarms support the objective of contamination avoidance. Rapid response can provide commanders with time to react, implement protective posture and adapt the mission.
- Be familiar with the equipment limits of detection (LOD); develop “exposure time limits” based on acceptable risks.

6.3.3. Agent Delivery and Dissemination Methods:

6.3.3.1. Theater Ballistic Missiles (TBM): Once a chemical weapon has detonated, it creates a "primary cloud," a solid or liquid aerosol cloud. The cloud then settles to the ground, landing on individuals and creating ground contamination. The ground contamination then has a finite lifetime; it can injure from direct contact or from contact with a "secondary cloud" of agent that has evaporated from the ground contamination. Some high yield detonations produce very small droplets. These may be difficult to see on M-8 & M-9 paper especially at night. Thickening agents produce larger droplets increasing contact hazard and persistency. Consider the imperfections in the manufacturing process which can result in impure agents and modified physical and chemical properties. It is unlikely that the agent will behave as a pure agent if it was developed by a rogue organization or unsophisticated nation-state.

Figure 6-1: Cloud Formation



Weather Conditions that Increase Primary Cloud Hazard: The factors that affect the hazard from the primary cloud are related to the local weather.

- Variable wind direction causes dilution by redirection of the cloud
- Wind velocity causing dilution by turbulence
- Unstable air causes dilution by turbulence
- Low temperature causes less evaporation from liquid or solid aerosol particles; aerosol particles settle to the ground more quickly than vapor
- Precipitation washes both aerosol particles and vapor out of the atmosphere

Weather Conditions that Decrease Primary Cloud Hazard: Factors increasing the danger of the primary cloud tend to be the opposites of those previously cited:

6.3.3.2. Bombs, Bomblets, and Mortars: Unlike TBMs, bombs, bomblets, and mortars disperse chemical agents over a much smaller footprint. Chemical fallout from bombs, bomblets, and mortars typically occurs within 3 minutes due to proximity to the ground. More advanced designed bomblets are capable of increasing this time and releasing dusty agents over larger areas.

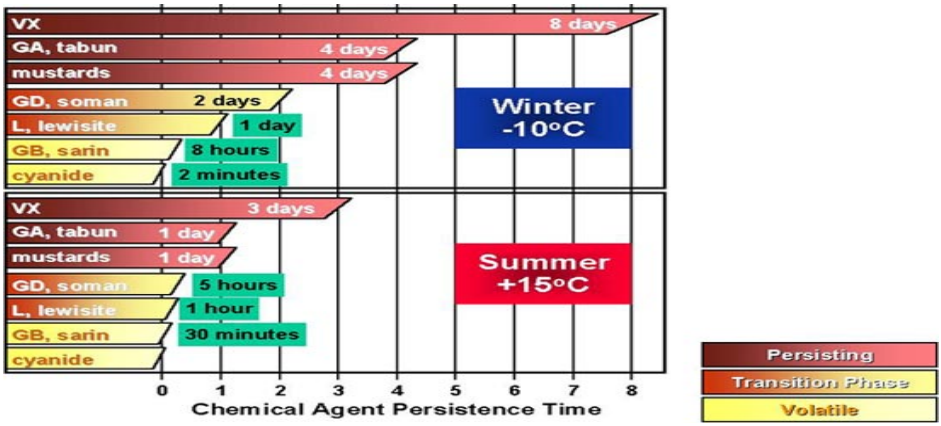
6.3.3.3. Improvised Dispersal Devices: Sprayers release chemical agents in a more localized manner, targeting specific groups of people in a nearby area. Also, mubtakkars or other package-style devices may be left in a location and triggered remotely to release hazards or begin a chemical reaction resulting in the release of other hazards.

6.3.3.4. Chemical Incidents/Accidents: Chemical accidents are a very real threat to installations. The follow scenarios should be considered: railroad accidents, vehicle accidents, aircraft accidents, chemical plant accidents/releases, and natural disaster-induced hazards from earthquakes, hurricanes, flooding, etc. Additionally, adversaries may target industrial centers and transportation nodes to affect operations.

6.3.3.5. Destruction of Enemy CBRNE Manufacturing Process, Stockpiles, or Weapons: During offensive operations, friendly forces or civilians may be located close to CBRNE targets. Depending on the type of counter-CBRNE weapon system employed, a successful strike may release agents into the surrounding environment. BE should work with operation planners to provide a health risk assessment to minimize collateral effects.

Figure 6-2 assumes average values for humidity, rainfall, and solar flux, and to provide approximate persistence of agents under generalized winter and summer conditions. Use this as a general guide to determine relative persistency.

Figure 6-2: Persistence of Agents



6.3.4. Response or Post Attack Phase: During post attack, the key objective is mission optimization. The mission varies based on the operational context. In order to respond appropriately, BE must have already identified the essential tasks and primary mission during the response or post-attack phase. BE must quickly identify hazards, determine sampling/analysis priorities, assess the risks, analyze controls, and provide MDG Commanders and IC with recommendations to support mission requirements.

6.4. Health Risk Assessment: Before engaging in sampling and analysis activities, BE must identify key decisions that must be made which require a health risk assessment. The

following list is intended to guide BE in supporting operational decisions in a timely manner. BE will also have to prioritize which samples should be taken with which instruments.

- Is the sector "clean" and can personnel in the sector deMOPP?
    - Limited by LOD of detectors
    - Confirmation that initial "non-detect" is a true "negative" result
    - Best case: Can calculate time until an expected health outcome
- The sector is "dirty" – what are the health risks of deMOPPing?
    - Confirmation that a "positive" detection is a true CWA hazard
    - Estimate physiological effects from initial detector output, ChemRAT, and CHART
    - Quantify exposure with measurements and CHART
- How long until the sector is "clean"?
    - Apply ChemRAT (see Appendix Q), persistency tables; support with measurements
    - Extrapolate based on measured concentrations at defined time intervals
    - Collect soil measurements and analyze with HAPSITE HSS
- Compare the risk associated with not accomplishing the mission (possible counter attack), delayed action (work-rest cycle), heat stress (limited rest), and exposure (less MOPP).
    - Optimize personnel for mission
    - Optimize health and safety
- How long will the Collective Protection shelter adequately protect its occupants?
    - Evaluate if the facility is in a vapor or liquid hazard zone
    - Plan to relocate within 72 hours
    - Monitor inside of shelter to confirm efficacy of system

6.4.1. Identification of a Chemical Hazard: The following may indicate the presence of a chemical hazard: (1) M8 papers and M-22 alarms; (2) substantiated intelligence reports; (3) observations of attack and chemical release; or (4) physiological responses. Less obvious signs are sick, dying wildlife, distressed vegetation, and the slow onset of physiological responses. These may be present when chemical hazards are present in low concentration, as is the case with a low-level attack, an attack that missed its target, or a failed attempt to release chemical hazards.

6.4.1.1. Initial Detection Alarms: Personnel may report changes to M8 paper or M-22 alarms. These positive results should be evaluated to identify what chemical caused the positive or alarm, since there are many potential chemicals (i.e., false positives for CWA) that could cause this result. BE has the capability to identify most chemical hazards. Use the flow charts in Figures 6-3, 6-4 and 6-5 below as a guide to help determine follow-on sampling/analysis requirements and equipment methods to identify and quantify the hazard. A key assumption to these flow charts is the instrument's detection limit.

Figure 6-3: Integration of Detectors to Determine Deposition

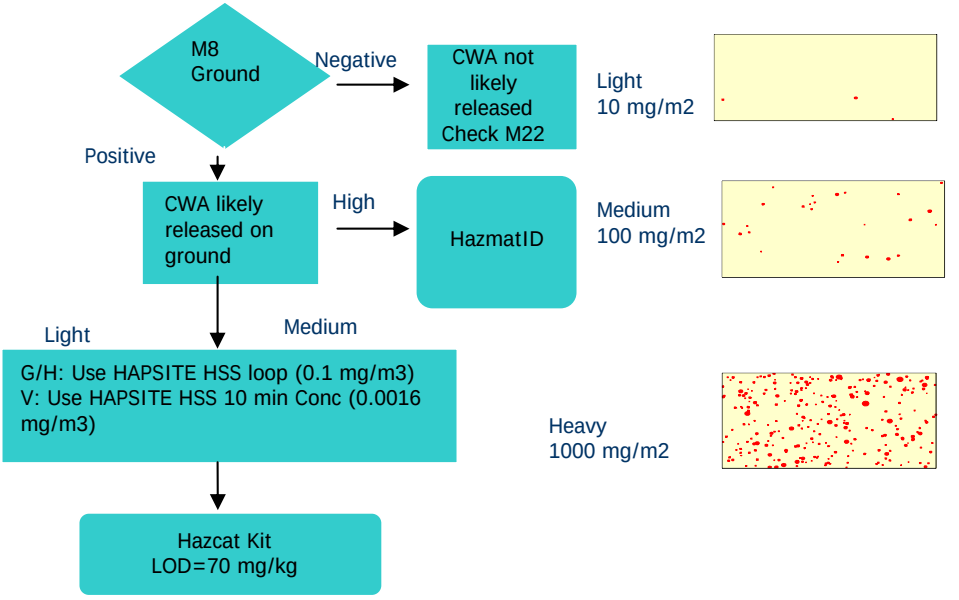


Figure 6-4: Integration of Detectors to Determine Gross Air Hazard

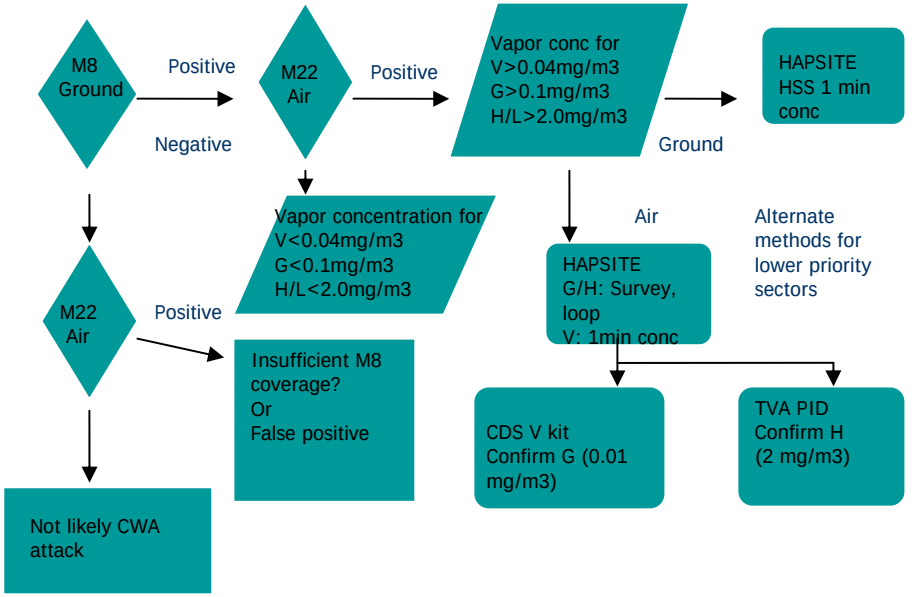
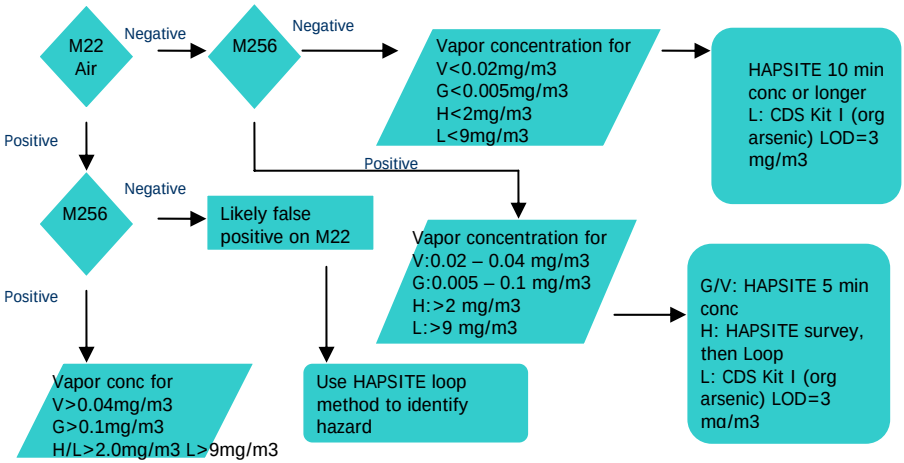


Figure 6-5: Integration of Detectors to Determine Low Level CWA



6.4.1.2. Physiological Responses: Physiological effects may be the first indication of an attack or that a hazard is present. Most harmful chemicals will result in manifestation of signs and symptoms. Typically, effects are determined based on the relationship of the concentration to a standard or reference dose (i.e., EPA toxicity data). In the context of CWA, physiological responses are defined as Threshold, Incapacitation and Lethal. Use the following screening tool as well as Table 6-1 to deduce a potential CWA based on type and timing of physiological responses. Note that the deposition process may take up to an hour following an airburst munitions attack, or shorter when a ground-based release occurs.

Table 6-2: Physiological Responses and Possible Chemical Agent Indicators

MOPP Level	Physiological Response Noted	Indicates Absence of
0,1,2,3, or 4	No miosis 30 minutes after exposure	Nerve agent
	No symptoms immediately after exposure	Lewisite, Phosgene oxime, Hydrogen cyanide, chloroacetophenone, Chlorobenzyllidene, Dibenzoxazepine
	No symptoms after 30 minutes	Tabun, Sarin, Soman, Cyclosarin, VX, Adamsite, Diphenylchlorarsine, LSD vapors
	No symptoms after 1 hour	BZ (3-quinuclidinylbenzilate) vapors
Alpha A	No symptoms up to 2.5 hours	Tabun, Sarin, Soman, Cyclosarin skin contact
	No symptoms up to 18 hours	VX skin contact
	No symptoms up to 48 hours	H and HD skin contact

6.4.2. Assess the Risk: Based on the existence of several hazards (some of which may not be chemical, such as heat stress, biological, or radiological), BE should develop a sampling

plan to quantify the hazards, evaluate the effects, and assess the overall risks to personnel and the mission. The table below lists the various chemical detectors and capabilities used throughout DoD. This can be used to help select the appropriate detection equipment to adequately assess the risk.

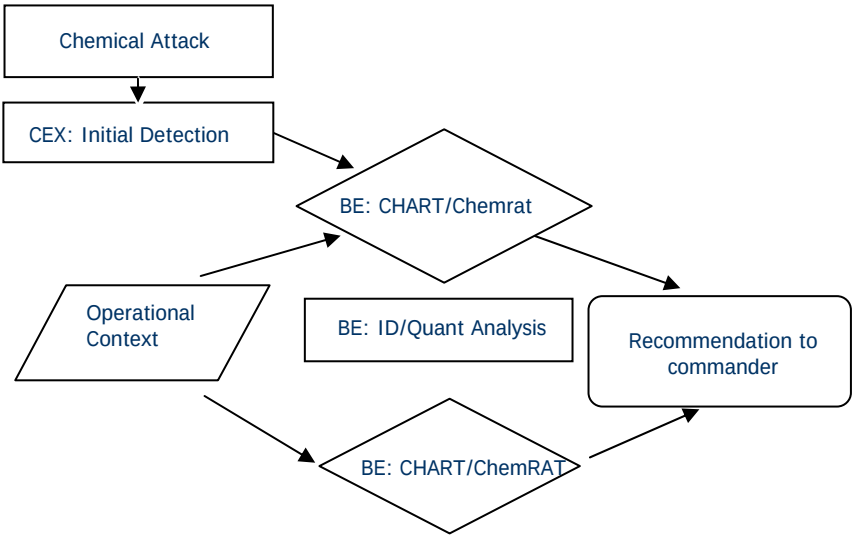
Table 6-3: Equipment Selection Guide

Equipment/ Owner	Media	Detection	Detection Limits (mg/m3)	Response Time	Limitations	Application, techniques, and procedures
M8 Paper / Shelter managers	Liquid	V/G Nerve and Blister	100-µ drops	30 sec to 3 minutes	False positives can occur from liquid insecticides, antifreeze, and petroleum products. Airburst munitions produce very small droplet sizes, which may be difficult for reconnaissance personnel to see with the naked eye—particularly at night.	Detection: Qualitative verification of the presence for early warning Color Change for positive screening
M-9 Paper / Shelter managers	Liquid	V/G Nerve and Blister	100-µ drops	<=20 sec	Only identifies the class and type of chemical agent. Blue, yellow, green, gray, or black spots are not the result of chemical agent exposure False positives from petroleum products (fuel, grease, brake/hydraulic fluid), DS-2 decontamination solutions, antifreeze, or liquid insecticide.	Early warning detection (1) Detects the presence of liquid chemical agent in droplets as small as 100 microns in diameter; (2) Worn on clothing or attached to vehicles which may have moved from the original area where CWA contact occured.
ACADA (XM22) / CEX	Gas	Nerve-G Mustard-HD	0.1 2	30 sec	Has a Radioactive source (license required)	Point Detector: Automatic early alarm for presence of CWA. Ion mobility spectrometry (IMS). Larger, man portable IMS system with a communications interface to support battlefield automation systems.
M-256A1 Detector Kit / CEX	Vapor	Nerve-G VX	0.005	15 min Series is longer AC--25 min	(1) Must have M-8 paper to classify liquid agents, (2) 20 minutes to register results	Detection & Identification: (1) Detects and classifies very low concentrations (2) Color Change for positive screening
		Nerve -G/VX	0.005			
		Mustard-HD	0.02			
		Lewisite-L	2			
		Phosgene oxime-CX	9			
		Blood-AC, CK	3			
ICAM Improved Chemical Agent Detector / CEX	Gas	Nerve-G/V Blister-HD and HN	0.03 0.1	10 sec <=30 sec	(1) False alarms to perfume, exhaust paint, additives to diesel fuel. (2) Not capable of simultaneous detection of both H and G agents. (3) Does not provide exact chemical concentration rather relative intensity of the CWA. (4) Can become contaminated or saturated if not used properly (5) Cannot identify the vapor hazard over a large area. (6) Radioactive source	Battlefield Device for early warning of CWA presence in a single location for a longer period of time. Ion mobility spectrometry (IMS). Determines the level of chemical agent present, and indicates on a display or by an alarm the level of hazard. (2) Automatically switches between G and H modes when contamination is detected warning the operator of chemical contamination.
ICAM-APD / CEX	Gas	Nerve-G	0.1 mg/m3	30 sec	Radioactive Source	Portable, commerical version of the ICAM.
		Nerve-V	0.04 mg/m3	30 sec		
		Mustard-H	2.0 mg/m3	10 sec		
		Lewisite-L	2.0 mg/m3	10 sec		
M-272 Water Test Kit / BEF	Water	Nerve-G VX	0.02 mg/l	7 min	Fuel can generate a false positive for cyanide.	(1) Tests raw or treated water (2) Enzyme detector tickets; Kit conducts 25 tests for each agent.
		Mustard-HD	2.0 mg/l	7 min		
		Lewisite	2.0 mg/l	7 min		
		HCN	20.0 mg/l	6 min		

Equipment/ Owner	Media	Detection	Detection Limits (mg/m3)	Response Time	Limitations	Application, techniques, and procedures
HAPSITE® Portable GC/MS and accessories /BEF	Gas/Vapor *	Volatile Organic Hazardous Air Pollutants	ppt-ppm	20+ min	(1) Mass spec mode of operation can result in both false positive or false negative results, depending on the concentration level of the COC relative to other compounds in the air. (2) ~40 lbs. (3) Expensive, limited resource.	Capable of detecting, identifying, and quantifying most CWAs. Can operate in MS only, GC/MS loop, or concentrator method. Headspace system enable water and soil monitoring.
Toxic Vapor Analyzer (TVA-1000B) / BEF	Gas*	Various organic and inorganic vapors	Varies by Chemical >100ppb	Seconds	**PID**: (1) Smaller dynamic range (0-2000 ppm) (2) Water interferences. **FID:** (1) Need sufficient oxygen for flame. (2) Requires hydrogen gas.	**PID:**(1) Does not require hydrogen or oxygen (2) Is more sensitive to aromatic and chlorinated compounds, and can measure some inorganic compounds that the FID does not detect (Ammonia, Carbon Disulfide, Carbon Tetrachioride, Chloroform, Ethylamine, Formaldehyde, and Hydrogen Sulfide, etc). **FID**:(1) Wide dynamic range (0 50,000 ppm)
Hazardous Material Identification (HazMatID) System / BEF	Solids Liquids	G/V/H/L agents; TIC; White powders; Explosives	10%	20 sec	(1) High detection limit, (2) Difficult to identify components of a mixture, (3) Water can obscure much of the spectra and result in false negatives.	Uses infrared spectroscopy to match IR spectra of agents with the IR library spectra.
XMX Outdoor Liquid Sample Collector / BEF	Air particulates (respirable)	NA, but can be used with PCR, ECL, and culture	NA	NA	Some of the components are not designed for decontamination after it has been exposed to certain live agents. Should such contact occur, certain portions of the unit may have to be destroyed and replaced, rather than decontaminated.	Concentrates particles at a flow rate of 800 liters/minute and then impinges the particles into a sample collection vial (centrifuge tube) containing customer specified liquid (normally type 1, sterile water or phosphate buffered saline). Once the sample is collected, the user removes the centrifuge tube for subsequent analysis (immuno-assay, PCR, culturing).
RADeCO (HVAS) Constant Flow Air Sampler / BEF	Air particulates	NA	NA	NA	All particle sizes are captured. Surface area of filter is smaller than ADM alpha probe; requires correction factor when calculating dpm/m3	Grab air sampler. Can be used for radiation or other particulate monitoring.
Hach DR/2400 / BEF	Water	Various inorganics and metals	Varies by Chemical	10-15 min	Not on Homeland Defense Allowance Std	USEPA approved/accepted Methods (potable/nonpotable)
CDS Dector tube kit / BEF	Air,Vapor, Gas	Detects specific CWAs	ppm range	5-10 min	Humidity may interfere; false positive can result from some compounds.	Detects: Chlorine, Hydrocyanic Acid, Phosgene, Cyanogen Chloride, Organic Arsenic Compounds and Arsine (e.g. Lewisite), Nerve Agents (via Phosphoric Acid Esters) and Blister Agents (Mustard and other Organic Basic Nitrogen Compounds).

6.4.2.1. Sampling Plan: After a chemical threat is detected or released, BE should coordinate with CEX and other intelligence personnel to initially detect and identify agents. When confident in the initial hazard identification, use the CHEMRAT program when CWAs are involved to determine expected persistency for a 72-hour period. Use Figure 6-6 below to begin determining potential scenarios. Use CHEMRAT initially, however once you have collected initial detection responses based on the type of alarms/detectors and LOD of equipment employed, use the LOD detection guide in Table 6-5 and Appendix Z with CHART to better quantify potential health effects. A similar technique can be used for TICs based on the reference dose data (RfD or slope factors provided by EPA) and AEGLs. Checklists for utilizing CHART and ChemRAT are included in Appendices Q and R.

Figure 6-6: Determine Potential Scenarios



BE should develop sampling plans and prioritize based on available detection data (both CEX and BE) and operational context. Areas or sectors with critical assets and missions showing contamination from point sources or exhibiting physiological symptoms are a high-priority for follow-on monitoring. Primary objectives may include:

- DeMOPP decisions
- Sortie generation
- Protection of critical assets such as water
- Recovery
- Life-saving

6.4.2.2. Assessment Based on Initial Detection and Subsequent Instrument Selection: By cross referencing the detection limits of common detectors with the toxicology of agents, it possible to use Table 6-4 to determine how many minutes personnel can be exposed to various agents when the detectors have NOT detected the agent before personnel may experience threshold effects or become incapacitated (ThE-min and IC-min respectively). This assumes that the concentration of the agent is at (just below) the instrument's detection limit and is the most conservative approach. This table is useful in developing a sampling strategy based on what you know and don't know about the potential concentration. For example, if you suspect VX, but the M256 and M22 are negative, BE should employ the HAPSITE 1-minute tenax concentrator method instead of the survey and loop method.

Table 6-4: Limit of Detection (LOD) Guide

		GD			V			H			L		
		LOD mg/m^3	**ThE-min** 84%	**IC-min** 16%	**LOD** mg/m^3	**ThE-min** 84%	**IC-min** 16%	**LOD** mg/m^3	**ThE-min** 84%	**IC-min** 16%	**LOD** mg/m^3	**ThE-min** 84%	**IC-min** 16%
M22		0.1	2.7	659	0.04	4.4	170	2	26	17	2	27	
M256		0.005	120	28500	0.02	8.5	340	2	26	17			
TVA-1000B		4.1						1.9	28	18			
CDS kit		0.186	1	302				4	55	35			
HAPSITE	1 min Tenax conc	0.02	26	4910	0.012	14	567	0.016	3350	2150			
	5 min Tenax conc	0.004	251	36600	0.0024	74	2828	0.0032	16800	10850			
	10 min Tenax conc	0.002	650	87000	0.0012	149	5650	0.0016	33600	21750			
	20 min Tenax conc	0.001	1750	207500	0.0006	295	11350	0.0008	67290	43500			
	SIM Tenax conc	0.0002	16500	1554000	0.0003	590	22700	0.0002	269000	174000			
	1 min Tribed	0.0143	24	7475				0.0009	59500	38500			
	5 min Tribed	0.0029	390	54900				0.0002	267000	172000			
	20 min Tribed	0.0007	2850	322000				0.00004	1320000	866000			

LOD = Limit of Detection
ThE-min = Threshold Effects (onset)
IC-min = Incapacitation Effects (onset)

All calculations were made with CHART-Final Version Oct 07 based on a temperature of 105° F and assuming a Light Work Load. This version of CHART does not calculate the HapSite Loop method.

For example, A series of M22 alarms are triggered around munitions storage facility. If the agent is GD and is present at or just below the LOD (0.1 mg/m^3), personnel can be unprotected for six minutes before 86% of the exposed population feels threshold effects, and 198 minutes before 16% of the population is incapacitated.

Table 6-5 provides data on the doses required to create effects ranging from debilitation to death for several agents.

Table 6-5: Dose-Effects of Several Chemical Agents

Route	Form	Effect	Type	GA	GB	GD	VX	Dose Units
Ocular	Vapor	Miosis	ECt_{50}[2]	-	<2	<2	<0.09	mg•min/m^3
Inhalation[1]	Vapor	Runny Nose	ECt_{50}	-	<2	<2	<0.09	mg•min/m^3
Inhalation	Vapor	Incapac-itation	ICt_{50}[3]	-	35	35	25	mg•min/m^3
Inhalation	Vapor	Death	LCt_{50}[4]	135	70	70	30	mg•min/m^3
Percutaneous	Liquid	Death	LDt_{50}[5]	4000	1700	350	10	mg

[1]Assumes a 15 liters/min respiration rate for a 70 kg person
[2]Effective Concentration Time – Gas debilitates 50% of the exposed population
[3]Incapacitating Concentration Time – Gas incapacitates 50% of the exposed population
[4]Lethal Concentration Time – Gas kills 50% of the exposed population
[5]Lethal Dose – Amount at which a substance kills 50% of exposed population

6.4.2.3. Confidence in Exposure Modeling: Continue to gather information on agents at various concentrations and exposure times and load this information into the CHART program to build confidence in your health risk assessment.

Exposure Time: Determine the operational context and duration of critical tasks; enter this information in the CHART program. If the agent will have dissipated by 75% over the first two hours and the mission is expected to last for five hours, model an estimated time-weighted average for the length of the mission; it may be feasible to de-MOPP over the course of the operation.

Number of Samples Needed: To determine the adequate number of samples to maintain confidence in characterization for a sector, use contaminant variability information generated from initial plots (i.e., HPAC, VLSTRACK, etc.) and establish data quality objectives. Tables 1-5 and 1-6 may be helpful in estimating the number of samples required to achieve the desired data quality objective.

6.4.2.4. Other Guidelines and Standards for Chemical Agents:

US Army TG 230: Provides MEG's for chemical risk assessment in a deployed environment. These are included in the equipment capability tables from Chapter 2.

Occupational Exposure Limits (OEL): Serve to protect workers from excessive exposure to toxic chemicals in the workplace. They were designed for healthy adults, usually for an exposure of an 8-hour work shift and are enforceable in-garrison. They were not meant to be applied for protection of the public or military members in deployed environments when mission requirements justify a level of exposure greater than "no effects".

Acute Exposure Guideline Levels (AEGL): Describe the risk to humans resulting from once-in-a-lifetime, or rare, exposure to airborne chemicals. Use these guidelines when dealing with emergencies involving spills, or other catastrophic exposures not lasting more than 8-hours. The guidelines define three-tiered AEGLs:

- AEGL-1: The airborne concentration of a substance, above which it is predicted, that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
- AEGL-2: The airborne concentration of a substance, above which it is predicted, that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- AEGL-3: The airborne concentration of a substance, above which it is predicted, that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Each of the AEGL tiers is sub-categorized into five exposure periods: 10 min, 30 min, 1 hour, 4 hours, and 8 hours.
Use AEGLs as levels of concentration (LOC), however personal judgment and experience should also be used both for selecting a LOC and for interpreting the data obtained from using it.

Table 6-6 presents the major exposure guidelines. Table X-8 and X-9 compares the values found in several guidelines for four chemicals which are commonly encountered during spill response.

Table 6-6: Summary of the Major Exposure Guidelines

Guideline	Target Group	Organization	Definition	Exposure Duration
AEGL	Public	COT NRC	Three-tier guideline for emergency response	10 min., 30 min, 1 hr, 4 hr., and 8 hr
ERPG	Public	AIHA	Three-tier planning guideline for emergency response	1 hour
1/10 IDLH	Public	EPA/FEMA/ DOT	LOC estimation based on IDLH	30 minutes
IDLH	Worker	NIOSH	Highest concentration from which escape possible without permanent damage	Was 30 minutes; revised IDLH (1994) mentions no exposure duration
TLV, PEL, REL	Worker	ACGIH, OSHA, NIOSH	Occupational exposure for 8-hour workday	8 hours per day, 20 to 30 years
STEL	Worker	ACGIH	Occupational short-term exposure limit	15 minutes

Table 6-7: Five Exposure Limits for Four Hazardous Chemicals

Chemical	ERPG-2	1/10 IDLH (Parentheses are pre-1994 version)	IDLH (Parentheses are pre-1994 version)	TLV-TWA (ppm)	TLV-STEL (ppm)
Ammonia	150	30 (50)	300 (500)	25	35
Chlorine	3	1 (3)	10 (30)	0.5	1
Hydrogen Sulfide	30	10 (30)	100 (300)	10	15
Sulfur Dioxide	3	10 (10)	100 (100)	2	5

Table 6-8: AEGL-2 for Four Hazardous Chemicals

Chemical	AEGL-2 (ppm)				
	10 Minute	30 Minute	1 Hour	4 Hours	8 Hours
Ammonia	220	220	160	110	110
Chlorine	2.8	2.8	2.0	1.0	0.71
Hydrogen Sulfide	41	32	27	20	17
Sulfur Dioxide	0.75	0.75	0.75	0.75	0.75

6.4.2.5. Other Risks: When evaluating alternatives, recommendations, and countermeasures, BE should address the effects of their recommendations on the overall risk, not just chemical risk. Refer to the Chapter 5 for additional information on risks related to heat stress and PPE.

6.5. Analyze Risk Controls

6.5.1. PPE: There are several types of PPE that can be worn to protect against chemical hazards. Refer to the Chapter 5 for information on chemical protective materials. The remainder of this section focuses on CWAs.

6.5.1.1. MOPP Considerations: Decisions to de-MOPP in order to enhance the mission are weighed against total mission completion, which may entail slower but sustained operations associated with increased MOPP conditions and implementation of a work/rest regimen. The IC makes the overall decision for MOPP considerations with recommendations from CEX. BE provides information to CEX concerning chemical monitoring and analysis as well as heat stress as needed for MOPP considerations. The following actions may support de-MOPP decisions.

- Verify negative measurements from sectors to allow for de-MOPPing in those areas before verifying areas where positive readings occurred. Couple assessment with CHART analysis.
- Use several instruments (i.e., TVA-1000B, CDS kit, etc.) to confirm initial detection in lower priority sectors when advanced detectors (i.e., HAPSITE) are limited.
- Consider the LOD of alarms in sectors showing negative agent presence before making de-MOPPing recommendations.
- Quantify heat stress risks and establish work-rest cycles in sectors where critical mission tasking occur when de-MOPPing is not an option.
- Agent persistency may drive relocation to a clean area when increased MOPP and work-rest cycle requirements can not adequately optimize mission effectiveness

Below are some additional criteria and associated actions to consider to when analyzing controls and making MOPP recommendations.

Commanders risk tolerance

- Determine acceptable risk to personnel – Incapacitation versus no effects
- Determine acceptable level of mission degradation

- Long-term risks associated with an incomplete mission

Criticality of the mission and tasks
- Compare critical mission tasks with expected individual performance from both chemical agents exposure and increase MOPP conditions.
- Recommend MOPP based on risk tolerance and optimal operational effect

Operational context
- Increase MOPP and lower operational tempo for anticipated, longer mission
- Decrease MOPP and higher operational tempo for shorter mission sustainment

Potential route of exposure
- Assess route based on agent characteristics and transport media (air, water, soil)
- Adjust respiratory or skin protection levels according to threatened exposure route and/or media pathway of the CWA (air, soil, or water).

Ability for personnel to perform under physiological distress
- MOPP may be decreased or increased based on acceptable level of distress (i.e., cook may be OK performing mission with miosis, but not the sharp-shooter or pilot)
- Balance criticality of mission with acceptable effects (i.e., does the cook need to be exposed to cook food faster? Does the bomb loader need to be exposed in order to shorten the process and minimize his risk of incapacitation from heat stress.

Agent persistency
- Increase MOPP and lower ops tempo to allow a non-persistent agent to dissipate if the mission allows as opposed to commencing operations in adjusted MOPP and work-rest cycles to complete tasks where a persistent agent is used.

6.5.1.2. Thermal Stress Associated with MOPP: If engineering controls are not feasible and MOPP levels are the primary protection measure from chemical agents, thermal stress can become a major consideration in a hot environment. If the commander states that a zero-negative-effects level is required (therefore initiating MOPP 4), and is not amenable to the required work-rest regimen (e.g., 15 minute work/45 minute rest), then there is the possibility of incapacitating more troops from thermal stress than would have occurred with a chemical exposures acquired in a lower MOPP level. The risks associated with the control must be considered. Refer to the heat stress section of Chapter 5 for tools to adequately analyze this control measure.

6.5.2. Administrative Controls

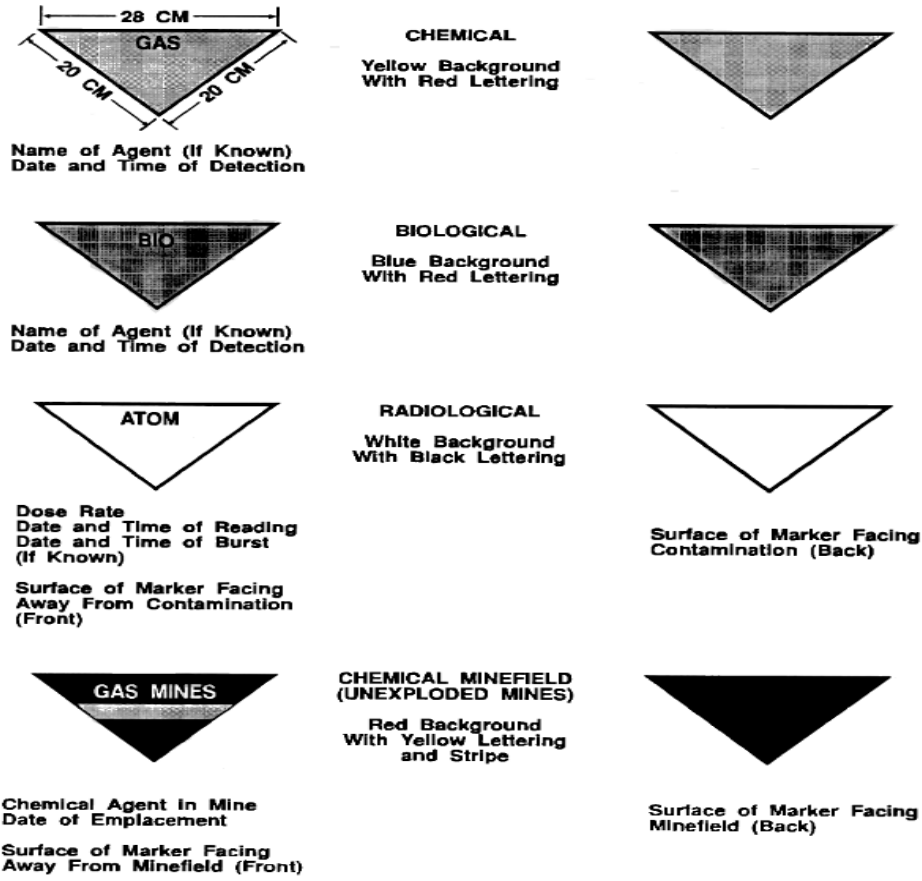
6.5.2.1. Marking: Once contamination is found, CEX is responsible for marking the area and reporting the contamination to the EOC. Marking contaminated areas and equipment warns friendly units and helps them avoid the contamination.

Signs used for marking contaminated areas are standard throughout NATO in color and size. This permits easy identification. The color of the sign indicates the type of contamination. The primary or background color indicates the general type of hazard. The

secondary color gives specifics as to what the hazard is. In addition, color, size and shape are also standard.

The NBC Contamination Marking Set contains everything needed to mark a contaminated area flags, ribbon, crayons, mounting stakes, and a carrying container. TM 3-9905-001-10 describes the kit and its use. If the kit is not available, then make the signs out of available metal, plastic, or wood.

Figure 6-7: Standard NATO Marking Signs



6.5.2.2. Marking and Monitoring Materials for Disposal: Appropriate disposition of materiel will vary based on the situation. Natural attenuation may be the best solution. If contaminated materiel is collected in a holding area, then the area has to be marked and monitored for residual hazards. Since vapor hazards are additive, several contaminated items together could create a serious vapor hazard when located near each other. Since residual hazards can also accumulate in inaccessible places, contaminated vehicles and equipment must be marked or identified.

6.5.3. Engineering Controls: Coordinate with CEX and facility managers to establish collective protection (ColPro) **s**ystems to protect those inside a building, room, shelter or tent against contamination. Minimize health risks by directing all personnel not performing critical missions into these facilities during an attack. BE should evaluate ColPro protection factors and ensure personnel understand the limitations associated with these facilities (i.e., breakthrough times, filter replacement cycle, filter breakthrough times for various chemicals).

6.6. Decontamination: Decontamination may be immediate, operational, or thorough as described in AFMAN 10-2602, or mass, emergency, gross or technical as described in AFI 10-2501. Immediate and emergency decon consists of standard decontamination kits (M291and M295) or flushing with water to decontaminate the skin and equipment, respectively. Skin decontamination is not necessary after exposure to vapor alone, but clothing should be removed because it may contain trapped vapor. Additionally, flushing with soap and water will likely remove most contamination.

Operational or gross decon enables targeted decon of surfaces to minimize contact exposures.

Thorough or technical decon may be used when equipment are being returned to service, or personnel are entering a clean facility (i.e., patients entering clinic for treatment). BE should work with decon operators to evaluate their performance effectiveness. For pre-determined operators such as patient decontamination, performance measures/goals should be trained during the preparation and planning phases. Spot evaluations can be performed for CCA operations. BE should not dedicate resources to constant monitoring of personnel or equipment; this is time-consuming, generally ineffective, and will delay patient treatment or critical movement. Execution of decon based on performance standards should be adequate for most situations.

6.7. Medical Countermeasures

6.7.1. Pretreatment: In the late 1990s, the United States military fielded pyridostigmine bromide as a pretreatment for nerve agent exposure. When given before soman exposure and when that exposure is followed by the standard Antidote Treatment-Nerve Agent Autoinjector (ATNAA) therapy, the use of pretreatment will increase the LD_{50} several fold over the LD_{50} obtained without the use of the pretreatment. When soman is the nerve agent, the use of pyridostigmine increases survival. When the agent is GB or VX, survival after standard ATNAA therapy is essentially the same whether or not pyridostigmine pretreatment is used (i.e., pyridostigmine use provides no benefit in GB or VX poison). Current data is not adequate to evaluate the effectiveness of pyridostigmine pretreatment for GA or GF exposure. Consult intelligence sources to determine the risk of soman being used in an attack when considering pre-treatment. Also, consider the potential side-effects as part of the risk management process.

6.7.2. Treatment: Management of a casualty with nerve agent intoxication consists of decontamination, ventilation, administration of the antidotes, and supportive therapy. The condition of the patient dictates the need for each of these and the order in which they are done. Atropine, pralidoxime chloride, and diazepam are used to treat nerve agent exposures.

Atropine is a cholinergic blocking or anticholinergic compound. It is extremely effective in blocking the effects of excess acetylcholine. In people not exposed to nerve agents,10 mg or higher may cause delirium. Potentially, the most hazardous effect of inadvertent use of atropine (2 mg, i.m.) in a young person not exposed to a cholinesterase inhibiting compound in a warm or hot atmosphere is inhibition of sweating, which may lead to heat injury. Atropine is packaged in autoinjectors, each containing 2 mg.

Pralidoxime chloride attaches to the nerve agent that is inhibiting the cholinesterase and breaks the agent-enzyme bond to restore the normal activity of the enzyme. Pralidoxime chloride is in an autoinjector for self-use along with the atropine injector. These atropine and pralidoxime chloride autoinjectors are packaged together in an ATNAA. Each airman is issued three ATNAAs.

Diazepam is an anticonvulsant drug used to decrease convulsive activity and reduce the brain damage caused by prolonged seizure activity.

Supportive medical interventions may be used for other types of exposures. Rapid identification of the hazard and its toxicology are important steps in treating some chemical exposures. BE should ensure that this information is provided to medical providers once identified.

Section 7.0: Biological Hazards

7.1. Introduction: Biological hazards include naturally occurring pathogens (e.g. bacteria), engineered agents, amplified agents, or toxins that can threaten personnel. The source of the threat may be natural, terrorist, nation-state, or industrial. Biological hazards may incapacitate or kill, and may be transmissible human-to-human. Exposure may occur through air, water, food, vectors, or human contact.

7.1.1. Threats to Air Bases: Potential threats to airbases can occur through various exposure routes. Based on recent intelligence, the highest threats from biological agents are through food or water media. Biological hazards can degrade the mission through incapacitation of personnel and contamination of assets.

- Agents sprayed or deposited on food
- Agents injected into the water system
- Aerial assaults from bombs, missiles, and artillery
- Packages and letters received in the mail containing agents
- Agents spread person-to-person (e.g., homicide dispersal)
- Natural disease (i.e., SARS, Pandemic Influenza, etc.)

7.1.2. Operational Effects: When determining the impact on mission operations, biological hazards must be evaluated for their potential to cause incapacitation as well as lethality. A large number of ill patients may overwhelm the medical and evacuation infrastructures, and will almost certainly create panic and disruption in the effected population. It may be considered useful to classify biological hazards by the effects they produce in an operational context, in order to provide guidance to the field commander on the consequences for continued operational effectiveness. Appendix P provides guidance for such a classification scheme by individual agent. Key parameters to consider include: incubation time, transmission rate, infectious dose, morbidity, and mortality. The commander will ultimately balance the importance of the current mission (e.g., training, deployment, war-fighting, responding to terrorism or disaster) against the risks posed by the operational impacts (e.g., grounding pilots, delaying mission, or operational readiness).

7.1.2.1. Psychological Effects: Impact of a biological exposure of any size may cause fear, confusion, panic, and most likely loss of confidence in protective gear and medical countermeasures.

7.1.2.2. Physiological Responses: Agent effects will vary based on exposure duration, dose, incubation period, and the agent type, as well as the individual's physical condition at the time of exposure. See Appendix P for agent information

7.1.3. Role and Responsibilities of BE: BE will partner with Emergency Management in biological air sample collection. Sample analysis will initially occur using the methods and equipment available to BE. The formal threat assessment process is a joint BE/Public Health effort as food and water are both likely media to be used to spread a biological agents. After initial detection, BE plays a supporting role by providing a health risk assessment.

7.2. Characteristics of Biological Agents: Biological agents are inherently more toxic then chemical agents on a weight-for-weight basis and can provide broader coverage per pound of payload. Moreover, they are potentially more effective because most are naturally occurring organisms (e.g., bacteria, viruses) which are self-replicating and have specific physiologically targeted effects, whereas chemical agents are manufactured chemicals that disrupt physiological pathways in a general way.

Table 7-1: Biological versus Chemical Agents

Characteristic	Chemical Agent	Biological Agent
Area affected	Relatively small	Can be very large
Detection	Easy	Very difficult
Time to detect and identify	Seconds-Minutes	Tens of minutes-Hours
Time until onset of effects	Minutes	Days to weeks
Medical treatment	Limited	Can be effective

7.2.1. Classification of Biological Agents: Characteristic classification of biological agents is important to the medical services in terms of detection, identification, prophylaxis, and treatment. Early identification may lead to effective treatment.

7.3. Threat Assessment

7.3.1. Risk Evaluation: The primary purpose for assessing health risks from biological agents is to give the commander information to decide which critical operations may be accomplished at a given location. With biological agents, it is rare to find an established standard or environmental limit to compare against personnel exposure. Appendix P provides data on the infective dose levels of various biological agents. Regardless, the commander will still require a qualitative threat assessment despite the lack of standards. In some cases, depending on the importance of conducting an operation at a reduced MOPP or PPE level, or lifting restriction of movement or quarantine measures, the commander may be willing to accept additional risks if the operational need is important enough.

The risk assessment starts with an evaluation of likely events or incidents. Using the modified RAM-W equation as a guideline, BE should be able to determine risk of a biological agent attack, the likely outcome of biological attacks/events, and evaluate the potential impact on the base mission and personnel.

Common threat types include:

- Terrorist or enemy operatives
- Disenfranchised individuals (e.g., fanatics, revenge-seekers)
- Extremist groups (e.g., militants)
- Insiders (e.g., disgruntled employees, contractors)
- Collusion, both insider and outsider
- Natural Diseases

Modified RAM-W Equation: For each incident, the assessor should utilize the modified RAM-W equation to determine risk. Guidelines for establishing values for each parameter are listed below:

$R = P_I(1-E_C)C$

Where:

R = Risk value
P_I = Probability of incident (threat)
E_C = Effectiveness of controls (vulnerability)
C = Potential consequences on people and mission (criticality)

Table 7-2: Parameters of Interest

Parameter	Classification	Threat Level	Points Assigned
Probability of Incident (P_I)	Most likely to occur	High	0.7 – 0.9
	Likely to occur	Medium	0.4 – 0.6
	Not likely to occur, but not impossible	Unlikely	0.1 – 0.3
Effectiveness of Controls (E_C)	Consider level of deterrence, detection, assets, and response (discussed below)	High	0.75 – 1.0
		Medium	0.45 – 0.70
		Unlikely	0.05 – 0.4
Potential Consequences (C)	Complete mission failure; loss of mission-critical system/equipment; death or permanent disability	Catastrophic	0.9
	Significant mission degradation; moderate damage to base systems and equipment; injury or illness to base personnel	Moderate	0.6
	Degraded mission capability; minor damage to base systems/equipment; isolated injury or illness to base personnel	Low	0.3

Probability of Incident (P_I): Evidence of such acts should be factored into the control effectiveness (E_C) evaluation, which considers deterrence, delay, detection, and response.

Effectiveness of Controls (E_C): The following four areas must be assessed. Effective controls for combat operations and contingency response will enable rapid and effective response to limit causalities, limit contamination, and conserve valuable resources (i.e., limit known vectors that could infect personnel).

1. Deterrence

- Illumination of installation
- On-site personnel readiness
- Training/personal hygiene
- Installation security checkpoints
- Barricades to include fencing/obstacles
- MPH sanitary surveys of workplaces, sleeping quarters, and mess halls
- Personnel properly vaccinated for diseases endemic to AOR
- Up to date water vulnerability assessment
- Food and water acquired from secure/approved sources (locked down with limited access)
- Reverse osmosis water purification units operating effectively (including proper maintenance) and chlorine residual maintained and monitored in distribution system
- Attack/event alarm system in place to warn personnel of impending attack or that an attack has occurred

2. Detection

- On-site screening tools (e.g., HHA)
- In place perimeter detection network
- Rapid agent laboratory analysis
- Active epidemiological surveillance
- Intrusion detection for water distribution system
- Trained medical staff and members of response teams

3. Assets

- 30-day secure supply of food/water for all personnel
- Medical supplies that include prophy, antibiotics
- PPE, respirators, masks, gloves, and filters, household bleach, decontamination supplies

4. Response

- Time to assess and respond to attack/event
- Medical diagnosis/counter-act agents
- Priority operations, personnel, assets are identified
- Personnel are trained/confident in self-aid and buddy care
- Personnel know MOPP levels and trained/confident in donning protective equipment

Potential Consequence (C): Consider the impact on emergency responders, first receivers, contaminated resources, as well as the mission. Exposed people may unknowingly carry contaminants through public transportation systems, business communities, doctors' offices, clinics, living quarters and emergency departments.

Refer to the list of threat questions below to assist in quantifying the potential consequence for each vulnerability with respect to the overall mission and safety and health of personnel, including noncombatants.

1. Does enemy have bio-weapon capability; are diseases endemic in this region?
   - Production capability
   - Medical/drug laboratories exist in the AOR
   - Existing agent stockpiles (known)
   - Established munitions plants that could be converted for biological agent use
   - This includes naturally occurring diseases
2. Is the base within range of enemy delivery systems, or environments capability of producing and proliferating the threat? Consider air, water, food, vectors.
3. Would the enemy launch a direct attack on the installation (e.g., artillery barrage) or use covert methods (e.g., sabotage of food and water supplies)?
4. Are weather conditions and terrain favorable for attack (e.g., installation located in tropical climate and land mass fairly level)?
5. Is the enemy trained to conduct biological operations?
6. Has the enemy ever conducted biological operations against a known enemy?
7. Does the installation have a mosquito control (spray) operation?
   - Is the truck stored and maintained on base
   - Is the truck operated by third country nationals
   - Is the chemical control agent used verified and approved by MPH and BES
   - Is the truck inspected before entry on the installation
   - Is there a scheduled spray time and predetermine route for mosquito control
8. Does the local populace suffer from highly communicable diseases?
9. Is the local populace vaccinated against endemic diseases?
10. Do vectors carry highly communicable diseases?
11. Is there a control plan to limit or eliminate vector infestation of food/water storage areas to included troop rest/relaxation areas?
12. Do personnel consume food and beverage from off base sources?
13. Do local nationals have access to food preparation and delivery facilities?
14. Has MPH accomplished a food vulnerability survey?
15. Do local nationals have access/work where they have access to areas such as: clinic, food/water storage areas, potable water disinfection systems, gym, and troop rest/relaxation areas?
16. Is the installation located within an agriculture area with active farming operations (e.g., crop dusting)?
17. Does the installation have structures that would make it susceptible to attack?
18. Does the installation have families or bases?
19. Does the installation share facilities or utilities with the civilian sector?
20. Does the installation acquire it water supply from the civilian sector and are treatment systems located off base?
21. Are there effective medical treatment(s) and vaccinations available?
22. Is there an agent detection network in-place and are personnel confident and knowledgeable in its capabilities/limitations?
23. Are military personnel, including commanders, capable and knowledgeable in quickly donning MOPP gear and know/act in regards to the alarm signals?
24. Is there an evacuation route or shelter in-place plan for personnel?
25. Is there a downwind (200km) weather prediction assessment model available from point of attack?

7.3.2. Agent Delivery and Dissemination Methods: The primary concern with biological agents is aerosolized agents which pose an inhalational and dermal contact hazards. Also, biological weapons can also be delivered through the sabotage of food and water supplies. Table 7-3 provides guidelines for assessing the likelihood of an attack based on environmental conditions, agent characteristics, and readiness postures. Engineered agents may be more persistent, and may disperse more efficiently.

Table 7-3: Threat Assessment of Biological Attack

Risk Level	Terrain	WX	Agent	Delivery Means	Command Capability
High	Valley, isolated or location; urban; near capital; in "hot spot"	Overcast, foggy	Pathogens for which there are no remedies or those without remedies available	Infusion into food/water supply	Anticipating CBW—well-equipped, on alert, etc. for all types of BW attacks
Medium			Pathogens with remedies available	TBM, aerosol dispersion	Aware and partially equipped for most likely BW attacks
Low	High altitude, remote, low significance	Sunny, clear	Pathogens/ toxins for which there are remedies and for which remedies are readily available		

7.3.2.1. Air: Conventional munitions are inefficient systems for biological warfare because they generate great heat from the explosive reaction which will inactivate most agents. Explosions will generate a wide range of particle sizes with only a fraction of the agent being aerosolized with the particle size necessary for disposition in the lower respiratory tract. There are two effective methods that exist for the aerial dissemination of biological agents:

Line Source: This method is most effective when using a dispersal means (e.g., a truck or air sprayer) that moves perpendicular to the wind during an inversion in which air temperature increases with altitude, holding surface air and pollutants down. Aerosol generators capable of generating particles of optimal sizes are easily constructed by adapting available agricultural and industrial sprayers.

Point Source: This method uses small bomblets deployed in a saturation mode. The saturation technique overcomes the meteorological requirements for line source dissemination. Agents may be introduced into a building' HVAC systems or via food or water contamination. Small packages or envelopes may also be used to disperse the agent. See the technical manual for more information.

7.3.2.2. Vector-Mediated Delivery: This occurs when insects, other animals, or humans are utilized to disseminate biological warfare agents. Vector-mediated delivery allows for

clandestine releases that are hard to identify or to attribute to a specific adversary. See the technical manual for more information.

7.3.2.3. Fomite Spread: Using inanimate objects (fomites) to spread agents is another potential way to disseminate biological agents, such as smallpox. Evidence suggests that while the primary means of transmission of smallpox is through person-to-person contact, the smallpox virons can also be spread via human contact with contaminated surfaces or by aerosolization, increasing the dissemination hazard of the contagion. The recent case of anthrax-mixed powders shows the efficacy of fomite spread.

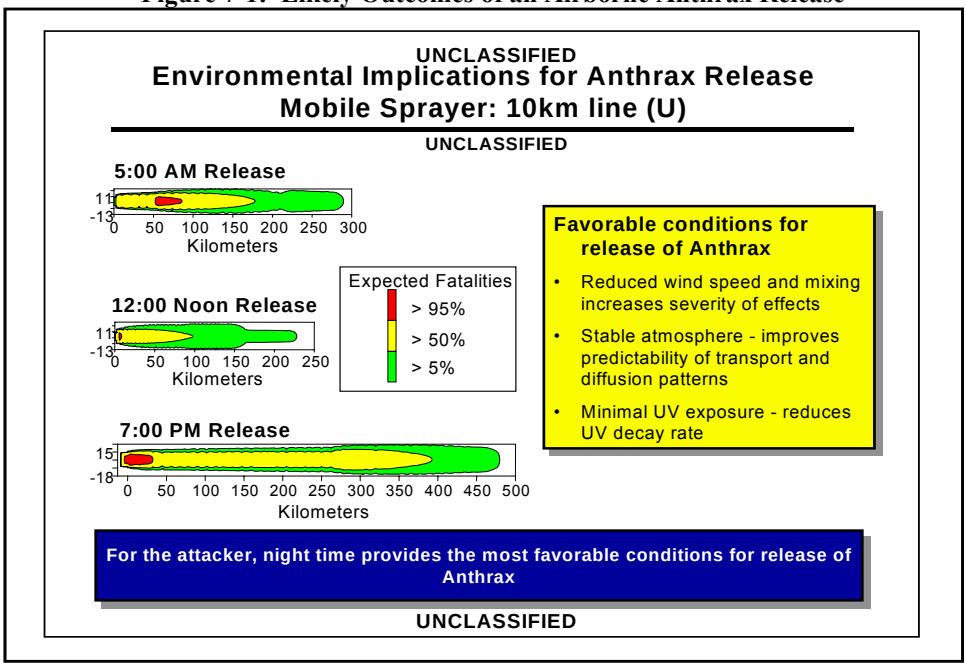
7.3.2.4. Food or Consumer Product Contamination: Food or other products for human consumption are also a group vulnerable to biological contamination. Many can be laced with pathogens. See the technical guide for more information**.**

7.3.2.5. Water Contamination: Some pathogens can grow in water, survive for considerable lengths of time, or survive normal chlorination and filtration treatments in municipal water supply systems. However, a successful attack would most likely have to occur after treatment with the point of contamination near the end-user. Toxins, which are generally unresponsive to normal water treatment, can be transported via water supplies. The amount of agent required to have an operational impact varies and in some cases could be as small as a few hundred grams. On the other hand attacking a specific building by creating a high-pressure "tap" into the water supply is technically straightforward and requires less agent. Several pathogens and toxins can survive standard water treatment; an example is Cryptosporidium parvum.

7.3.2.6. Environmental Parameters: Wind direction, ambient temperature, sunlight (UV radiation), humidity, and etc. all effect the spread of the agent. The environment the agent will be used in dictates agent dissemination. In addition, agent persistency/decay is greatly affected by weather conditions. Since UV light is the primary cause of decay, night attacks would likely be most effective, but daytime attacks can still be effective on a fixed site target. Most agents can survive hours to days in the environment, however, agents can be engineered to persist longer.

Figure 7-1 below shows the significance of the time of attack for a successful anthrax release**.** A nighttime line sprayer attack produces the largest hazard area and the highest dosages due to weak, stable near surface air typically found on a clear night, at a lower temperature and humidity; and under minimal UV intensity. The convergence of these environmental conditions at nighttime would optimize the results of an attack. The chart demonstrates the dramatic improvement in the size of the affected area, almost double, and the intensity of dosage of a nighttime attack compared to a daytime attack.

Figure 7-1: Likely Outcomes of an Airborne Anthrax Release



Potential for Re-aerosolization: Most biological agents are not persistent, and will decay within hours or days under exposure to the environment. However, anthrax spores can survive in a non-vegetative state for years if embedded just beneath the surface where they would be shielded from UV radiation, temperature, and humidity effects. Some evidence, including the recent experience with anthrax, suggests that if disturbed, anthrax can re-aerosolize, possibly generating a local dosage hazard. Also, there are modifications or coatings that can be applied to agents to increase persistency and re-aerosolization. Therefore, references stating the persistency and survivability of agents may not be as valuable.

The conditions necessary to cause an operationally significant re-aerosolization hazard are not completely understood. However, re-aerosolization is most likely in areas where the agent is highly concentrated and where there is low UV light, and where favorable temperature and humidity conditions ensure its longevity. Thus, the form of the agent at the time of delivery is significant. Dry anthrax may be deposited over large areas with relatively small deposition levels on the ground. It is unlikely that re-aerosolization of anthrax from these depositions will generate an operationally significant hazard. An initial deposition of wet anthrax, however, can result in high, localized concentrations of agent directly around the release point. Such high agent depositions around the source in a small area of the surface, could, if disturbed, re-aerosolize hours to days after an attack.

7.4. Evaluation and Sampling Strategies: There are a wide range of tools available to BE, but each has limitations either in the scope of the analytes they can detect or because of

the limits of detection. Appendix P lists a wide range of biological agents and provides detection information for HHAs, JBAIDS, M1M, and HazMatID.

7.4.1. Coordination with Reach-back Laboratory: Because of the limits of the field portable analytical equipment available to BE, a reach-back laboratory (either at the local base if in-garrison or other military analytical facility) must be utilized for sample confirmation. Before sampling occurs, provide the lab with advanced notice that a biological sample will be delivered. Typically, the analytical methods that labs use involve diluting the sample which might bring the results below the limit of detection. To help minimize this problem either increase sample collection time or ask the lab to not dilute. Also, if the sample is going to be sent in an aqueous solution, try to use the same diluent (typically a phosphate buffer solution) that is used by the lab for analysis. Do not bring a sample of powder to a lab unless specifically requested to do so. It is important to coordinate sample collection and transmission procedures with the laboratory in advance. Finally, consider the length of time it takes to run the various analyses; there may be a different course of action proposed to the commander if the biological agent confirmation analysis takes twenty minutes versus four to six hours.

Table 7-4: Biological Agent Analysis Methods and Times

Device	Analysis Time	Detection Capabilities
HHA	20 min	Presumptive ID of 10 biological weapons threats and 4 simulant agents
M1M	45 min	Anthrax Botulinum toxin Ricin toxin
JBAIDS	4-6 hours	Anthrax Brucellosis Ebola EE Encephalitis VE Encephalitis Glanders Marburg Orthopox Plague Q-Fever Small pox Typhus Tularemia

7.4.2. Detection: Early detection and identification of a biological agent attack is important in providing a trigger to initiate physical protection measures, medical prophylaxis, and effective treatment. Also, detection may help determine the concentration/dose, area affected, and expected duration of the hazard. Samples should be collected from air, surfaces, and water.

7.4.2.1. Limits of Detection: See Appendix P for specific agent identification, equipment capability, and limit of detection (LOD) for the JBAIDS, M1M, and HHA.

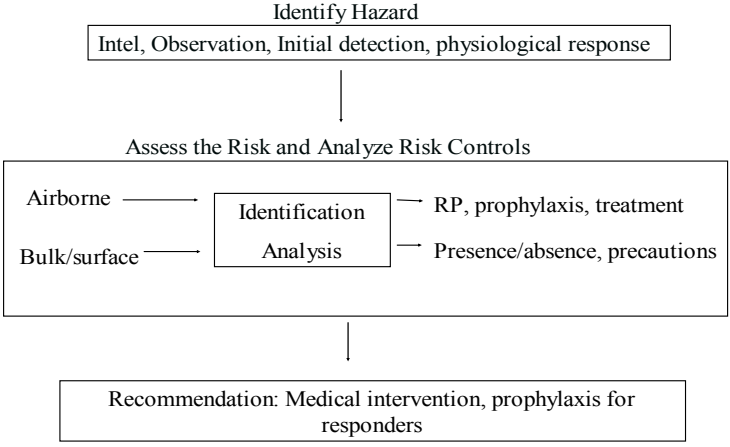
7.4.3. Point Source Detectors: These are field portable analytical instruments that can be used at the site of an initial attack to detect the presence of an agent and possibly identify the agent. Instruments used are: Portal Shield, HHAs, HazMatID, JBAIDS, M1M, and XMX. See technical manual for additional equipment information.

7.4.4. Standoff Detectors: Standoff detection uses electromagnetic radiation (e.g., UV/IR lasers) to detect the threat agent (e.g., aerosol cloud) at a specific distance. The technology of this system type (non-specific) is being reviewed by numerous governmental departments and would afford the earliest warning systems for military installations. While this technology may detect a potential hazard, identification is required to confirm since there is a high potential for false positives.

7.4.5. Sampling Scenarios: The following outlines several sampling strategies using field portable equipment on the BE allowance standards.

7.4.5.1. Suspected Biological Hazards Released from Mail Inside Building

Chart 7-1: Sampling Flowchart for Biological Agent Release Inside Building



Identify the Hazard – Look at available intelligence

- Was there a report of an attack?
- Were there any witnesses?
- Did the initial detectors identify anything? Monitor bulk materials and air.
- Any physiological responses will take 24-48 hours to manifest

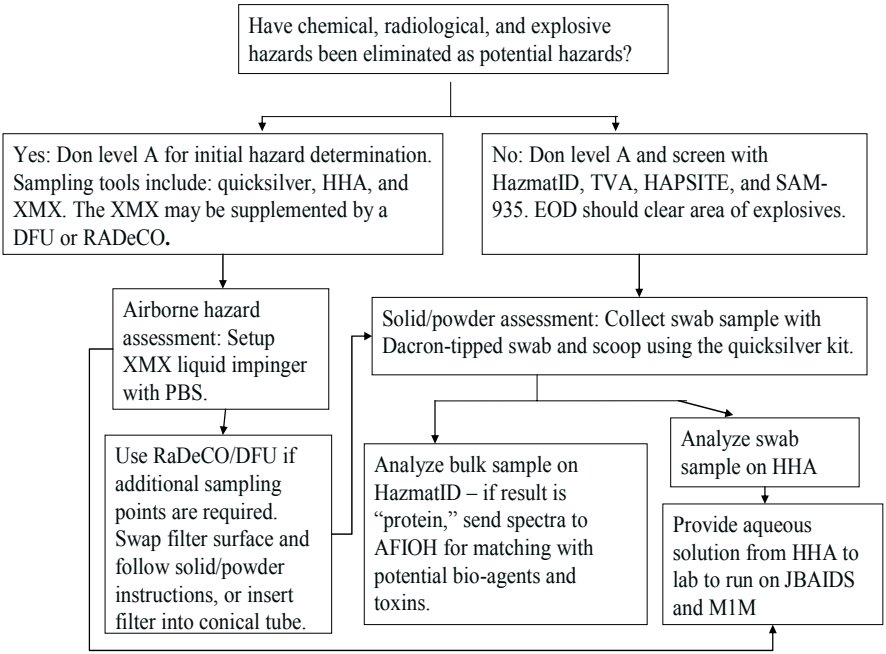
Assess the Risk

- Follow ASTM-compliant sample collection and analysis methods
- Screen materials with HazmatID and HHA
- Use on-site or reachback laboratory analysis to confirm identification
- Compare airborne concentrations with toxicology information in Appendix P

Analyze Controls

- Is respiratory protection necessary? Other PPE?
- Is prophylaxis necessary? Can prophylaxis reduce risk of disease and help return to operations after incubation period?

Chart 7-2: Sampling Strategy for Biological Agent Release Inside Building



7.4.5.2. Potential Water System Contamination

Natural Water Threats

- E. coli
- Salmonella
- Vibrio cholera
- Cryptosporidium parvum

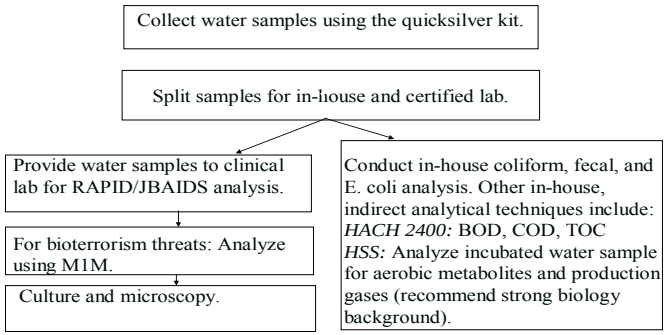
Bioterrorism Threats

- Bacillus anthracis
- Ricin
- Botulinum toxin

Analytical Tools

- JBAIDS capability – All except toxins
- M1M capability – Bioterror threats
- HHA capability – All except E. coli and Cryptosporidium
- HACH2400 capability – Biological indicator tests – BOD, COD, TOC
- HAPSITE Headspace – Biological metabolites present

Chart 7-3: Sampling Strategy for Biological Agents Released in Water System



7.4.5.3. Potential Food Contamination: Food samples for CBRN response fall under the responsibility of BE, not Public Health.

Consult Laboratory for Type of Analysis
- M1M subject to less interferences than JBAIDS
- Collection, preparation and extraction techniques will vary; consult CBRN sampling guide

7.4.5.4. Release of Agent Outdoors: When an agent is released into air, a massive dilution occurs moments afterwards limiting the effectiveness of air sampling. Unless intelligence sources can pinpoint a future time of a release, or if BE is properly equipped and in the field moments after a release, sampling should focus on water and bulk sampling.

Identify Potential Boundaries
- Evaluate weather conditions; collect samples under various weather conditions

Sample Collection
- Locate nearest stagnant water source and collect sample.
- Locate likely fallout area, collect swab samples and analyze.
- Locate likely airborne contaminant area, run XMX, and RADeCO air samplers.

7.4.5.5. Biological Weapons Laboratory: In the case of biological weapons laboratories, BE will most likely be partnered with CE or other line functionals for the evaluation.

Don Personal Protective Equipment
- Don level A PPE
- Level C PPE may be appropriate if chemical hazards are ruled out, however constituents from toxin production labs involve chemical extraction processes which may present a chemical hazard if present.

Sample Collection

- Airborne constituents – Set up XMX liquid impinger; split sample and analyze with HHA, RAPID and M1M. The figure below shows several methods to determine sample volume based on the type of analysis.
- Surface samples– Swab all surfaces, tubes, glassware, etc; analyze with HHA, RAPID and M1M (use diluent from HHA for RAPID and M1M).
- Bulk samples – Screen samples with HazMatID, then swab for HHA, RAPID and M1M analysis; higher concentrations will result in shorter turnaround times for RAPID andM1M.

7.4.6. Sampling Parameters: At the time of publication, air sample collection methods for biological agents had not been established for the equipment on BE allowance standards. However, some general guidelines can be followed to mirror practices used in collecting chemical samples.

For outdoor sampling, follow the DQO techniques provided in chapter one for determining the number of samples to collect. For indoor sampling, collect several air changes of room air. The number will depend on the level of confidence desired. For indoor clearance sampling, follow a practice similar to that used for asbestos clearance sampling – aggressive sampling for 8 hours. The number of samples or time of sampling for indoor environments can be calculated using the following equation:

$$t_{sampling} = \frac{V}{Q} \times C$$

Where:
V is the volume of the room
Q is the flowrate of the collection device
C is the number of room air changes desired

If the time required by this equation is excessive, you may setup multiple air samplers. Divide the time of sampling by the number of air samplers to calculate a new sampling time.

The limit of detection for the analytical method and the adverse effects level of the agent must also be considered when determining sampling time. Use the following 2 equations to determine the effect concentration and corresponding sampling time based on the agent of concern and limit of detection.

$$C_{eff} = \frac{Dose_{eff}}{t_{\exp} \times BR}$$

Where:
$Dose_{eff}$ is the number of organisms or mass of toxin required to effect or infect a person
t_{exp} is the exposure duration in minutes; for clearance, use 24 hours
BR is the breathing rate in liters per minute (15, 30, or 45 lpm based on work level)
C_{eff} is the effective concentration (organisms or mass/L)

$$t_{sampling} = \frac{LOD \times V_{col}}{C_{eff} \times Q}$$

Where:
LOD is the limit of detection of the analysis method (concentration) – Appendix P
V_c is the volume of liquid that the sample is placed into (i.e., 5 mL for XMX inpinger)
C_{eff} is the effective concentration of an agent, calculated from above equation
Q is the flowrate of the instrument (lpm)
$t_{sampling}$ is the sampling time required to collect sufficient sample to be detectable by the analysis when the concentration of the agent is at or above its effective concentration in the air.

7.5. Controls: An adequate understanding of the threat and preventive measures will help counter and control biological hazards. Many positive defensive measures can be taken prior to, or in anticipation of, this contingency.

- Food chains and water sources should be protected
- The control of rodents and insects should be a hygiene priority
- Available biological detection equipment and decontamination equipment should be fielded
- Airmen must be trained in the proper use and rapid deployment of individual protective equipment

Additionally, defensive measures should not be limited to the military population. It is imperative that medical planning include coordination between military and civilian medical authorities in order to minimize casualties and prevent panic. As an initial step, such fundamental concepts as protection of food and water supplies, creation of rudimentary collective protection shelters, and the effectiveness of hygiene and sanitation in a CBRNE environment might be introduced.

7.5.1. Engineering Controls

7.5.1.1. Shelter-in-Place: Shelters can protect personnel from chemical or biological contamination. As a minimum they provide a physical barrier which keeps a portion of the contamination away from the people inside. When airborne attacks occur, personnel take shelter to protect themselves against the hazards to include blast, heat, shrapnel, and airborne contamination depending on the type of weapons employed. Restricting flow of air into a shelter increases its value as a chemical or biological shelter. Unless employed in combination with other types of weapons, chemical and biological weapons normally involve limited destructive force allowing them to disseminate the agent without destroying it in the dispersal process. Studies have shown that a properly sealed building can provide a building protection factor of 17-44.

7.5.1.2. Collective Protection (ColPro) Systems: A ColPro system protects those inside a building, room, shelter or tent against contamination through the combination of impermeable structural materials, air filtration equipment, air locks, and over-pressurization. ColPro systems reduce contamination levels when personnel enter or exit the structure. They enable personnel to work or gain rest and relief without the

encumbrance of individual protective equipment. If ColPro systems are not available and chemical and biological contamination is present and persists beyond a few hours, it may become necessary to designate contamination-free areas for rest and relief.

All shelters must have capable shelter management teams (SMT). Without these teams, shelters will not function and the purpose for rest and relief will be severely degraded. SMT positions are key leadership positions. Assignment of dedicated personnel to these teams is a benefit through all phases of airbase operations. Proper training and exercise of these teams is vital to shelter operations.

7.5.1.3. Open Air Toxic-Free Areas (TFA): If personnel do not have ColPro, then another means must be provided for rest and relief of personnel. This can be accomplished by establishing rest and relief operations in a contamination free environment. If there is no area on base that is contamination free, then an open-air TFA will have to be established outside the confines of the base. An open-air TFA must be located away from contact and vapor contaminated areas. Although traditionally thought to be off-base, the TFA may be established in clean areas on the installation. The open-air TFA must be stocked with provisions just as personnel shelters are. This means stocking enough food, water, and clothing for personnel who are off duty as well as providing accommodations for sleep and sanitation.

7.5.2. Administrative Controls and Training

7.5.2.1. Time: Biological agents may be subject to environmental degradation. Commanders must weigh this option based upon input from BE and PH personnel. However, weaponized agent may be engineered to increase persistence, survivability, and virulence.

7.5.2.2. Distance: Only effective in aerosol dissemination attack/event; based upon agent type, stability, and environmental factors.

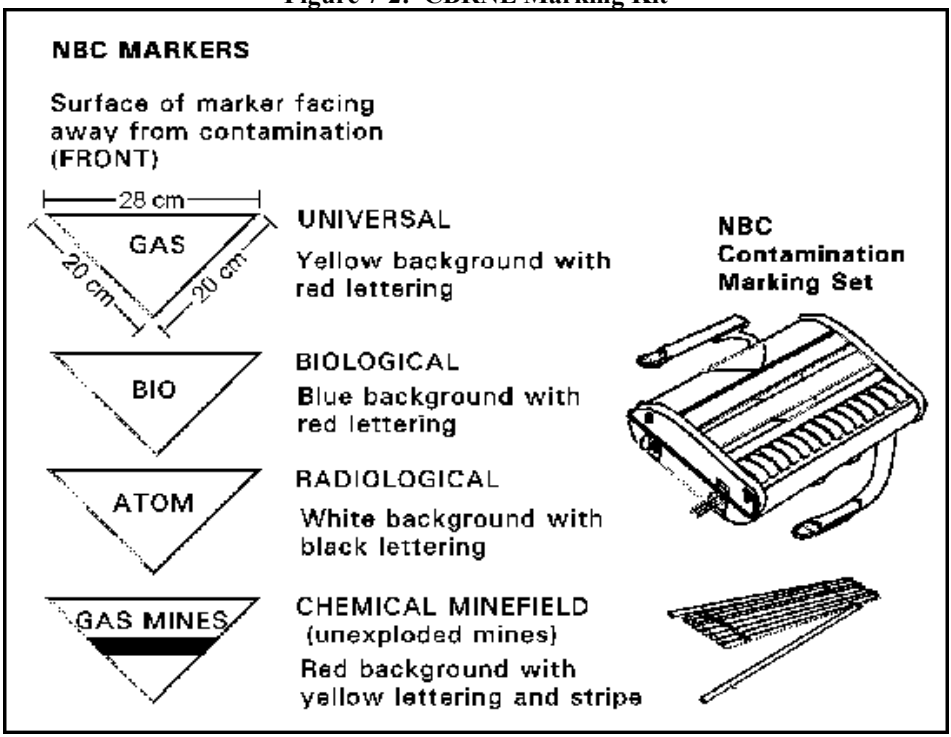
7.5.2.3. Marking Contamination: Contamination must be marked so unsuspecting personnel will not be exposed to it. When detection, monitoring, or reconnaissance teams detect or suspect CBRNE hazards, they mark all likely entry points into the area and report the contamination to higher headquarters.

7.5.2.4. Isolation: The separation of a person or group infected with a communicable disease from other people, while such disease is in a communicable phase, to prevent the spread of infection.

7.5.2.5. Quarantine: Compulsory detention or other restriction, including isolation, for purposes of preventing or limiting the spread of disease, or individuals or groups reasonably believed to be infected with a communicable disease, while such disease is in a communicable or pre-communicable phase.

7.5.2.6. Restriction of Movement: Limiting personnel movement to prevent or limit the transmission of a communicable disease.

Figure 7-2: CBRNE Marking Kit



7.5.3. Personal Protective Equipment (PPE): Level A, B, and C may be appropriate for response to biological hazards. The CDC categories provide some indication of the relative hazard presented by each agent. As with chemicals, level A is appropriate for unknown environments.

7.5.3.1. Armed Forces PPE: Protective actions against biological agents depend on the threat, mission, situation, and weather. As with nuclear and chemical protective actions, biological protective actions fall into three categories: action before the attack, during the attack, and after the attack. MOPP levels are established by the commander depending on the risk of attack. Commanders use MOPP analysis to determine appropriate MOPP levels based on the tactical situation. Leaders must balance the risks from stress and fatigue of their personnel, criticality of the mission, and physiological effects from potential exposure.

The currently fielded chemical protective equipment which includes the protective mask, the Joint Services lightweight integrated suit technology (JSLIST), protective gloves, and multi-purpose over-boots (MULO) protect against an airborne, biological agent attack. The

filter MUST be changed and replaced in a non-contaminated area under the following circumstances:

- The elements become immersed in water, crushed, cut, or otherwise damaged
- Excessive breathing resistance is encountered
- The "ALL CLEAR" signal is given after exposure to a biological agent
- Thirty days have elapsed in the combat theater of operations; the filters must be replaced every 30 days once opened
- Supply bulletins indicate lot number expiration
- When ordered by the unit commander

7.5.4. MOPP Levels, Alarms, and Signals: Airmen on the integrated battlefield will face a combination of CBRNE and conventional attacks. Individual and unit protection against chemical attack or contamination hinges on effective use of the MOPP and on individual proficiency in basic CBRNE skills. All personnel must be familiar with the standard MOPP levels shown in Table 7-5.

Table 7-5: MOPP Levels and Equipment Requirements

MOPP Level 0	MOPP Level 1	MOPP Level 2	MOPP Level 3	MOPP Level 4
Available for Immediate Donning	Worn	Worn	Worn	Worn
Individual protective equipment (IPE)[1]	Overgarment and field gear	Overgarment, overboots and field gear	Overgarment, protective mask, hood, overboots and field gear	Overgarment, protective mask, hood, overboots and field gear
Carried	Carried	Carried	Carried	Carried
Protective mask with C2 canister or filter elements and hood installed, field gear worn when directed	Overboots, protective mask and gloves	Protective mask and gloves	Gloves	
Primary Use: Pre- attack	Primary Use: Pre-attack	Primary Use: Pre- or Post-attack	Primary Use: Pre- or Post-attack	Primary Use: Post-attack
During periods of increased alert when enemy has NBC offensive capability; no indication of NBC use in immediate future	Periods of increased alert when CBRNE attack could occur with little or no warning; when CBRNE contamination is present or suspected, and higher levels of protection are not required.		When CBRNE attack is imminent or in progress; contamination is present or suspected.	

[1]IPE includes the groundcrew chemical ensemble and field gear, carry M8/9 paper, the M291 & M295 decontamination kits, and nerve agent antidotes in MOPP 1-4.
Additional Notes:
Air Force MOPP levels are consistent those used by the Army and Marine Corps, with the exception that these forces use the additional term "MOPP Ready." When operating as part of a joint or combined force, Air Force units that are directed to assume MOPP Ready will assume MOPP 0.

When a CBRNE attack is recognized, every airman must receive the warning and assume the appropriate MOPP level. Those in immediate danger need warnings they can see or hear. The alarm or signal must be simple and unmistakable for quick and correct reaction.

Units not immediately affected need the information to prepare for the hazard or to change plans.

7.5.5. Personal Protection for Casualties: Causalities unable to continue wearing protective equipment should be held and/or transported within casualty wraps designed to protect the patient against further exposure. Adding a filter blower unit to provide overpressure enhances protection and provides cooling.

7.5.6. Personal Protection for Medical Providers/Patient Care: Universal precautions involve the use of protective barriers such as gloves, gowns, aprons, masks, or protective eyewear, which can reduce the risk of exposure of the skin or mucous membranes of medical personnel to potentially infectious materials. Contact, splash, and droplets are common transmission methods.

7.5.7. DeMOPP or Reducing MOPP Levels: The incident commander and infection control officer or infectious disease advisor determines the appropriate level of personal protection. The local environment, threat analysis, personal vulnerability, and working conditions will determine if a level of personal protection beyond universal precautions is appropriate. BE should consider the following issues when making MOPP/de-MOPP recommendations:

- Nature of the mission (i.e., offensive or defensive; expeditionary or in-garrison; critical or non-critical)
- Likelihood of biological attack/event, targets, and anticipated agents
- Agent persistency, dissemination, and environmental conditions
- Additional available protection (e.g., shelter or cover)
- Physical and mental demands of the projected work
- Duration and speed required for mission accomplishment
- Likely follow-on mission
- Adequacy of available water and food supplies

7.6. Decontamination

7.6.1. Immediate Decontamination: Immediate decontamination minimizes casualties, saves lives, and limits the spread of contamination. There are three immediate techniques: skin decontamination, personnel wipe down, and operator spray down.

7.6.2. Operational Decontamination: Operational decontamination sustains operations, reduces the contact hazard, and limits the spread of contamination to eliminate the necessity or reduce the duration of wearing MOPP gear. It is restricted to specific parts of operationally essential equipment/material and/or working areas, in order to minimize contact and transfer hazards and to sustain operations. Examples of techniques include: vehicle wash down and MOPP gear exchange.

7.6.3. Through Decontamination: Thorough decontamination reduces contamination on personnel, equipment, material, and/or working areas to the lowest possible level (i.e.,

negligible risk) to permit the reduction or removal of individual protective equipment and maintain operations with minimal degradation.

7.6.4. Biological Agent Decontamination: Most patients who have been infected with a pathogen do not develop symptoms until one day to several weeks after exposure. The exceptions to this are patients exposed to biological toxins, who may develop symptoms several hours after exposure. At present, most biological agents do not survive for long periods outside a host. Consequently, decontamination is not typically necessary unless there is an overt attack and contamination persists. For mass causality decontaminations, copious amounts of soap and water are sufficient.

7.6.5. Decontaminate as Appropriate: Decontamination plays a very important role in the approach to casualty management. The incubation period of biological agents, makes it unlikely that victims of an attack will seek out medical care until days after an attack. At this point, the need for decontamination is minimal or non-existent. In those rare cases where decontamination is warranted, simple soap and water bathing will usually suffice. Routine use of caustic substances, especially on human skin, however, is rarely warranted following a biological attack.

7.6.6. Decontamination Methods: Decontamination methods have always played an important role in the control of infectious diseases. However, it is often impossible to use the most efficient means of rendering microbes harmless (e.g., toxic chemical sterilization), as these methods may injure people and damage materials which are to be decontaminated. Biological agents can be decontaminated by mechanical, chemical and physical methods:

Mechanical Decontamination: Involves measures to remove but not necessarily neutralize an agent. An example is the filtering of drinking water to remove certain water-borne pathogens (e.g., *Dracunculus medinensis*). In a biological warfare context, the use of an air filter to remove aerosolized anthrax spores, or water to wash agent from the skin.

Chemical Decontamination: Renders biological agents harmless by the use of disinfectants that are usually in the form of a liquid, gas or aerosol. Some disinfectants are harmful to humans, animals, the environment, and materials. This method should not be used for personnel decontamination.

Physical Methods: Agents used as biological weapons can be rendered harmless through such physical means as heat and radiation. To render agents completely harmless, sterilize with dry heat for two hours at 160 ºC. If autoclaving with steam at 121 ºC and one atmosphere of overpressure (fifteen psi), the time may be reduced to twenty minutes, depending on volume. Solar ultraviolet radiation has a disinfectant effect, often in combination with drying. This is effective in certain environmental conditions but hard to standardize for practical usage for decontamination purposes.

7.6.7. Decontamination Training: Patient decontamination teams should train using various simulants (e.g., oils, powders, etc.) and check decontamination efficacy with UV lights. By improving their techniques and demonstrating proficiency with a variety of invisible simulants, the patient decontamination teams can achieve an acceptable standard of performance.

7.7. Medical Countermeasures

7.7.1. Pretreatment: Vaccines, antibiotic, antiviral, or antitoxins are available for some biological agents. Vaccines are generally used before potential exposure so that the immune system has time to develop immunity. It also must be noted that not all agents have vaccines.

7.7.2. Prophylaxis: Antibiotics are not effective against toxins or viruses (e.g., smallpox). However, several antibiotics can be used to prophylax personnel and protect from them further exposure. Note, that adversaries have been engineering and developing antibiotic-resistant strains of several organisms.

7.7.3. Treatment: Some vaccines require a series regiment over time and may not be effective in a compressed regiment (any vaccine is better than not starting the regiment at all). In a post-exposure situation, the effectiveness of many antibiotics is heavily dependent upon their administration within the first few days of exposure. Prolonged use of antibiotics in a pre-exposure situation to prevent infection must be balanced against the risk due to the potential to compromise the immune system, drug administration side-effects (i.e., diarrhea, cramps, nausea), or select antibiotic resistance of the biological agent. Several agents have already been genetically engineered to be resistant to various antibiotics (e.g., some new anthrax strains developed are resistant to penicillin). Bacteria, even in the absence of genetic engineering, have the capability to naturally mutate in the presence of antibiotics and may become resistant.

7.7.4. Clinical Sample Collection for Biological Threat Agents: Appendix P outlines clinical sample collect requirements. Proper collection of specimens from patients is dependent on the time-frame following exposure. Sample collection is described for "Early post-exposure", "Clinical", and "Convalescent/ Terminal/ Postmortem" time-frames. These time-frames are not rigid and will vary according to the concentration of the agent used, the agent strain, and predisposing health factors of the patient.

- Early Post-Exposure Sample – When it is known that an individual has been exposed to a biological agent aerosol; aggressively attempt to obtain samples as indicated
- Clinical Samples – From those individuals presenting with clinical symptoms
- Convalescent/terminal/postmortem Samples – Taken during convalescence, the terminal stages of infection or toxicosis or postmortem during autopsy

7.7.4.1. Shipping Samples: Most specimens sent rapidly (i.e., less than twenty-four hours) to analytical labs require only blue or wet ice or refrigeration at 2 - 8 °C. However, if the time span increases beyond twenty-four hours, contact the USAMRIID's Hot-Line (1-888-USA-RIID) for other shipping requirements such as shipment on dry-ice or in liquid nitrogen.

Section 8.0: Radiological

8.1. Radiological Threats to Airbases: Radiological attacks may include a nuclear weapon detonation, electro-magnetic pulse, Radiological Dispersal Device (RDD), Improvise Nuclear Device (IND) and destruction of a nuclear power plant or reactor. The most damaging but least likely radiological attack is a nuclear weapon detonation or an IND (i.e. bomb). A RDD attack uses an explosive or incendiary mixed with radioactive materials intended to kill persons in the immediate vicinity with the radionuclide decay continuing to threaten first responders and others in the immediate area. The dissemination of other radiological attacks occurs via a public water supply, food source, aircraft, building ventilation system, etc. Exposure occurs through inhalation, ingestion and contact with the intent to kill or incapacitate.

8.2. Response Activities: Radiological response activities depend upon the incident, environmental factors and mission requirements. Use the tables below as a quick reference for generic radiological incident scenarios. The tables will aid in prioritizing what types of monitoring and sampling should be conducted following an incident. It depicts monitoring, surveying and sampling that should be considered during the radiological incident.

Table 8-1: Quick Reference for Generic Radiological Incident Scenarios

Threat:	Nuclear Reactor Accident, Nuclear Weapon, IND	Nuclear Fuel Repocessing Accident, Spent Fuel RDD, Mixed Nuclides	Abandoned, Lost or Malicious Use of Intact γ Source	Industrial, Medical or Research Accident, or RDD with γ Emitter	Nuclear Weapon Accident*, or RDD with α Emitter	Industrial, Medical or Research Accident, or RDD with β Emitter	Reactor Fuel Production Incident, DU Muntion Use	Luminescent Military Commodities, Some Nuclear Weapon Accidents**
Area of Concern:	Base & accident surrounding/downwind area							
Typical Radionuclides:	Noble Gases, Radioiodines, other Fission Products (FP), Transuranics	Mixed FPs, Transuranics, 236Ra	^{137}Cs, ^{60}Co, ^{192}Ir	^{137}Cs, ^{60}Co, ^{192}Ir	$^{238,239,240}Pu$, ^{235}U, ^{232}Th	^{90}Sr, ^{241}Pu, ^{32}P	^{238}U(DU)	^{3}H (Tritium)
Radiological Exposure Route:	External/Skin Dose, Internal Exposures	External/Skin Dose, Internal Exposures	External Dose	External/Skin Dose, Internal Exposures	Internal Exposures	Skin Dose, Internal Exposures	Internal Exposures (DU - mainly chemical toxicity)	Internal Exposures
Radiological Pathway:	Air, Soil, Water	Air, Soil, Water	Air	Air	Air, Soil, Water	Air, Soil, Water	Air, Soil, Water	Air, Soil, Water
Determine time, distance, and/or PPE requirements:								
Direct-reading dosimeter (EPDs)	1	1	1	1	2	2	2	
Dose-rate meter (ADM 300, 451P)	1	1	1	1	1	1	2	
Contamination meter (ADM 300, 451P)	1	1	2	1	1	1	1	3 (Special)
Determine medical countermeasures:								
Identify Isotope (SAM 935)	1	1	1	1		1		
PPE requirements:								
Anti-Contamination Clothing	1	1		1	1	1	1	3 (water proof)
RPP with HEPA/charcoal filters	1**	2		2	1**	2	3	3**

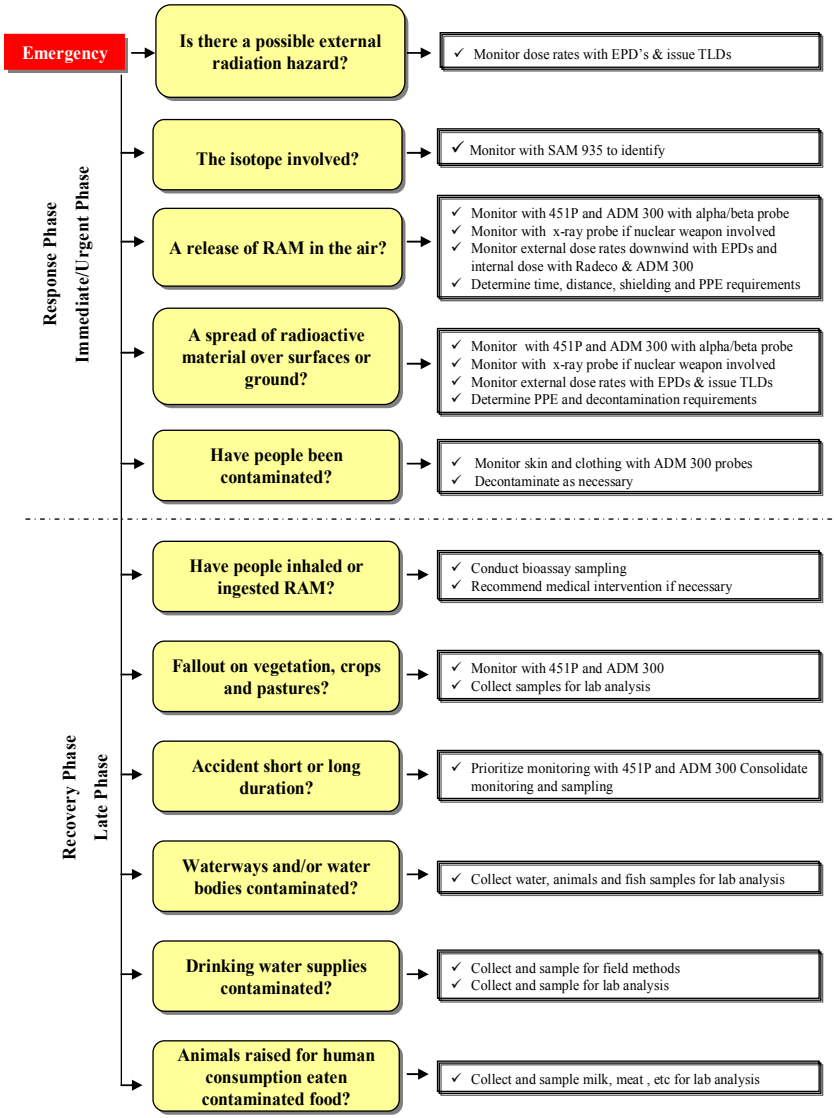
Key: 1 = Required, 2 = Recommended, 3 = Optional, Blank = Generally not necessary, consult HP expertise

* Nuclear weapon accident may result in tritium beta contamination in addition to alpha contamination

** Self-contained breathing appartatus required for very high airborne concentration and for tritium airborne environment

Source: *Extracted from NATO Handbook for Sampling and Identification of Radiological Agents (2000) with additional information*

Figure 8-1: Radiological Monitoring and Sampling Activities



Source: Extracted from NATO Handbook for Sampling and Identification of Radiological Agents (2000) with additional information

8.3. Identifying Health Hazards: Identifying the risk provides commanders with the information needed to determine protective postures and to tailor protective actions. It also confirms the realization of the threat and serves as the initial data point for further

characterization. Accurate identification of agents enables selection of the most effective protective actions, including medical treatment, limits mission degradation that results from taking unnecessary actions. The table below indicates the importance of identifying radiological hazards in field conditions.

Table 8-2: Potential Radiological Measurements and Importance to Identification of Unknown Radiological Emitters in Field Conditions

Measurement	Field Team Entries in Contaminated Areas	Contamination on Equipment, Personnel, and Casualties	Air Samples
γ-Radiation Exposure	Moderate	Limited, no photon energy information	Limited, no photon energy information
γ -Spectroscopy (SAM-935)	High	Low to Medium, dependent on amount of material	Low to Medium, dependent on amount of material
α-Contamination	Moderate	Moderate	Moderate
β-Contamination	Moderate	Moderate	Moderate
γ -Spectroscopy Analysis of Sample	High	Moderate	NA
Relative α -to β -Contamination Levels Measured on Surfaces	Low, due to uncertainty in detection efficiency	Low, due to uncertainty in detection efficiency	Moderate to High
Swipe α - to β -Contamination Levels	Moderate	Moderate	NA

Source: *Extracted from Table 13-5, IOH-SD-BR-SR-2005-0004)*

8.3.1. Detectors: Ionizing radiation can be detected through stand-off detectors, portals, point detection systems, and observations in the case of a nuclear detonation. There are a variety of detection systems that may be used for initial detection.

Table 8-3: Isotopes of Concern

Isotope	Common Uses	Availability	Source Quantities
P-32	Radiotracer Research	Common	Small
Co-60	Radiography, Irradiation, Medical Therapy	Common	Large
Sr-90/Y-90	RTGs, Gauges, Irradiation, Medical	Less Common	Large
Mo-99	Medicine	Common	Moderate
I-131	Medicine	Common	Moderate
Cs-137	Radiography, Gauges, Irradiators, Calibration	Common	Large
Ir-192	Radiography, Medical	Common	Large
Ra-226	226Ra:Be Neutron Sources, Dials, Medical	Common	Large
U-238	Counterweights, Shielding, Ammunition	Common	Small
Pu-238	RTGs	Uncommon	Moderate
Am-241	Gauges, 241Am:Be Neutron Sources	Less Common	Moderate

Extracted from "Radiological Dirty Bombs and Initial Risk Assessment" briefing by Lt Col Rademacher, May 2006

8.3.2. Occupational Exposure Limits: Table 8-6 provides a listing of permissible occupational exposure limits per AFI 48-148, and Table 8-7 presents the Environmental Protection Agency's Emergency Action Dose Guidelines. Additionally, Appendix Y provides guidance on the radiation dose rate associated with emergency response activities (e.g., establishing hot line, turn-around dose rate for life-saving, etc.). Also in Appendix Y is a gamma dose rate stay time table that details the length of exposure an individual may have at various dose rate levels.

Table 8-4: Detector Information

Detector / OPR	Type of Radiation	Principle Use	Principle of Operation	Range of Detection	DQO
ADM-300 / BEE/CEX	Gamma/Beta With external probes: alpha, beta, gamma, x-ray, and neutron radiation	Dose assessment for source contamination. Area and perimeter monitoring. Recommended for general survey measurements where dose assessments are required for low-range (10 µR/hr to 5 R/hr)	High and low range Geiger-Mueller **Note**: Dead time occurs in high radiation areas.	Gamma: 10 µR/hr to 10,000 R/hr (0.1 µSv/hr to 100 Sv/hr) Beta: 10 µR/hr to 5 R/hr (0.1 µSv/hr to 0.05 Sv/hr)	Determines time, distance and shielding
GSP-100 / AFRAT	Gamma/x-ray	Dose assessment for source contamination. Area and perimeter monitoring.	NaI Scintillation detector	50 KeV - 3 MeV	Determines time, distance and shielding
AP-100 / BEE/CEX	Alpha	Dose assessment for surface contamination. Monitor personnel, equipment, structures and air sampling filters.	Scintillation **Note**: Delicate and easily damaged	0 - 1,200,000 cpm	Identifies and quantifies inhalation hazards Determines PPE requirements
BP-100 / BEE/CEX	Beta	Dose assessment for surface contamination. Monitor personnel, equipment, structures and air sampling filters.	Scintillation **Note**: Delicate and easily damaged	0-999 Kcpm	Identifies and quantifies inhalation hazards Determines PPE requirements
XP-100 / BEE/CEX	x-ray	Low energy photon for weapn grade plutonium	CaF2 (Eu) Scinitillation	Measures low energy photon from 8.5 to 25.5 keV	Identifies inhalation hazards Determines PPE requirements
SAM935 / BEE	Gamma	Identifies unknowns. Dose assessment for source contamination.	NaI Scintillation detector **Note**: Cannot ID pure alpha or beta emitters.	Measures/analyzes gamma/photon energies between 18 KeV and 3 MeV	Determines time, distance and shielding Determines treatment and pre-treatment medical interventions
451P / BEE	Gamma, X-rays	Dose assessment for source contamination. Area and perimeter monitoring.	Ion Chamber.	Beta above 1 MeV and gamma above 25 KeV	Determines time, distance and shielding
APD-2000 / CEX	Gamma	Dose assessment for source contamination. Area and perimeter monitoring.	Geiger-Mueller	1 mR/hr -999 R/hr	Determines time, distance and shielding
EPD-Mk2 Dosimeter / BEE	Beta/Gamma	Dose tracking for source contamination. Area monitoring. Protection factor identification	Silicon diode detectors with amplifiers and counter circuits	Gamma, X-rays :5 keV to 10 MeV Beta radiation: 250 keV to 1.5 MeV	Provides immediate dose rate assessment Determines time, distance and shielding
EPD-N2 Dosimeter/ BEE	Neutrons/Photons	Dose tracking for source contamination. Area monitoring. Protection factor identification.	Silicon diode detectors with amplifiers and counter circuits	25keV-10MeV (photon), thermal- 15MeV (neutron)	Provides immediate dose rate assessment Determines time, distance and shielding
Inspector 1000 / AFRAT	Gamma	Dose rate for source contamination. Area and perimeter monitoring. Identifies unknowns.	Internal GM for high dose/count rate External NaI Scintillation detector	30keV- 1.4 MeV GM detector 50keV-3MeV NaI detector	Determines time, distance and shielding
FIDLER AFRAT	Low energy gamma radiation	Dose assessment for nuclear weapons grade plutonium Area and perimeter monitoring.	Internal NaI Scintillation detector	0 - 100 keV	Identifies inhalation hazards Determines PPE requirements
Ludlum / AFRAT	Alpha, Beta and Gamma	Dose assessment for nuclear weapons grade plutonium Area and perimeter monitoring.	GM or Scintillation	Varies depending upon equipment and model	Identifies inhalation hazards Determines time, distance and shielding Determines PPE requirements
Ion Chambers / NDI	Detects Beta Measures Gamma	Area and perimeter monitoring.	Scintillation	Varies depending upon equipment and model	Determines time, distance and shielding

Table 8-5: AFIOH WMD Alarm Settings

EPD Mk2 (Gamma-Beta)				
Dose Alarm Thresholds			Rate Alarm Thresholds	
			On	Off
Hp10 (1)	2,500 mrem		10 mrem/hr	8 mrem/hr
Hp10 (2)	25,000 mrem		5,000 mrem/hr	4,990 mrem/hr
Hp07	250,000 mrem		10,000 mrem/hr	9,990 mrem/hr
EPD N2 (Neutron-Gamma)				
Dose Alarm Thresholds			Rate Alarm Thresholds	
			On	Off
HpG (1)	2,500 mrem		10 mrem/hr	8 mrem/hr
HpG (2)	N/A		5,000 mrem/hr	4,990 mrem/hr
HpN	500 mrem		100 mrem/hr	90 mrem/hr
HpG+HpN	5,000 mrem			

(1) Continuous Single Tone
(2) Continuous Dual Tone
Source*: AFIOH Brooks AFB*

Table 8-6: Annual Dose Limits for Practices[1, 3]

Application	Occupational	Declared Pregnant Females	Minors (16 - 18 years)[4]	General Public
Total effective dose equivalent[2] Deep-dose equivalent + Committed dose equivalent	50 mSv (5 rem) in a single year, and 500 mSv (50 rem) to any tissue, except lens of the eye	5 mSv (500 mrem) for remainder of pregnancy to the embryo/fetus, avoiding substantial variation from a uniform monthly exposure rate	5 mSv (500 mrem) per year 50 mSv (5 rem) to any tissue, except lens of the eye	1 mSv (100 mrem) in a year[5]
Annual Dose Equivalent				
The lens of eye[6]	150 mSv (15 rem)		15 mSv (1.5 rem)	
The skin[6]	500 mSv (50 rem)		50 mSv (5 rem)	
The hands and feet	500 mSv (50 rem)		50 mSv (5 rem)	

[1]Based on the requirements 10CFR20.
[2]The limits apply to the sum of relevant doses from external exposure in a period of 1 calendar year and the 50-year committed dose from intakes in the same period.
[3]The mSv is the preferred unit of dose for radiation protection purposes.
[4]Conditions for Minors: No person under the age of 16 years shall be subjected to occupational exposure, and no person under the age of 18 shall be allowed to work in a restricted area unless supervised, and then only for the purposes of training.
[5]In special circumstances, an effective dose of up to 5 mSv in a single year, provided the average over five years does not exceed 1 mSv per year.
[6]Averaged over 1 cm^2, regardless of the area exposed.

Table 8-7: EPA Emergency Action Dose Guidelines (Actual)

Dose Limit (Whole Body)	Activity Performed
5 rem	All activities
10 rem	Protecting major property
25 rem	Lifesaving or protection of large populations
> 25 rem	Lifesaving or protection of large populations, only by volunteers who understand the risks

Dose includes the sum of external dose and dose due to internal contamination. Dose limits for eyes is 3 x the values listed above. Dose limits for any other organ (including skin and extremities) is 10 times the value listed above. EPA Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, EPA 400-R-92-001.

8.3.3. Biological Responses: The biological effects of radiation exposure depends upon the dose.

Table 8-8: Biological Effects of Radiation Exposure

Radiation Exposure	Biological Effects
1 rem	- no acute affects, very small chance of cancer
5 rem	- no noticeable changes
25 rem	- blood changes
200 rem	- nausea, vomiting, malaise, fatigue, fever, blood changes several hours after exposure - hair loss within weeks after exposure
400-600 rem	- reversible bone marrow destruction
700 rem	- irreversible bone marrow destruction
1000 rem	- severe nausea, vomiting and diarrhea immediately after exposure - death 1-2 weeks after exposure

Source*: Table obtained from EPA Radiation Safety Superfund Sites (165.1), Environmental Response Training Program*

8.4. Assess Risks: All monitoring activities shall be conducted so that exposures are maintained ALARA. Prior to entering the incident area, obtain background levels to subtract from the readings obtained in the field and establish a turn back or retreat level for team members entering the contamination area. Assessing the risk begins with identifying and quantifying the hazard using the methods stated below.

8.4.1. Air Monitoring for Alpha, Beta and Gamma: The RADeCO and/or Staplex may be used to collect air samples to determine the inhalation hazard. The NARP recommends a minimum air sample volume of 1,000 ft^3. If time or dust-loading constraints do not allow the collection of 1000 ft^3, then an air sample volume of 100 ft^3 can be substituted for the RADECO air sampler to meet analytical requirements. Use the ADM-300 alpha and beta probe to analyze the amount of radiation collected on the RADeCO/Staplex filters. Appendix H provides information on the operational use of the ADM-300. Check the filter for gamma radiation also since a gamma ray is released during both alpha and beta decay. Furthermore, the SAM-935 can be employed to identify the isotope. In absence of a SAM-

935, 3-M Post-it notes can be placed on top of the filter paper when beta is identified. The number of Post-it notes covering the filter correlates to the isotope based on the energy required to penetrate each sheet of paper. This is referred to as half-layer values. Use the following data to deduct the isotope using this method:

- <1 sheet: C-14
- 1 sheets: Tc-99
- 2.3 sheets: Cs-137
- 6 sheets: Sr-90/Y-90

The equation for converting cpm to dpm for alpha is as follows:

$$\frac{dpm}{m^3} = \frac{cpm \cdot x \cdot A_f}{0.5 \cdot x \cdot m^3 \cdot x \cdot F \cdot x \cdot E_f \cdot E_c \cdot x \cdot A_c}$$

cpm	Alpha or beta meter reading on air filter in counts per minute
0.5	Constant used to correct detector 2 π efficiency to a 4 π efficiency.
A_f / A_c	Alpha only: area of filter used (approximately 62 cm^2 [4" diameter reduced to a 3.5" diameter in the filter holder])/Area of filter paper is smaller than the detector, as in this case, no correction is necessary, therefore $A_f / A_c = 1.$)
A_f	Beta only: area of filter used (approximately 69 cm^2
A_c	Beta only: area of filter actually counted by the detector (same units as A_f)=15.5 cm^2 for the BP-100 (Note: When the filter paper is smaller than the detector, as in this case, no correction is necessary, therefore $A_f / A_c = 1.$)
m^3	= Total volume of sampled air in cubic meters (conversion 1 m^3 = 35.3 ft^3 = 1000 liters)
F	Alpha or Beta absorption factor for filter (approximately 0.5 for alpha particles and 0.1 for beta particles, based on conservation estimate with a maximum energy for 300 keV)
E_f	= Collection efficiency of filter used (0.95 per manufacturer) Note: If the collection efficiency of the filter is >95% E_f = 1 per NUREG 1400
E_c	= Efficiency of counting instrument (2 π efficiency for the detector, used a conservation value of 0.3 for the AP-100 or BP-100).

Source*: AFIOH consultative letter dated 7 February 2006, Consultative Letter, IOH-SD-BR-CL-2006-0017, Minimum Air Sample Volume for the RADECO High Air Sampler Model H-809VII*

By substituting these values into the above equation, the resulting correction factors for alpha and beta become 500 and 10,000, respectively. These are conservative correction factors using the RAECO Model H-809VII air sampling pump and RADECO Type LB-5211, Model 0750-49 4" filter paper, and analyzing the filter with an ADM-300 with AP-100 alpha probe (i.e., $dpm/m^3 = 500 \times cpm/ft^3$ for alpha; $dpm/m^3 = 10{,}000 \times cpm/ft^3$ for beta.).

The air sampling results (dpm/m3) can be divided by the unit-DAC (table 8-12 below) to determine the DAC-equivalent exposure. This can be compared with Table 8-19 to determine the recommended respiratory protection.

8.4.2. Area and Perimeter Monitoring: Perform base-level area and perimeter monitoring using the ADM-300 and the 451P. Use the SAM 935 to identify the radiological hazards. A reading of twice the background is recommended to mark the perimeter when low energy and/or x-ray instruments are used to establish the perimeter. (Source: NARP 2005)

- Protect the meter from contamination by wrapping it in plastic (except the detection window).
- Begin monitoring in a low exposure area and than move toward the higher exposure area. If the meter reading drops when approaching the high exposure area, it is likely the meter electronic processors have become saturated from too much data load. When this occurs, retreat to a known lower exposure location.
- Hold meter/probe 3 feet above ground level or area for beta and gamma
- Hold meter/probe 4" above ground level or area for low energy x-ray
- Hold probe 1/8" above ground level or area (protect mylar) for alpha
- Walk slowly to allow the meter to respond
- Lift feet when walking instead of shuffling to prevent resuspension
- Monitor area and around perimeter - record readings as needed
- Mark and walk around high radiation areas to prevent unnecessary exposure
- Record readings and locations using a GPS.

8.4.3. Ground/Soil Monitoring: After the contamination has settled to the ground, it may be re-suspended by wind or mechanical action. Other than during the initial release of contamination, airborne radioactivity is caused by re-suspension. Conduct ground monitoring to determine deposition of contamination and resulting radiation from the deposition. Follow the procedures above for ground monitoring as you would for area monitoring. Ensure readings and locations are recorded. Collecting surface soil samples helps to define the contamination contours or distribution pattern. The number of samples collected depends upon purpose and mission requirements.

- Sample least contaminated areas first and work your way to the most contaminated areas.
- Take ground reading of the area being sampled and record prior to sample collection.
- Avoid cross contamination by disinfecting sample collection devices and change gloves between each sample.
- Measure out two $3ft^2$ areas spaced approximately 3 meters apart. Collect the top 5 cm of soil, including vegetation from the middle and the four corners of each area in a sample container.
- Note the location of the sample using a GPS and label the sample as required by the lab.

8.4.4. Personnel monitoring: Conduct personnel monitoring to track exposures during an incident for cumulative dose records. Two methods are used. First, EPDs (See Appendix V) provide immediate results and alarms of personnel dose. EPDs document immediate exposures and verify PPE requirements. Periodically check the EPDs and notify IC if readings approach dose guidance. Second, TLDs provide a record of dose but do not provide immediate results. The TLD results become a permanent documentation of workers exposure history. Both are used when radiation exposures are suspected.

8.4.5. Bioassay: Perform bioassays on personnel suspected of being exposed to radiation. Once the isotope is identified, the bioassay sampling method is determined. Use Table 8-9 to determine what type of bioassay is needed and how long after exposure to collect the sample.

Table 8-9: Applicability of Bioassay Methodology

Methods	"General" Applicability of Bioassay Methodology for Airborne Releases in Accidents/Incidents				
	P-32	I-131	Co-60	Ra-226	Pu-238
			Mo-99		Pu-239
	Sr-90/ Y-90		Cs-137		DU/HEU
			Ir-192		Am-241
Fecal Sampling	Yes	No	Yes	Optimum	Optimum
Urine Sampling	Yes	Limited	Yes	Yes	Yes
Lung Counting	No	No	Yes	Yes	Yes
Whole-Body Counting	No	Limited	Optimum	Limited	No
Thyroid Counting	No	Optimum	No	No	No
Nasal Smears (Screening Tool)	Limited	Limited	Limited	Limited	Limited

Source*: Bioenvironmental Engineer's Guide to Ionizing Radiation, 2005*

Fecal Sampling: Collect sample within five days following a suspected acute intake since insoluble compounds pass through the GI tract rapidly post exposure. Recommend collecting samples within 24 hours of exposure. Collect specimens in sample container or a gallon plastic bag for a period of 24 hours.

Urine Sampling: Collected within the first week after a suspected exposure for maximum sensitivity. Recommend collecting specimens within 24 hours of exposure. Urine specimens should consist of total output for a period of 24 hours. For Plutonium, collect samples 2-3 weeks after exposure. For Tritium, collect one sample within 4-8 hours. Collect specimens in a plastic cube container.

Lung Counting: Most accurate method of determining internal exposures. No time limit noted.

Whole-Body and Thyroid Counting: No time limit noted.

Nasal Swab: Collect within one hour of termination exposure. Note that nasal swabs are only indicative of an inhalation exposure and cannot be used to quantitatively assess the amount of contamination inhaled. Swabs have limited usefulness since they may provide a false negative result if mucous clears the contamination prior to sampling. *Source: AFIOH website*

Note: It is recommended that AFIOH/SDRR analyze and be consulted on all routine and special bioassay samples. While some private sector laboratories have the capability to perform bioassay, they should only be used as a last resort since all internal radiation dose exposure must be documented on the AF Master Radiation Exposure Repository.

8.4.6. Toxicology

8.4.6.1. Dose Response: The dose response model suggests any increase in dose, no matter how small, results in an incremental increase in risk. The clinical signs of toxicity from high radiation doses follow the classic dose effect curve, some with organs more severely affected at each dose than others.

8.4.6.2. Agent exposure guidelines: Annual occupational exposure limits may not apply during radiological incidents or accidents. Exposures result from specific actions performed to mitigate the source of exposure, to save life or limb, protect high value assets, or to accomplish mission critical tasks. The commander's decision to allow exposures should be made in the context of the situation and the mission. Table 8-10 lists five categories for dose and recommended protection and surveillance actions for doses projected in that range

Table 8-10: Operational Dose Guidance

Total Cumulative Doses	Radiation Exposure Status Category	State	Actions	Increased Risk of Long Term Fatal Cancer	Acute Effects if Total Dose is Received in 1 Day
0 to 0.5 mSv or 0 to 0.5 Rad	0	***No Risk***	• None	***Negligible***	***None***
0.5 to 5 mGy or 0.05 to 0.5 Rad	***1A***	Normal Risk	• Record individual dose (TLDs, bioassays, EPDs) • Initiate periodic environmental monitoring • Shelter or evacuate exposed personnel	1:4,000	None
5 to 50 mGy or 0.5 to 5 Rad	1B	Minimal Risk	• Same as above • Initiate radiation survey • Prioritize tasks • Establish dose control measures during operations (time, distance, shielding, PPE)	1:400	None

Total Cumulative Doses	Radiation Exposure Status Category	State	Actions	Increased Risk of Long Term Fatal Cancer	Acute Effects if Total Dose is Received in 1 Day
50 to 100 mGy or 5 to 10 Rad	1C	Limited Risk	• Same as above • Update radiation surveys as necessary • Execute priority tasks only • Relocate exposed personnel • Recommend pretreatment and treatment medical countermeasures	1:200	None
100 to 250 mGy or 10 to 25 Rad	1D	Increased Risk	• Same as above • Execute critical tasks only	1:80	Temporary Sterility, Blood Changes, Chromosone Damage
250 to 750 mGy or 25 to 75 Rad	1E	Significant Risk	• Same as above	1:30	Depression of blood cell forming process

Table extracted from AFI 18-148 and amended with information from Army TG-239, June 1999

Table 8-11 shows the calculated acceptable airborne concentration based on the anticipated exposure time. The acceptable airborne concentration can then be used in conjunction with Table 8-12 to determine the actual DAC based on the respective isotope.

Table 8-11: Acceptable DACs Based on Exposure Time

Anticipated Exposure Time (hours)	Acceptable Airborne Concentration
25	80 DAC
50	40 DAC
100	20 DAC
200	10 DAC

Extracted from "Radiological Dirty Bombs and Initial Risk Assessment" briefing by Lt Col Rademacher, May 2006

Table 8-12: Recommended DACs for Emergency Response (Values from FGR 11)

Isotope	DAC (dpm/m3)	Inhalation Class	Isotope	DAC (dpm/m3)	Inhalation Class
P-32	4.4 E+05	W	**Tm-170**	2.0 E+05	W
Co-60	2.2 E+04	Y	**Ir-192**	2.0 E+05	Y
Se-75	6.7 E+05	D or W	**Po-210**	670	D or W

Isotope	DAC (dpm/m3)	Inhalation Class	Isotope	DAC (dpm/m3)	Inhalation Class
Mo-99	1.3 E+06	Y	**Ra-226**	670	W
I-125	6.7 E+04	D	**DU or HEU**	44	Y
I-131	4.4 E+04	D	**Pu-238/239/240**	18	Y
Cs-137	1.3 E+05	D	**Am-241**	6	W
Yb-169	6.7 E+05	Y	**Cf-252**	22	Y

The residence time of a radioactive particle in the lungs depends in part upon the solubility of the material. Three broad categories have been defined, and specify a characteristic half-time for inhaled material to clear from the pulmonary region of the lung to the blood and the gastrointestinal tract (Eckerman, 1988):

- Y: Radionuclides in insoluble compounds typically remain in the lungs for a long time; these are of Solubility Class Y (for years), also called Lung Clearance Class Y.
- W: Radionuclides in moderately soluble compounds remain in the lungs for weeks; these are of Solubility Class W (for weeks), also called Lung Clearance Class W.
- D: Radionuclides in soluble compounds remain in the lungs for only a short time; these are of Solubility Class D (for days), also called Lung Clearance Class D.

Source: Eckerman 1988, K.F. Eckerman, A.B. Wolbarst, A.C.B. Richardson. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*. Federal Guidance Report No. 11, U.S. Environmental Protection Agency, Washington, DC, DE89-011065.

8.5. Sampling Strategy

The sampling strategy depends upon the incident. Typical incidents include:

- A RDD uses any mechanism to distribute radioactive materials over a given area. Dispersal can include chemical explosives, aerosol sprays and hand distribution. Hazards include external exposure to beta/gamma radiation, gamma radiation alone, or internal exposure from alpha, beta, or gamma emitting radionuclides that are ingested or inhaled
- Nuclear Incident Response is the least likely threat but has the potential to cause the greatest damage. Actual energy distributions will vary with weapon employment technique, type of weapon, and weapon yield. Hazards include external exposure from neutron/gamma radiation in the event of a yield and internal exposure from alpha and low energy gamma radiation that are ingested or inhaled.
- Nuclear Reactor Release results from an attack on an installation, sabotage or from an accident. A damaged reactor can release large amounts of radioactive material, composed of many different radionuclides including particulate fission products, over an extended period. Hazards include both internal and external radiation hazards.

See table below for the different strategies and actions required.

Table 8-13: Sampling Strategies

RDD Known *(Know radiological hazard dispersed)*	
Equipment	
Primary • TLDs • EPDs – immediate dose tracking and feedback. • RADeCO • ADM Probes – dose assessment and surface/filter contamination • 451P – Id presence and 2 mR/hr line	Secondary • SAM 935 – identify unknown isotopes • APD-2000 with radiation capability
Actions	
• Establish and document exposures • Issue TLDs and EPDs – set alarm rates or use AFIOH rates • Monitor clothing, personnel or equipment exiting the hot zone to identify source • Set up RADeCO o Monitor for airborne contamination; internal dose assessment o Monitor for beta – open/close beta window to determine presence of beta and use half-value layer principle if necessary • If entering the hot zone, use 451P and SAM-935	
DQO's	
• Determine time, distance and shielding control practices • Determine internal inhalation hazards • Determine PPE requirements based on internal inhalation hazards • Medical pre and post interventions	

RDD Unknown *(Bomb exploded not sure if radiological device was used)*	
Equipment	
Primary • TLDs and EPDs • 451P • RADeCO and ADM 300 with probes at hot zone	Secondary • SAM 935 • APD-2000
Actions	
• Determine presence/absence of radiation hazard • Same as RDD known if radiation is present • Identify unknown for medical intervention	
DQOs	
• Determine time, distance and shielding control practices • Determine internal inhalation hazards • Determine PPE requirements based on internal inhalation hazards • Medical pre and post interventions	

Nuclear Incident Response *First concern: Determine if fission occurred*:

Equipment

Primary	Secondary
• 451P • EPDs N2 and Mk2 • TLDs	• ADM 300 • APD-2000

Actions

- Reference NARP
- Monitor for neutron and gamma radiation
- Issue TLDs and EPDs – set alarm rates or use AFIOH alarm rates
- Establish and document exposures

Fission did occur

Equipment

Primary	Secondary
• 451P • EPDs N2 and Mk2 • TLDs • ADM 300 neutron probe, x-ray probe	• SAM-935

Actions

- Reference NARP
- Issue TLDs and EPDs
  - Neutron dose for EPDs = N2 dose – EPD Mk2 dose
- Monitor for neutron and gamma radiation
- Focus on external dose evaluation and monitoring
- Hot line exposure dose is 10 mR/hr
- Establish and document exposures
- Determine stay times and other control measures

Fission did not occur

Equipment

Primary	Secondary
• RADeCO • ADM 300 probes (x-ray, alpha and beta) • TLDs and EPD Mk2	• Ion Chamber • APD-2000

Actions

- Reference NARP
- Focus on loose contamination for internal dose concentrations – external will be minor
- Monitor with ADM 300 x-ray probe – weapon grade monitoring for Pu^{239} and Am^{241} (not x-ray applications)
- Set up RADeCO
  - Monitor for alpha dose concentrations
  - Monitor for beta dose concentrations(use half-value layers as needed)
  - Monitor for gamma dose concentrations
  - Hot line exposure dose is 105 cpm for alpha and 10 mR/hr for gamma
- Monitor ground shine levels with x-ray probe (Am^{241})
- Establish and document exposures

DQO's

- Determine time, distance and shielding control practices (if fission did or did not occur)
- Determine internal inhalation hazards (if fission did not occur)
- Determine PPE requirements based on internal inhalation hazards (if fission did not occur)
- Medical pre and post interventions (if fission did or did not occur)

Nuclear Reactor Release	
Equipment	
Primary • TLDs • EPDs – N2 and Mk2 • RADeCO • ADM 300 with probes • 451P	Secondary • APD-2000 • SAM-935
Actions	
• Focus on fission products • Monitor for external gamma dose concentrations o Hot line exposure dose is 10 mR/hr • Monitor for internal dose concentrations • Set up RADeCO o Monitor for alpha dose concentrations o Monitor for beta dose concentrations (use half-value layers as needed) o Monitor for gamma dose concentrations o Hot line exposure dose is 105 cpm for alpha • Monitor for groundshine using 451P and ADM x-ray probe • Establish and document exposures	
DQO's	
• Determine time, distance and shielding control practices • Determine internal inhalation hazards • Determine PPE requirements based on internal inhalation hazards • Medical pre and post interventions	

8.6. Analyze Controls: During a radiological emergency, BE must act to protect the public and response forces from potential health hazards associated with the emergency. Controls for a radiological emergency are described below.

8.6.2. Administrative Controls:

8.6.2.1. Time: When necessary due to critical operations, calculate stay times to manage a person's exposure. Typically, 10 REM is the dose limit for emergency operations since at this level, no adverse, short or long term effects are anticipated. If necessary, commanders may increase this to 25 REM for limited operations and to 50 REM for missions where the alternative is significant risk to personnel or the operation based on the NATO guidelines provided in Table 8-10, *Operational Dose Guidance*. Stay times are calculated using the following formula:

T = D/R
T = Time of exposure to ionizing radiation expressed in hours or decimal fractions.
R = Dose rate expressed in R/hr or mR/hr, as determined from beta/gamma instrument.
D = The predetermined maximum exposure level.

8.6.2.2. Distance: Apply the inverse square law can to determine the change in radiation exposure with change in distance from a radiation source. By doubling the distance from the source of the radiation, the exposure decreases to one-fourth the original amount. The

inverse square law is an approximation; it applies only to a point in free space where there is no scattering of radiation.

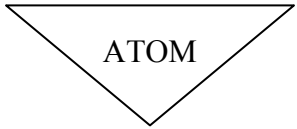
For alpha and beta sources, the 10 foot rule used for chemical exposures can be used as a quick guide to prevent unnecessary exposures.

For gamma and x-ray point sources and to some extent, neutrons, the inverse square law can be used to estimate intensities at various distances.

$$\mathbf{I_1 d_1^2 = I_2 d_2^2}$$

Where: I_1 and d_1 = original intensity and distance
I_2 = intensity at new distance
d_2= new distance

8.6.2.3. Marking and Labeling: Mark radiological contamination immediately upon discovery as to warn others of the hazard. If mission requirements prevent immediate marking, document the location and type of contamination and provide information to the OSC or unit control center.



- Face marking away from contamination
- Record the following on the marker:
  - Radionuclide
  - Dose rate
  - Date and time of reading
  - Date and time of burst

8.6.3. Engineering Controls

8.6.3.1. Shielding: Includes respiratory protection for alpha and beta particles as well as whole body shielding or collective protection. Table 8-19 shows the corresponding respiratory protection requirements based on airborne concentration. Additionally, mass placed between the source and the person will create shielding. Attenuation of photon energy is determined by using the following:

$$\mathbf{I = I_0 e^{-\mu x}}$$

I = attenuated radiation exposure rate
I_0 = original radiation exposure rate
e = base of natural logarithms
μ = linear absorption coefficient (cm^{-1}) from table 8-14

x = absorber thickness (cm)

Table 8-14: Typical μ - Linear Absorption Coefficients

Isotope	Gamma Energy (MeV)*	μ** Water	μ** Aluminum	μ** Plain Concrete	μ** Pb	μ** Fe	μ** Glass
Co 60	1.173	0.071	0.166	0.143	0.805	0.472	0.141
	1.333	0.063	0.148	0.128	0.666	0.421	0.126
Mo 99	0.181	0.151	0.372	0.316	22.839	1.546	0.310
	0.74	0.090	0.211	0.181	1.415	0.606	0.179
I 131	0.284	0.137	0.330	0.282	11.323	1.149	0.278
	0.364	0.119	0.281	0.241	4.571	0.865	0.238
	0.64	0.090	0.211	0.181	1.415	0.606	0.179
Cs 137	0.662	0.090	0.211	0.181	1.415	0.606	0.179
Ir 192	0.308	0.119	0.281	0.241	4.571	0.865	0.238
	0.468	0.106	0.250	0.215	2.634	0.740	0.213
	0.607	0.090	0.211	0.181	1.415	0.606	0.179
Ra 226	0.295	0.137	0.330	0.282	11.323	1.149	0.278
	0.352	0.119	0.281	0.241	4.571	0.865	0.238
	0.609	0.090	0.211	0.181	1.415	0.606	0.179
	1.12	0.071	0.166	0.143	0.805	0.472	0.141
Am 241	0.0595	0.227	0.994	0.751	91.185	15.409	0.674
Density g/cm^3		1	2.7	2.2	11.34	7.87	2.23

* Extracted from BEE Guide to Ionizing Radiation (2005)

** cm^{-1}

The following tables offer guidelines for the amount of shielding required to reduce the radiation level to one-half its original value for photons and one-tenth its original value for nuclear accidents respectively.

Table 8-15: Half-Value Thicknesses for Photons (Broad Beam) in Materials

Radionuclide	Photo Energy	Half-Value Thickness (cm)			
	(keV)	Water	Concrete*	Steel	Lead
Am-241	59	4.9	1.4	0.11	0.016 (160 μm)
Cd-109	88	6.4	2.4	0.24	0.034 (340 μm)
Cs-137	662	16	7.4	2	0.85
Co-60	1,173/1,332	18	8.5	2.5	1.2
Diagnostic x-ray	100 keV	4.4	1.1	0.09	0.011 (110 μm)
Industrial x-ray	10 MeV	31	14	3.2	1.8

* density (ρ) = 2.2 g/cm2

Source*: Extracted from Table 3-8, IOH-SD-BR-SR-2005-0004)*

Table 8-16: Tenth-Value Layers for Common Materials for Nuclear Accidents

Gamma	2" lead	6" gravel or sand	18" wood
	4" steel	7" earth	24" water
	4" concrete	8" hollow concrete blocks	14" books or magazines
	5-6" brick		
Neutron	10" water or poly material		
Alpha	1 sheet paper		
Beta	1 sheet aluminum foil		

Source*: FEMA HS-4 (Mar 87), Prepardness Planning for a Nuclear Crisis*

8.6.3.2. Collective Protection: Collective protection is an important aspect of airbase radiological defense. The basic concept is to provide overpressure, filtration, and controlled entry and exit. Maintaining a higher internal air pressure than external pressure and filtering incoming air prevents contaminated external air from entering the shelter.

- Pros
  - It provides a temperature-controlled, contamination-free environment to allow personnel relief from continuous wear of radiological PPE.
  - Personnel are able to carry out tactical functions, such as medical care, command, control, and communications, without being restricted by wearing NBC protective clothing
- Cons
  - Requires close-mode operations for safe unmasking
  - Requires entry and exit procedures
  - Increases logistical support requirements

8.6.3.3. Shelter In-Place: Sheltering is 10-80% effective in reducing dose depending upon the duration of exposure. The HVAC system must be turned off and vents, windows and doors closed and sealed for optimum protection.

- Pros
  - In-place sheltering provides low-cost, short-term protection
  - Under emergency conditions, it may provide limited protection to unprotected personnel or casualties that cannot wear the protective mask
  - Techniques applied rapidly, required little or no specialized training, and use common skills and supplies.
- Cons
  - Only provides short –term limited protection
  - Should only be used when there is no time for evacuation

8.6.3.4. Decontamination: According to AFMAN 10-2602 *Nuclear, Biological, Chemical and Conventional (NBCC) Defense Operations and Standards*, the Air Force and Joint Services conduct decontamination operations at three levels: Immediate, Operational and Thorough. AFI 10-2501, *Air Force Emergency Management Program Planning and Operations*, describes decontamination operations as: Mass, Gross, Emergency and Technical.

There is no single procedure, machine, kit or technique presently capable of fulfilling all airbase decontamination requirements. Table 8-18 outlines the specifics of each decontamination level.

Table 8-17: Decontamination Operations

AFMAN 10-2602		Draft AFI 10-2501	
Decontamination Level	**Definition**	**Decontamination Level**	**Definition**
Immediate	Carried out by individuals immediately upon becoming contaminated. Minimizes casualties, saves lives and limits the spread of contamination.	**Mass**	Process of rapidly reducing or removing contaminants from multiple persons in potentially life-threatening situations.
		Emergency	Process of immediately reducing contamination of individuals in potentially life-threatening situations.
Operational	Reduces contamination to specific parts or operationally essential equipment, material, and/or working areas, in order to minimize contact and transfer hazards and to sustain operations.	**Gross**	Process used to significantly remove surface contamination. Includes flushing with water and the removal of most or all of a person's clothing while continuing to flush.
Thorough	Reduces contamination on personnel, equipment, material and working areas equal to natural background or to the lowest possible levels, to permit the partial or total removal of individual PPE and reduce MOPP levels.	**Technical**	Physical or chemical process of deliberate decontamination to achieve a thorough cleansing and removal of contaminants from personnel or equipment.

EPA does not require runoff controls when decon processes are used to save lives or reduce injury.
EPA requires run-off controls during operational and thorough decontamination techniques.

Table 8-18: Levels of Decontamination

Level	Purpose	Who	What	When
Immediate, Gross, Mass, or Emergency	Minimize casualties, save lives, and help limit contamination exposure and spread	Individuals	Skin, personal clothing and equipment, frequently touches surfaces	As soon as contamination is suspected or detected
Operational	Limit contamination exposure and spread, helps to sustain operations by providing temporary and in some cases, long-term relief from wearing PPE	Individuals, crews, teams, units	Parts of essential operation equipment, work areas, vehicles and material	When operations require and resources permit
Thorough or Technical	Reduces or eliminates the need for wearing PPE	Units or wings, with or without external support	Personnel (CCA), equipment, material, vehicles, aircraft, work areas and terrain	When required for MOPP reduction, when operations, manning and resources permit; required for total reconstitution and return to unrestricted use.

Source*: Table extracted from AFMAN 10-2602 with additional information*

8.6.4. Respiratory Protection and Personal Protective Equipment: Usually considered as a last resort but needed during initial response activities to determine and document radiation levels for mission requirements. The result from air sampling and analysis helps to determine the appropriate level of respiratory protection in conjunction with Table 8-12,

Recommended DACs for Emergency Response above in section 8.4.6.2. and Table 8-19, *Respiratory Protection Requirements* below. To calculate the DAC equivalent for respiratory protection, divide the measured concentration (dpm/m^3) by the unit DAC equivalent for the specific isotope found in Table 8-12. Use Table 8-19 to determine the corresponding respiratory protection requirement.

Table 8-19: Respiratory Protection Requirements

DAC Equivalent	Respiratory Protection
< 1	No respiratory protection needed.
1 – 100 (Assume 100X PF)	Full-face respiratory protection required (M-series Protective Mask or NIOSH approved HEPA respirator
100 (Assume 10,000X PF)	Pressure demand SCBA or limited entry restricted to essential personnel wearing full-face respiratory protection. Source of contamination should be fixed as soon as possible.

Adapted from the NARP and converted to unit DAC for application with isotopes other than $^{238/239}Pu$

Example:

- Air sampling results indicate $^{238/239/240}Pu$ results are 30 dpm/m^3.
- Divide 30 dpm/m^3 by 18 dpm/m3 (from Table 4-XX) = 1.67 DAC
- 1.67 DAC is between 1 and 100, so full-face respiratory protection is required according to the Respiratory Protection Table above

Air sampling data is usually unavailable until some time after personnel have arrived on-scene. During the initial response, and when working in areas where available air sampling data may not be applicable, use Table 8-20 below.

Table 8-20: Respiratory Protection and PPE for Emergency Workers as a Function of Surface Contamination Using the ADM-300

Surface Contamination CPM	Surface Contamination µCi/m^2	Respiratory Protection and PPE
<20,000	<6	None required.
20,000 to 200,000	6 to <60	No respiratory protection for limited entries up to 4 hours. Full protective clothing.
200,000 to 2,000,000	60 to <600	Air purifying respirator and full protective clothing.
Above 2,000,000	Above 600	Wear pressure demand SCBA and full protective clothing. Source contamination should be fixed ASAP to prevent resuspension.

Source*: Table obtained from NARP (2005)*

8.6.5. Medical Countermeasures

In accordance with 41-106, *Medical Readiness Planning and Training*, the Medical Defense Officer provides health risk assessment (impact on personnel health and wing mission) advice to medical and line commanders to reduce adverse health impact and prevent further exposures in the event of an incident involving radiological agents. Intervention decisions are ultimately made by physicians, but BE can provide advice based on hazards identified, isotopes, and exposure.

8.6.5.1. Pretreatment: After time, distance, and shielding measures have been taken to minimize the exposure consider pre-treatments for operators that must continue the mission while being exposed to radiation.

8.6.5.2. Treatment: Treatments for internal contamination should begin within hours of exposure. The particular radioisotope determines the treatment method. After the initial treatment, there will generally be time to assess the situation as data from monitoring become available.

Treatments include blocking and diluting agents which decrease the likelihood of absorption by decreasing the availability of the radionuclide. Mobilizing agents are compounds that enhance and increase the natural turnover processes and thereby induce the release of radioisotopes from tissues. Chelators are substances that bind with some metals more strongly than others to form a stable complex that, when soluble, can be more readily excreted by the kidneys.

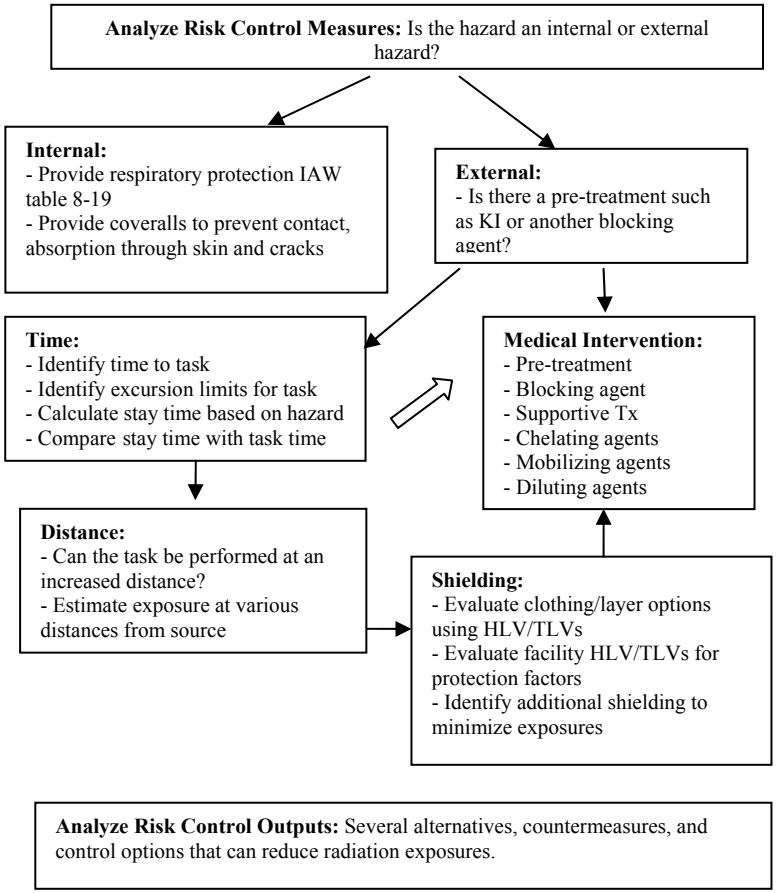
Table 8-21: Isotopes of Concern & Radiological Treatment Agents

Isotopes of Concern & Treatment Agents				
Radionuclide	**Radiation Type**	**Critical Body Site**	**Contamination Mode***	**Treatment Agent**
Americium	α, γ	Bone	I/W	DTPA†
Californium	γ, α, η	Bone	I/W	DTPA
Cerium	β, γ	GI, lung	I/GI	DTPA
Cesium	β, γ	Total body	I/S/GI	Prussian blue£
Curium	α, γ, η	Bone	I/GI	DTPA
Iodine	β, γ	Thyroid	I/GI/S	KI(sat.)¥
Plutonium	α, γ	Bone	I/W	DTPA
Polonium	α	Lung	I	Dimercaprol‡
Strontium	γ	Bone	I/GI	$AlPO_4$**
Tritium	β	Total body	I/S/GI	Forced H_2O§
Uranium	α, β, γ	Bone	I/S/W	$NaHCO_3$***

Isotopes of Concern & Treatment Agents	
*	**I** Contamination by inhalation
	GI Contamination by gastrointestinal absorption
	S Contamination by skin absorption
	W Contamination by wound absorption
**	The antacid aluminum phosphate in gel form used as a gastrointestinal adsorbent for radiostrontium
***	Sodium bicarbonate to maintain alkalinity of urine used in conjunction with diuretics

Source*: Guidance for Industry Internal Radioactive Contamination – Development of Decorporation Agents February 2005*

The diagram below summarizes the actions and risk control measures for radiological incidents.



8.7. Depleted Uranium. Depleted Uranium (DU) is a byproduct of the uranium enrichment process that is used to produce fuel for reactors. DU is a highly dense metal (19.1 g/cm^3), has a relatively high melting point (1132 ^{O}C), and has a low fabrication cost. U.S. Forces primarily use DU as aircraft counterbalances and for Armor Piercing/Incendiary (API) munitions.

8.7.1. Hazards. The hazards associated with DU depend on its physical form (solid versus particulate) and its chemical form (oxide versus elemental). For the applications normally found on the battle field, the primary hazards are radiological and toxicological.

- Radiological hazards associated with DU occur from both external and internal exposures. DU decay products emit alpha, beta and gamma/x-ray radiation that can result in external radiation for personnel. Contact doses from bare DU can be on the order of 15 mrem/hr for gamma radiation and 238 mrem/hr for beta radiation. However, DU counterbalances and API munitions are normally clad (covered) to prevent corrosion. This cladding essentially eliminates the alpha and beta radiation exposure and reduces the gamma/x-ray exposure. In its clad form, DU typically exhibits whole body gamma levels of 1 mR/hr. Adequate training on DU occupational hazards reduces the contact hazard from external radiation. However, those personnel engaged in decontamination of DU contaminated equipment, facilities, and environmental media are of primary concern for internal exposure resulting from inhalation of DU.
- Toxicological hazards associated with DU occur from ingestion or inhalation of particulate matter. Insoluble particulates that reach the lungs are primarily a radiological concern. However, the most significant health threat posed by DU is from the soluble DU fraction that is inhaled or ingested.

8.7.2. Potentially Contaminated Media. Typical contaminated media found on the battlefield are intact DU components, vehicle surfaces, and environmental media (air, water, and soil).

- Intact DU components such as aircraft counterbalances and API munitions will corrode or oxidize if exposed to air. This surface oxidation can become a minor source of contamination to personnel, equipment, vehicles, and the environment.
- Vehicle surfaces may become contaminated with DU as a result of direct API munitions strikes, traveling through DU contaminated environments. API munitions that hit an armored target essentially burn their way through the metal. As a result, DU oxide particles are deposited in or on the vehicle and as far as 100 yards down wind. The metal surrounding the penetration hole is generally the area of highest contamination. Resuspension of DU particulates inside vehicles is also a concern.
- Environmental media can be contaminated from weathering of intact DU components and release of DU oxides from API munition strikes or fires. However, environmental contamination is minor compared to vehicle surface contamination.
- The surfaces of equipment, vehicles, and facilities can be contaminated as a result of ground handling and/or storage accidents/fires.
- The A-10 gun can become contaminated as a result of misfiring or jamming.

8.7.3. Precautions. As discussed previously, ingestion/inhalation of DU particles from any form of contamination is the primary hazard of concern. The following commonsense rules apply when dealing with DU contaminated material.

- Ensure protective equipment (respirators, gloves, etc.) is operational and use it.
- Establish appropriate controls (contamination control station, radiological monitors, air sampling, etc.) to minimize the spread of contamination.
- Do not eat, drink, or smoke in potentially contaminated areas.
- Minimize time, maximize distance, and utilize shielding in order to keep doses received as low as possible.
- Minimize/eliminate unnecessary contact/entry into vehicles that have been impacted by DU munitions.

8.7.4. Exposure Standards. The limit for radiation exposure is expressed in terms of annual dose equivalent that combines internal and external sources. The annual dose equivalent limits are:

- 5 rem to the whole body or major part of the body
- 50 rem to any one organ, including the skin
- 50 rem to any extremity
- 15 rem to the lens of the eye

Compliance with these standards for external radiation sources is typically measured by use of personal dosimetry. Dose equivalents for internal radionuclides are based on the Annual Limit of Intake (ALI). The ALI is the amount of a radionuclide that will result in a committed effective dose of 5 rem per year for the whole body or 50 rem to any one organ. The ALI for insoluble DU is 4×10^{-2} Curies per year (Ci/yr). Since inhalation is the primary concern, compliance with established ALI is also defined in terms of meeting Derived Air Concentration (DAC) values. The DAC assumes exposure of 2000 work hours per year and breathing 1.2 cubic meters of air per hour. The DAC for insoluble DU (oxide) is 2×10^{-11} Ci/ml.

8.7.5. Contamination Limits. The Nuclear Regulatory Commission (NRC) has established limits for DU contamination in terms of average fixed contamination (one square meter average area), maximum fixed contamination (over any 100 cm^2 area) and removable contamination (that which can be removed by wiping with dry filter paper). All three criteria must be satisfied to comply with contamination limits. Limits for vehicles/equipment and persons and clothing are as follows

- Vehicles/equipment. Alpha = 5,000 dpm/100 cm^2 average fixed; 15,000 dpm/100 cm^2 maximum fixed; and, 1,000 dpm/100 cm^2 removable. Beta = 0.05 mrad/hr fixed at 2.5 cm and 500 dpm/100 cm^2 removable.
- Persons and clothing. Alpha = as low as possible. Attempt to decontaminate to background, but in no circumstances above 200 dpm/100 cm^2 over any 100 cm^2 averaging area. Respirators should be decontaminated to 100 dpm/100 cm^2 or less. Beta = 0.05 mrad/hr fixed at 2.5 cm, to background for removal.

8.7.6. Protective Clothing/Equipment. The purpose of protective clothing is to minimize the spread of contamination, personnel contamination, decontamination requirements, and the risk of ingesting/inhaling radioactive material. The type of protective clothing depends on the circumstances. However, the primary risk is ingestion/inhalation of DU oxide from contaminated vehicles/equipment that have been hit by API munitions. It has also been determined that DU oxide concentrations are highest in the enclosed spaces of destroyed armor/vehicles. Based on experience, the following protective clothing/equipment is required for the conditions cited.

- Interior of vehicles/equipment: Cotton work gloves, disposable coveralls with hood, and full face respirator. Shoe covers are preferred but regular combat boots may be worn if all openings are sealed with tape. Take breathing zone samples to assess the extent of DU contamination and for use in approving the downgrade of respiratory protection.
- Exterior of vehicles/equipment: Cotton gloves and disposable coveralls. Shoe covers are preferred but combat boots may be worn if all openings are sealed with tape.
- Handling intact exposed DU components: Cotton gloves and disposable coveralls.

8.7.7. Radiation Detection Equipment and Surveys. The type of equipment/surveys depends on the conditions. The following equipment/surveys are required for the scenarios indicated.

- Personnel monitoring. The most likely sources of personnel contamination will be from direct contact with contaminated media. Contamination on personnel should be monitored using the ADM-300 with AP-100 alpha probe and BP-100 beta probe. Probes should be held close to, but not in contact with, the surface to be surveyed.
- Large-area soil and gross vehicle monitoring. Weathering and subsequent attenuation of alpha/beta radiation, coupled with the need to screen large areas or pieces of equipment require monitoring for gamma radiation from decay of DU daughter products. A calcium fluoride or sodium iodide solid gamma scintillator type probe (i.e., SAM 935) is required. A micro R or microrem type instrument must be used to assess external exposure rates.
- Vehicle/equipment surveys. A suitable alpha survey meter is required for monitoring vehicle/equipment contamination where the surface is relatively free of oils, grease, or other debris that might reduce the alpha particles. For vehicles/equipment coated with oil, grease, or other debris a thin window pancake GM probe is appropriate.
- On-site air sample analysis. Use the ADM-300 meter for screening of collected air samples collected with a RADeCO high volume air sampler. The intent of this screen is primarily to validate the continued need for respiratory equipment.

Appendix A:
Sources of Information & Key Questions

Note: Document all information regarding Potential AOC, Sources, Activity, Exposure Routes & SEG directly onto the Conceptual Site Model Form located in Appendix

Homestation Documentation.

1. What are the OEH hazards/exposures in relation to weapon systems and base operations?

Mission planners or key deployment personnel

1. Where the operation(s) will occur?
2. When the operation(s) will occur and how long will it last?
3. What is the mission (training, consequence management, disaster relief, combat, nation building, etc.)?
4. Who is involved?
5. Task specifics
6. What tasks will be performed
7. How many people will perform the task?
8. Will these tasks be continual or intermittent?

OSI

1. Is there key Local threat information
2. Have local Force protection plans been developed

AFIOH

1. Previous EHSA or EBS

MGRL/PAM currently on site

1. What are the current visual observations and sampling and analysis results

AFMIC

1. Infectious Diseases and Industrial Facility Health assessments
2. Historical and current property use of the site such as the type of agricultural, industrial, institutional, commercial and/or residential uses.
3. Known hazardous waste sites.
4. Known contamination and pollution in air, water and soil media.
5. Typical climate conditions including normal and extreme temperatures, seasonal precipitation, and seasonal prevalent wind directions and velocities.

Meteorological and Climatological Data: Obtain applicable meteorological data to help determine COC concentrations in the air. Air contaminants are effected by specific meteorological conditions and surrounding topographical features. Obtain long-term meteorological data records to determine relationships between air pollution episodes and observed meteorological conditions. Surface meteorological is collected each hour at major worldwide airports. This normally includes the following:

Means and extremes of temperature.
Relative humidity.
Dew point, surface winds.
Cloud cover.

Note: Document all information regarding Potential AOC, Sources, Activity, Exposure Routes & SEG directly onto the Conceptual Site Model Form located in Appendix

Thunderstorm and fog occurrence.

Flying weather by ceiling and visibility categories. The climatology summaries can be expressed in daily, monthly, annual, or period of record statistics and can support pre-deployment planning.

Name	URL	Comment
USAF Weather Agency	http://afwin.afwa.af.mil/cgi-bin/nfgwc.cgi?h_index.txt	Worldwide Hourly Observations; Charts; Satellite Imagery
National Oceanic Atmospheric Administration	http://weather.noaa.gov/weather/ccus.html	CONUS 24-hr Weather Observations
National Oceanic Atmospheric Administration	http://weather.noaa.gov/weather/ccworld.html	OCONUS 24-hour Weather Observation
USN Fleet Numerical Meteorology and Oceanography Center	http://www.fnoc.navy.mil/PUBLIC/	DOD Numerical Weather Prediction Model Graphics (Unclassified and Password Protected)

Name	**URL**	**Comment**
USN Fleet Numerical METOC Detachment	http://navy.ncdc.noaa.gov/	Climatology Support Services
USAF Combat Climatology Center	http://www.afccc.af.mil/cgi-bin/index.pl	Climatology Support

6. Known property use including type of infrastructure such as existing buildings, transportation networks, water treatment and distribution systems, wastewater collection and treatment systems, and known power generation and transmission systems.

7. Maps, topographic and geological information relevant to the deployment area.

Medic CD

1. Disease and environmental health risks
2. Military and civilian health care delivery capabilities
3. Disease vector ecology information

Air Field Surveys (https://xop-web.scott.af.mil; http://www.amc.scott.af.smil.mil.)

1. Orientation to the site location.
2. Areas of concern, geographic features, hazards, and other pertinent information.

Medical Readiness & Intelligence Officer

Note: Document all information regarding Potential AOC, Sources, Activity, Exposure Routes & SEG directly onto the Conceptual Site Model Form located in Appendix

1. After Action Reports of interest
- Industry types and problems identified
- Location and lessons learned during past deployments.
- Continuity on past practices, issues, and problems.

Department Of State

1. Contact information for embassies and consulates at the bed down site (http://www.state.com/)

Embassies

1. Exchange rate policies,
2. Medical capabilities
3. Foreign intelligence threats
4. Local threats
5. Name of the military attaché

Military attaché

1. Current intelligence
2. How to expedite deploying units requests to the host nation

US Environmental Protection Agency

1. Major industries
2. Typical chemical used
3. Materials produced as waste
4. Most common emissions

Current allowance standard listings can be found at:
https://medlog.detrick.af.mil

Appendix B:
SIPRNET Sources

AFMIC: **http://www.dia.smil.mil/intel/afmic/afmic.html**
NGIC (CBR): **http://www.ngic.army.smil.mil/functionpgs/nbc/index.php**
GEMINI: **http://magellan.dia.smil.mil/gemini**
OTHER GENERAL SITES
http://www.dia.smil.mil/
http://ismc.sgov.gov/
http://www.ismc.sgov.gov.Intelink_servers/Text_listing/
NIMA (National Image and Mapping Agency):
http://www.nima.smil.mil/products.html#force
PACE (Port and Airfield Collaborative Environments):
http://intelinks-s.intel.scott.af.smil/pace/query.cfm
COLISEUM (Community On-line Intelligence System For End Users and Managers):
http://coliseum.dia.smil.mil
USACHPPM: **http://usachppm1.army.smil.mil**

U.S. Air Force Institute for Operational Health:
https://www.brooks.af.smil.mil/afiera/afiohmain.htm

Open Sources
The Library of Congress Country Studies: http://lcweb2.loc.gov/frd/cs/cshome.html
State Department Country Background Notes: http://www.state.gov/r/pa/ei/bgn/
Department of Energy Country Analysis Briefs:
http://www.eia.doe.gov/emeu/cabs/contents.html
CIA World Fact book: http://www.odci.gov/cia/publications/factbook/indexgeo.html
Perry-Castañeda Library Map Collection: http://www.lib.utexas.edu/maps/
CountryWatch: http://www.countrywatch.com/
WHO Health Intelligence Network for Advanced
Planning: http://www.who.int/disasters/
Environmental Network: http://unep.net/
U.S. Environmental Protection Agency
http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/index.html

Appendix C: Site Reconnaissance Checklist
Review Predeployment/Baseline Activities is consolidated in the CSM
1. Look to refute or confirm preliminary hazard analysis
Investigate the area immediately around the bed-down area
1. Seek an elevated location (hill, rooftop, etc) to observe the site and surrounding area.
2. Drive or walk the perimeter of the site
3. Identify onsite environmental releases, potential releases, possible releases, and/or other environmental conditions that might compromise the bed down site.
4. Identify potential hazardous/radioactive material/waste sources, including source types, dimensions, locations and evidence of poor containment. Estimate the area or volume of these sources.
5. Identify any potential environmental conditions that may require the use of personal protective equipment during site reconnaissance.
6. Look for evidence of hazardous/radioactive material migration on or from the site, including stressed vegetation, areas of visible stained soil, or outfalls.
7. Identify potential harborage areas, breeding sites and/or other evidence of pest infestation.
Conduct Interviews
1. Contact the U.S. Embassy's Defense Attaché Office to schedule interviews
2. Seek the to interview the following people;
- U.S. Embassy Defense Attaché
- host nation military liaison
- health officials
- local fire brigade
- emergency responders
- Occupants, site workers, and occupants of adjacent properties.
3. Ask questions regarding;
- waste disposal practices and if there are any environmental problems
- Spills in the area, problems with contaminated wells
- Health problems in site workers, complaints from adjacent properties, and odors
- Use of pesticides, herbicides and fertilizers
- Communicable and/or infectious diseases
Key of Air, Soil & Water Reconnaissance Reminders:
Air: Look for the following;
- identification of source material
- identification of contaminants of potential concern and contaminants of concern
- potential source locations
- source locations where a release has been confirmed
- delineation of release areas
- distribution and magnitude of contaminant of potential/concern contaminants of concern

Appendix C: Site Reconnaissance Checklist
Soil:
- Topographical features (including hills, gradients, and surface vegetation or pavement).
- Surface geology including soil types and parameters, outcrops, faulting, and other features
Water:
- surface water features (including the routes of drainage ditches on the facility and how they migrate to other surface water bodies such as creeks or lakes)
- subsurface geology, including stratigraphy, continuity, connectivity, and other characteristics
- hydrogeologic information identifying water-bearing zones, hydrologic parameters, and impermeable strata • soil boring and monitoring well logs and locations
On base industrial sources
1. Inspect building interiors and exteriors for contamination
2. Measure the distance between facilities and processes and the discharge or releases
3. Identify sewers systems, utilities, solid waste units
4. Identify truck or railcar loading/unloading areas
Off-base industry
1. Municipal water treatment and sewer
2. Local bottling plants
3. Raw materials used and waste disposal.
4. All industrial facilities within 6 mile radius of the base
5. Nuclear facilities within 500 miles
6. Identify all discharges such as industrial plumes or wastewater discharges.
Water
1. Look for beneficial resources around the facility
2. Identify water bodies and well locations with potential contamination

Appendix D: CSM Example					
AOC	**Source of Release**	**Environmental Threat (Air, Soil, Water, Drinking Water)**	**Activity/Point of Exposure**	**Exposure Route**	**SEG**

Appendix E: TVA-1000B User's Information & Instructions

Using the Instrument While operating this instrument in the field, you normally carry the TVA-1000B at your side, using the shoulder strap. With the pump on, detector(s) on, and the unit warmed up, you monitor the area of concern. As soon as the instrument analyzes a sample, the probe displays concentration of the vapor. The display on the sidepack duplicates the vapor concentration on the probe display. Using the BASIC probe, you can toggle the display between detector types by pressing the DET button on the probe, log the survey data by pressing the LOG button, and backlight the LCD display by pressing the lamp button.

Quick Start Procedures

1. Charge battery.
2. Connect sample probe.
3. Fill/install hydrogen tank (FID versions).
4. Open the hydrogen valve (FID versions).

To start the unit, execute the following procedure:

1. Press ON.
2. Press CONTROL.
3. Press 3 to ignite. Allow the instrument to warm up for 30 minutes.
4. Press 2 = Setup.
5. Press 1 = Calibrate
6. Press 2 = Span Concentration.
7. Enter Span Concentration for calibration gas being used.
8. Press 3 = Zero
9. Press 1 = Both
10. Challenge analyzer with zero gas sample. If a zero gas sample is unavailable, use contaminant free ambient air.
11. Press ENTER = start
12. Wait for stabilization
13. Press ENTER = start
14. Press 4 = Span
15. Press 2 = PID
16. Press ENTER = start
17. Apply isobutylene span gas and wait for readings to stabilize
18. Press ENTER to accept
19. Press 4 = Span
20. Press 3 = FID
21. Press ENTER = Start
22. Apply methane span gas and wait for readings to stabilize
23. Press ENTER = Accept
24. Press 5 = Response Factor
25. Confirm that Response Factor say "RFOtDEFAULT"
26. Press ENTER = Accept
27. Press 6 = Background
28. Take background readings outside monitoring/contaminated area

29. Press ENTER = Accept **Background Correct Note**: Under the Calibration/Config/Menu the background correction function can be enabled. Once enabled, the last background reading stored in memory will be subtracted from the measured reading
30. Press EXIT 2 times to main menu
31. Press 1 = Run

PID/FID output ratio	Chemical Categories
1	Alkanes (methane, ethane, butane, etc.), alcohols (propanol, ethanol)
2-3	Branched alkanes (trimethyl pentane, dimethyl hexane)
2-5	Branched alcohols (Isopropanol, 2-butanol, cyclohexanol)
4-6	Alkenes (Pentene, octene, etc.)
8-11	Aromatics (BETX, naphthalene)

Using Hapsite in Suspect CWA Environment

- Select "Run Method
- Select "JPMESG Survey" Folder
- Select "JPMESG Survey" Method
- Press "RUN"
- Sample 1 minute "clean" (blank)
- Sample unknown (no longer than 1 minute)
- Press "RUN" to stop

Not in the 45 – 300 AMU
Not Volatile
BP>250 C
Concentration < 10 ppm

No TIC Increase

Other Analytical Methods that GC/MS

NOT IDed

TIC < 60,000,000
Sample 45 – 300 AMU
Concentration > 10 ppm
< 12 Carbons
BP < 250°C
Volatile?

TIC > 60,000,000
Back the Probe away

TIC Increase

Compound not in library
Sample is a mixture

YES, Compound Identified

"Identification and Quantification"
Select GC/MS Method

AIR

WATER
SOIL

Tri-bed Concentrator

gc_cb1m	Air Tri-bed 1 Minute Sample
gc_cb5m	Air Tri-bed 5 Minute Sample
gc_cb20m	Air Tri-bed 20 Minute Sample
gc_cbqc	Air Tri-bed Performance Standard

TENEX Concentrator Tube

gc_tx1m	Air Tenax 1 Minute Sample
gc_tx5m	Air Tenax 5 Minute Sample
gc_tx10m	Air Tenax 10 Minute Sample
gc_tx20m	Air Tenax 20 Minute Sample
gc_txsim	Air Tenax Single Ion Mode
gc_txqc	Air Tenax Performance Standard
gc_txcl	Air Tenax Clean-up

Air Loop

gc sl	Air Sample Loop Sample

Headspace methods

Tri-bed Concentrator

hs_cbls	Headspace Tri-bed Liquid/Solid
hs_cbw	Headspace Tri-bed Water
hs_cbwqc	headspace Tri-bed Water Performance Standard
hs_cbwcl	Headspace Clean-up with Tri-bed
hs_cbcl	Tri-Bed Clean-up with Headspace

Loop

hs_slls	Headspace Sample Loop/Liquid Solid
hs_slw	Headspace Sample Loop Water
hs_slwqc	Headspace Sample Loop Water Performance Standard

NOTE: When other instruments (with known LODs) are used prior to the HAPSITE, and show non-detect, users should go directly concentrator methods if the suspected target compound is detectable by the other instrument.

15-minute Loop

- Select RUN method
- Select "JPMESG GC MS" folder
- Select "JPMESG loop"
- Select gc sl method

Background/Blank Identification Criteria
Will reflect 3 peaks ONLY:
Air Peak, IS#1 and IS#2

RUN Sample Sample Identified

YES → Review Cal/Qant Report Complete HRA

NO → Not 42 – 300 AMU Not Volatile; Low ppb Run Concentrator

Quantitative Results

- Low ppm to high ppb

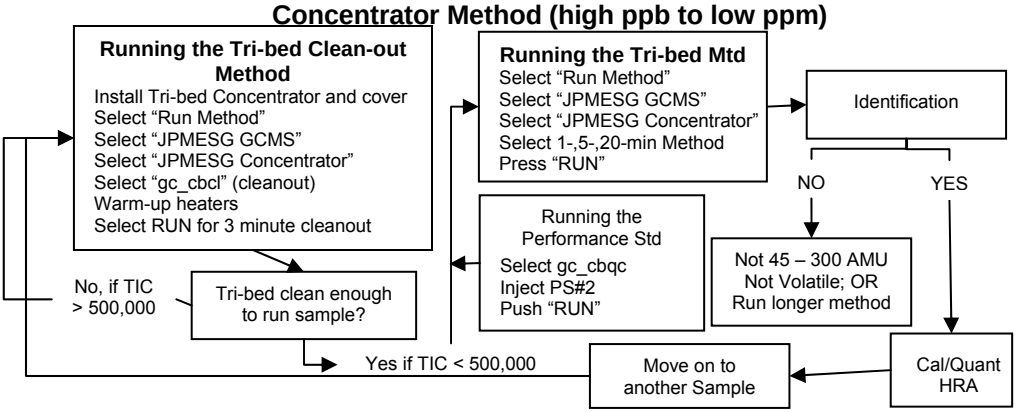


Table F-1: CWA LODs

		GD			V			H			L		
		LOD mg/m^3	ThE-min 84%	IC-min 16%	LOD mg/m^3	ThE-min 84%	IC-min 16%	LOD mg/m^3	ThE-min 84%	IC-min 16%	LOD mg/m^3	ThE-min 84%	IC-min 16%
M22		0.1	2.7	659	0.04	4.4	170	2	26	17	2	27	
M256		0.005	120	28500	0.02	8.5	340	2	26	17			
TVA-1000B		4.1						1.9	28	18			
CDS kit		0.186	1	302				4	55	35			
HAPSITE	1 min Tenax conc	0.02	26	4910	0.012	14	567	0.016	3350	2150			
	5 min Tenax conc	0.004	251	36600	0.0024	74	2828	0.0032	16800	10850			
	10 min Tenax conc	0.002	650	87000	0.0012	149	5650	0.0016	33600	21750			
	20 min Tenax conc	0.001	1750	207500	0.0006	295	11350	0.0008	67290	43500			
	SIM Tenax conc	0.0002	16500	1554000	0.0003	590	22700	0.0002	269000	174000			
	1 min Tribed	0.0143	24	7475				0.0009	59500	38500			
	5 min Tribed	0.0029	390	54900				0.0002	267000	172000			
	20 min Tribed	0.0007	2850	322000				0.00004	1320000	866000			

LOD = Limit of Detection
ThE-min = Threshold Effects (onset)
IC-min = Incapacitation Effects (onset)

All calculations were made with CHART-Final Version Oct 07 based on a temperature of 105° F and assuming a Light Work Load. This version of CHART does not calculate the HapSite Loop method.

Table F-2: Detection Limits for CWAs Using a 20-Minute Concentration Full Scan and SIM

CWA	DL (mg/m^3) Full Scan/SIM	OEL-TWA (mg/m^3)	CWA	DL (mg/m^3) Full Scan/SIM	OEL-TWA (mg/m^3)
VX-G	0.0006/0.0003	0.00001	Tabun (GA)	0.0062/0.001	0.0001
Sarin (GB)	0.0007/0.0002	0.00003	Sulfur Mustard (HD)	0.0008/0.0003	0.003
R33-G	0.0025/0.0008	NE[1]	Cyclosarin (GF)	0.0004/0.0002	NE
Soman (GD)	0.001/0.0002	0.00003			

[1] Not established.

Headspace Method

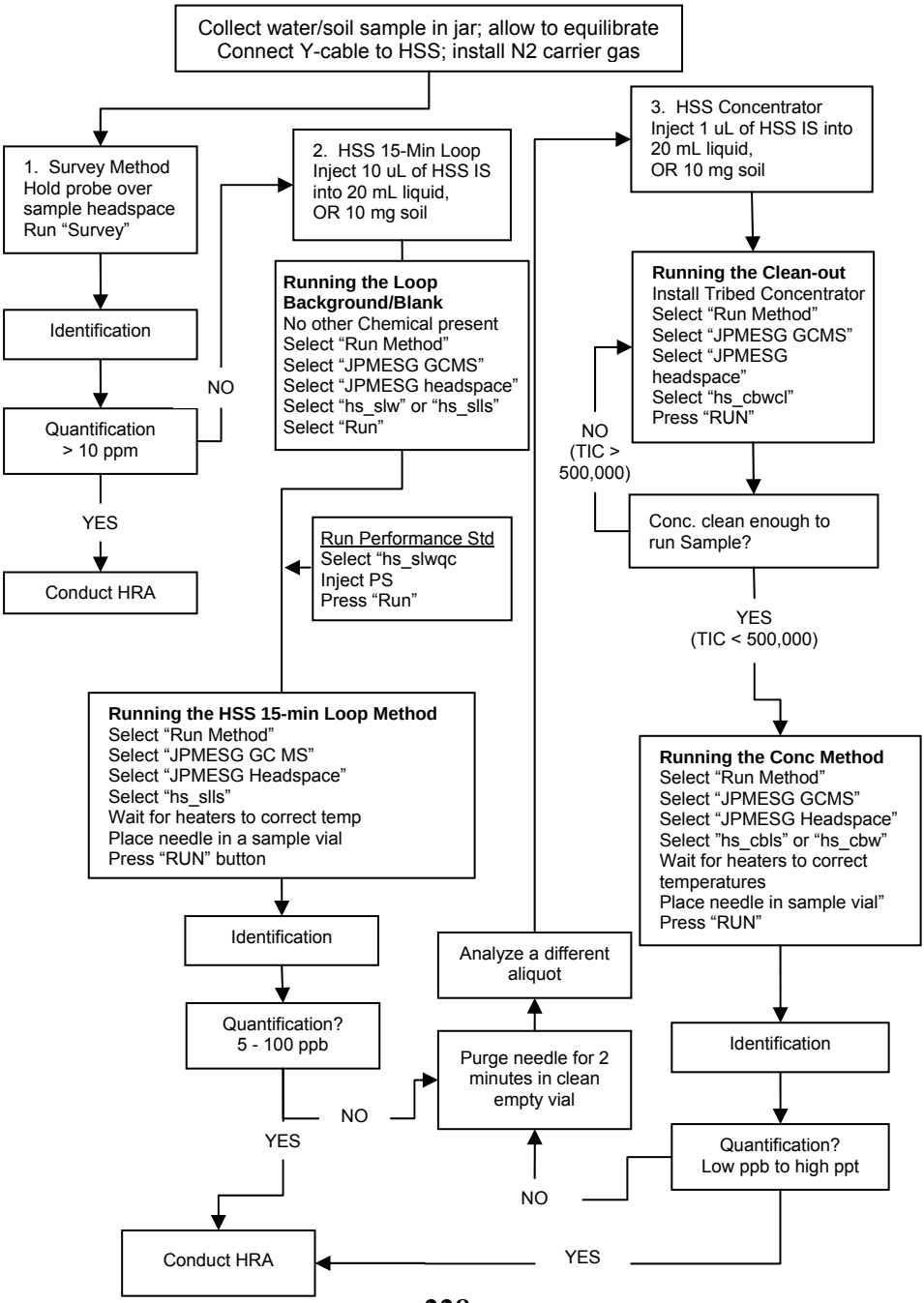


Table F-3: Method gc_cb1m Library Directory

Reference Document for the Method gc_cb1m SOP Tri-Bed Concentrator: Air				
HazMatID Detect	**Chemical Name**	**RT (min)**	**Quant Ion (m/z)**	**MDL (mg/m^3)**
N; Gas	Chloroethane	1:43	64	0.008
Y; Aldrich	Ethanol	1:45	45	0.004
Y; Aldrich	Acetone	1:46	58	0.005
Y; Aldrich	2-Propanol	1:51	45	0.026
N; Gas; Not in Lib	Freon 11	1:51	101	0.013
Y; Aldrich	2-Chloropropane	1:52	78	0.008
Y; Aldrich	1,1-Dichloroethene	1:56	61	0.017
Y; Aldrich	Methyl acetate	1:57	74	0.018
Y; CCORGNCS	Diethyl ether	1:57	59	0.020
Y; SENSIRCC_TX	Methylene chloride	1:59	84	0.012
Y; SENSIRCC_TX	Freon 113	2:00	101	0.010
Y; Aldrich	Halothane	2:06	117	0.006
Y; Aldrich	cis-1,2-Dichloroethene	2:09	96	0.013
Y; FDM_ORG2	1,1-Dichloroethane	2:12	63	0.015
Y; Aldrich	Methyl t-butyl ether	2:13	73	0.011
Y; SENSIRCC_CC	Methyl ethyl ketone	2:15	72	0.016
Y; Aldrich	Isopropyl Isocyanate	2:19	70	0.014
Y; Aldrich	3-Methylpentane	2:20	56	0.006
Y; CCORGNCS	Isopropyl ether	2:23	87	0.014
Y; Aldrich	trans-1,2-Dichloroethene	2:24	61	0.017
Y; Aldrich	Ethyl Acetate	2:25	61	0.020
Y; Aldrich	2,2-Dichloropropane	2:26	77	0.011
Y; CCORGNCS	n-Hexane	2:27	57	0.008
Y; Aldrich	Bromochloromethane	2:28	130	0.011
Y; Aldrich	Chloroform	2:29	83	0.010
	TRIS (Int. Std.)	2:35	213	
Y; CCORGNCS	t-Butyl alcohol	2:37	59	0.012
Y; Aldrich	t-Butyl ethyl ether	2:37	87	0.010
Y; Aldrich	Tetrahydrofuran	2:37	72	0.017
Y; Aldrich	t-Butyl isocyanate	2:41	84	0.028
Y; Aldrich	1,2-Dichloroethane	2:44	62	0.014
Y; Not in Library	Methylcyclopentane	2:44	56	0.015
Y; FDM_ORG2	1,1,1-Trichloroethane	2:49	97	0.026
N; Not in Library	1,1-Dichloropropene	2:57	75	0.013
Y; Not in Library	1-Methyl-1-cyclopentene	2:57	67	0.003
Y; Aldrich	Benzene	3:01	78	0.022
Y; Aldrich	Carbon tetrachloride	3:04	117	0.009
Y; Aldrich	Cyclohexane	3:08	56	0.005
Y; Aldrich	Acetonitrile	3:09	42	0.026
Y; Aldrich	2-Pentanone	3:10	86	0.018
Y; Aldrich	t-Amyl methyl ether	3:18	73	0.007
Y; Aldrich	Ethyl acrylate	3:20	55	0.006
Y; Aldrich	Dibromomethane	3:25	174	0.011
Y; Aldrich	1,2-Dichloropropane	3:25	63	0.014
Y; Aldrich	Bromodichloromethane	3:30	83	0.011
Y; FDM_ORG2	Trichloroethylene	3:31	130	0.005
Y; Aldrich	1,4-Dioxane	3:33	88	0.011

Y; Aldrich	Methyl methacrylate	3:38	69	0.007
Y; Aldrich	Heptane	3:42	71	0.009
Y; Aldrich	cis-1,3-Dichloropropene	4:06	75	0.012
Y; CCORGNCS	Methyl isobutyl ketone	4:07	58	0.032
Y; Aldrich	Dimethyl disulfide	4:17	94	0.007
N; Not in Library	trans-1,3-Dichloropropene	4:33	75	0.012
Y; Aldrich	1,1,2-Trichloroethane	4:42	83	0.012
Y; Aldrich	Toluene	4:59	91	0.019
Y; Aldrich	1,3-Dichloropropane	5:03	76	0.013
Y; Aldrich	Ethyl methacrylate	5:23	69	0.008
Y; Aldrich	Chlorodibromomethane	5:29	129	0.011
Y; Aldrich	Hexanal	5:41	56	0.046
Y; Aldrich	1,2-Dibromoethane	5:47	107	0.018
Y; Aldrich	Butyl acetate	6:17	73	0.012
Y; Aldrich	Octane	6:20	85	0.006
N; Not in Library	Tetrachloroethene	6:27	166	0.013
Y; Aldrich	1,1,1,2-Tetrachloroethane	7:37	131	0.011
Y; Aldrich	Chlorobenzene	7:37	112	0.013
	BPFB (Int. Std.)	8:03	117	
Y; SENSIRCC_TX	Ethylbenzene	8:12	91	0.014
Y; Aldrich	m&p-Xylene	8:28	91	0.028
Y; Aldrich	Bromoform	8:29	173	0.011
Y; Aldrich	Cyclohexanone	8:39	55	0.011
Y; Aldrich	Cyclohexanol	8:41	57	0.030
Y; Aldrich	2-Heptanone	8:45	58	0.009
Y; Aldrich	Styrene	8:54	104	0.014
Y; Aldrich	n-Butyl acrylate	8:56	73	0.011
Y; Aldrich	o-Xylene	9:01	91	0.014
Y; Aldrich	1,1,2,2-Tetrachloroethane	9:04	83	0.013
Y; Aldrich	1,2,3-Trichloropropane	9:14	75	0.018
Y; Aldrich	Isopropylbenzene	9:44	105	0.014
Y; Aldrich	Trimethyl phosphate	9:45	110	0.033
Y; Aldrich	Bromobenzene	9:45	77	0.017
Y; Aldrich	2-Chlorotoluene	10:14	126	0.013
Y; Aldrich	4-Chlorotoluene	10:18	126	0.014
Y; SENSIRCC_TX	n-Propylbenzene	10:18	120	0.014
Y; Aldrich	p-Ethyltoluene	10:26	119	0.010
Y; Aldrich	Diisobutyl ketone	10:30	85	0.011
Y; Environmental	1,3,5-Trimethylbenzene	10:31	105	NA
Y; Aldrich	α-Methylstyrene	10:44	118	0.010
Y; Aldrich	2-Chloroethyl ethyl sulfide	10:44	75	0.004
Y; Aldrich	sec-Butylbenzene	10:56	105	0.016
Y; Aldrich	1,2,4-Trimethylbenzene	10:56	105	0.014
Y; Aldrich	1,4-Dichlorobenzene	11:03	146	0.016
Y; SENSIR_CC	n-Decane	11:09	57	0.014
Y; Aldrich	p-Isopropyltoluene	11:23	105	0.014
Y; Environmental	t-Butylbenzene	11:23	119	0.015
Y; Aldrich	1,2-Dichlorobenzene	11:28	146	0.012
Y; Aldrich	1,3-Dichlorobenzene	11:29	146	0.013
Y; Aldrich	n-Butylbenzene	11:49	91	0.016
Y; SENSIRCC_TX	1,2-Dibromo-3-chloropropane	11:56	75	0.023
Y; Aldrich	Nitrobenzene	12:02	77	0.018
Y; Aldrich	Undecane	12:28	57	0.008
Y; Aldrich	1,2,4-Trichlorobenzene	13:24	180	0.018
Y; SENSIR_CC	Napthalene	13:31	128	0.010
Y; Aldrich	Dodecane	13:44	57	0.019
Y; Aldrich	1,2,3-Trichlorobenzene	13:51	180	0.014
Y; Aldrich	Hexachlorobutadiene	14:03	225	0.021
Y; Aldrich	2-Chloroacetophenone	14:40	105	0.031

Table F-4: Method hs_cbw Library Directory

Reference Document for Method hs_cbw SOP: Tri-Bed Conc: Water				
HazMatID Detect	**Chemical Name**	**RT (min)**	**Quan Ion (m/z)**	**MDL (mg/L)**
	Fluorobenzene	2:59.40	96	
	Chlorobenzene-d5	7:39.00	82	
	117_BPFB	8:09.00	117	
	167_BPFB	8:09.00	246	
	98_BPFB	8:09.00	98	
	246_BPFB	8:09.00	167	
	1,4-Dichlorobenzene-d4	14:31.85	152	
N; Gas	Dichlorodifluormethane	1:30	85	0.0012
N; Gas	Chloromethane	1:31	50	0.0010
N; Gas	Vinyl chloride	1:33	62	0.0005
N; Gas	Bromomethane	1:37	94	0.0011
N; Gas	Chloroethane	1:40	64	0.0005
Y; Aldrich	1,1-Dichloroethene	1:47.23	61	0.0007
Y; SENSIR_TX	Methylene chloride	1:48.00	49	0.0009
Y; Aldrich	trans-1,2-Dichloroethene	1:59.48	61	0.0007
Y; Aldrich	Methyl t-butyl ether (MTBE)	2:03.32	73	NA
Y; Aldrich	1,1-Dichloroethane	2:02.55	63	0.0005
Y; Aldrich	cis-1,2-Dichloroethene	2:14.86	61	0.0006
Y; Aldrich	Bromochloromethane	2:17.17	49	0.0013
Y; Aldrich	Chloroform	2:20.24	83	0.0006
Y; Aldrich	1,2-Dichloroethane	2:35.56	62	0.0002
Y; FDM_ORG2	1,1,1-Trichloroethane	2:40.95	97	0.0007
N; Not in Library	1,1-Dichloropropene	2:47.87	75	0.0007
Y; Aldrich	Benzene	2:52.48	78	0.0006
Y; Aldrich	Carbon tetrachloride	2:57.09	117	0.0012
Y; Aldrich	Dibromomethane	3:16.26	174	0.0010
Y; Aldrich	1,2-Dichloropropane	3:16.26	63	0.0039
Y; Aldrich	Bromodichloromethane	3:23.18	83	0.0005
Y; FDM_ORG2	Trichloroethylene	3:23.95	95	0.0007
Y; Aldrich	cis-1,3-Dichloropropene	3:58.50	75	0.0006
N; Not in Library	trans-1,3-Dichloropropene	4:25.36	75	0.0007
Y; Aldrich	1,1,2-Trichloroethane	4:36.12	97	0.0004
Y; Aldrich	Toluene	4:52.27	91	0.0006
Y; Aldrich	1,3-Dichloropropane	4:54.52	76	0.0004
Y; Aldrich	Chlorodibromomethane	5:22.21	129	0.0003
Y; Aldrich	1,2-Dibromoethane	5:41.38	107	0.0007
Y; Aldrich	Tetrachloroethene	6:22.84	166	0.0007
Y; Aldrich	Chlorobenzene	7:38.86	112	0.0006
Y; Aldrich	1,1,1,2-Tetrachloroethane	7:38.86	131	0.0004
Y; Aldrich	Ethylbenzene	8:29.50	106	0.0005
Y; Aldrich	Bromoform	8:55.59	173	0.0008
Y; Aldrich	m&p-Xylene	8:54.05	106	0.0014
Y; Aldrich	Styrene	9:40.91	104	0.0005
Y; Aldrich	o-Xylene	9:53.21	91	0.0005
Y; Aldrich	1,1,2,2-tetrachloroethane	9:56.29	83	0.0004
Y; Aldrich	1,2,3-Trichloropropane	10:13.92	75	0.0006
Y; Aldrich	Bromobenzene	11:19.94	77	0.0005
Y; Aldrich	Isopropylbenzene	11:19.17	120	0.0006
Y; Aldrich	2-Chlorotoluene	12:20.63	91	0.0004
Y; Aldrich	4-Chlorotoluene	12:32.88	126	0.0005
Y; SENSIR_CC	n-Propylbenzene	12:35.18	120	0.0008
Y; Environmental	1,3,5-Trimethylbenzene	13:12.81	105	0.0006
Y; Aldrich	tert-Butylbenzene	14:11.91	119	0.0008
Y; Aldrich	1,2,4-Trimethylbenzene	14:13.45	105	0.0005
Y; Aldrich	1,3-Dichlorobenzene	14:27.29	146	0.0010
Y; Aldrich	1,4-Dichlorobenzene	14:39.54	146	0.0007
Y; Aldrich	sec-Butylbenzene	14:56.45	105	0.0003
Y; SENSIR_CC	p-Isopropyltoluene	15:28.69	119	0.0006
Y; Aldrich	1,2-Dichlorobenzene	15:32.54	146	0.0004
Y; Aldrich	n-Butylbenzene	16:39.33	91	0.0006
Y; SENSIR_TX	1,2-Dibromo-3-chloropropane	16:49.32	75	0.0015
Y; Aldrich	1,2,4-Trichlorobenzene	19:49.70	180	0.0009
Y; SENSIR_TX	Naphthalene	19:58.93	128	0.0005
Y; Aldrich	1,2,3-Trichlorobenzene	20:29.63	180	0.0008
Y; Aldrich	Hexachlorobutadiene	20:46.55	225	0.0015

Appendix G: RADeCO -- H-809VII

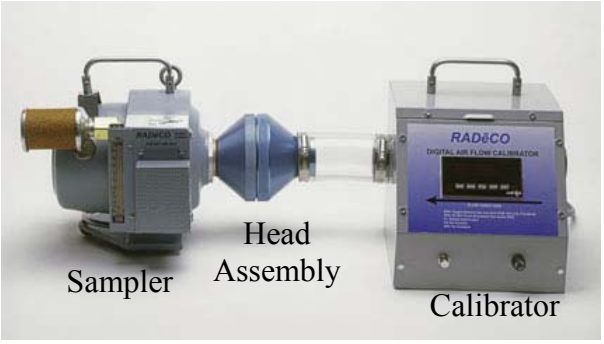
CALIBRATION/RECALIBRATION PROCEDURE

1. Change rotometer (if required).
2. Connect the equipment as shown in the test set-up. Use cartridge and/or filter paper, which will be used in actual sampling operations (Diagram A).
3. Turn on AC power supply.
4. Turn on H-809V.
5. Adjust to 5-7 CFM and allow to run for approximately five minutes.
6. Re-adjust the maximum air flow as required.
7. Scribe (mark) a line one inch below the top of the rotometer. This will be the maximum CFM mark. When recalibrating/resetting a rotometer, top mark is the one inch indicator.
8. Adjust the needle valve until the red ball comes to rest at the one inch mark. Lock needle valve in place.
9. Adjust the variable speed control knob for air flow as follows:
   - 2 to 20 CFM in 2 CFM increments
   - Calibrate from maximum flow rate to minimum flow rate.
10. Mark the rotometer at each increment.
11. Disconnect set up.
12. Replace rotometer guard.

NOTES

A. If rotometer has been calibrated with a different cartridge/filter combination than actual sampling use, unit should be recalibrated, as the markings are not the same for all combinations.

B. Cartridge and filter paper that will be used in field sampling can be specified when ordering, and the factory will make initial calibrations to that combination.

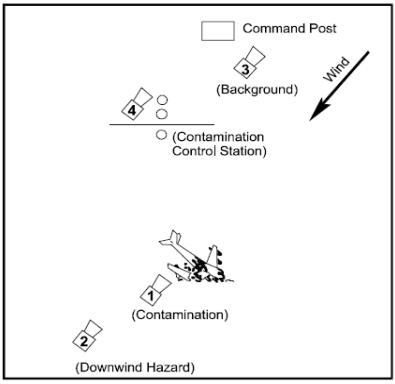


PREDEPLOYMENT CHECKLIST

1. Obtain clean filter – record filter number
2. Take background reading of filter prior to placing filter in holder
3. Place a small "x" in pencil on the outer edge of the exposed (fuzzy) side of the filter and install filter
4. Cover filter head with plastic bag to protect the filter
5. Tape on 1 gallon sample bag with paperwork
6. Mark RADeCO with potential location (downwind, CCS, etc.)

DEPLOYING RADeCO

1. In area of highest contamination
2. Downwind (refer to chart for distance)
3. Background
4. Contamination Control Station (CCS)
5. Downwind to supplement #2
6. Locate sampler away from structures and adjust sampler height to 5 feet. (at lead 2X the horizontal distance of any bldg.
7. Relay GPS location and request time hack
8. Relay starting flow rate



Wind Speed		Approximate Downwind Distance	
Miles Per Hour (MPH)	(Knots)	(Meters)	(Feet)
6 to 10	4 to 9	1,000	3,300
11 to 15	10 to 13	1,500	5,100
16 to 20	14 to 17	2,000	6,600
Above 20	Above 17	2,500	8,200

COLLECTING THE SAMPLE

1. Take dose rate reading, relay info
2. Remove filter, place in bag
3. Label bag with GPS coordinates and sample name
4. The ECP NCO/OIC will collect samples at CCS, take final readings using alpha and beta probes.
5. Finish processing the proper paperwork and chain of custodies.

Figure G-1: Sequence of Operations for Radiological Sampling Analysis

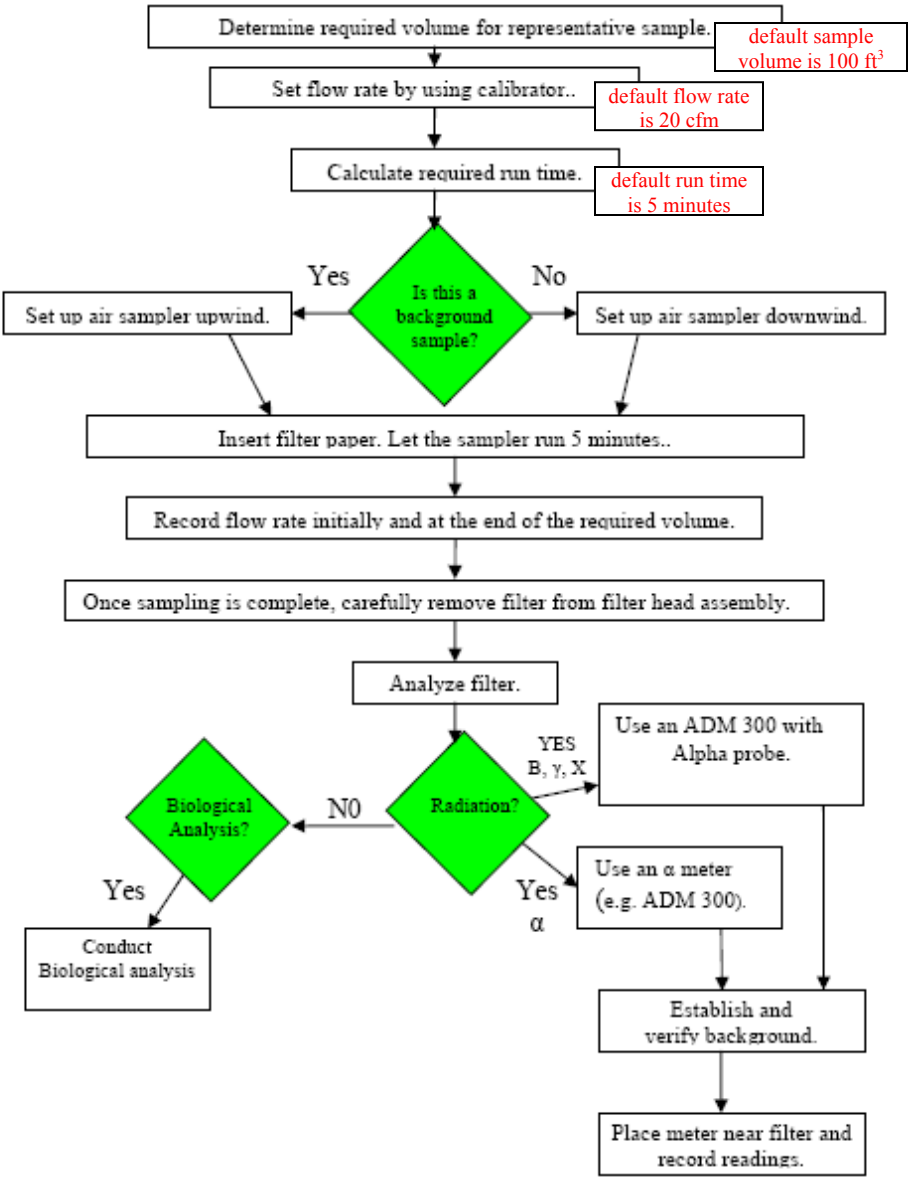
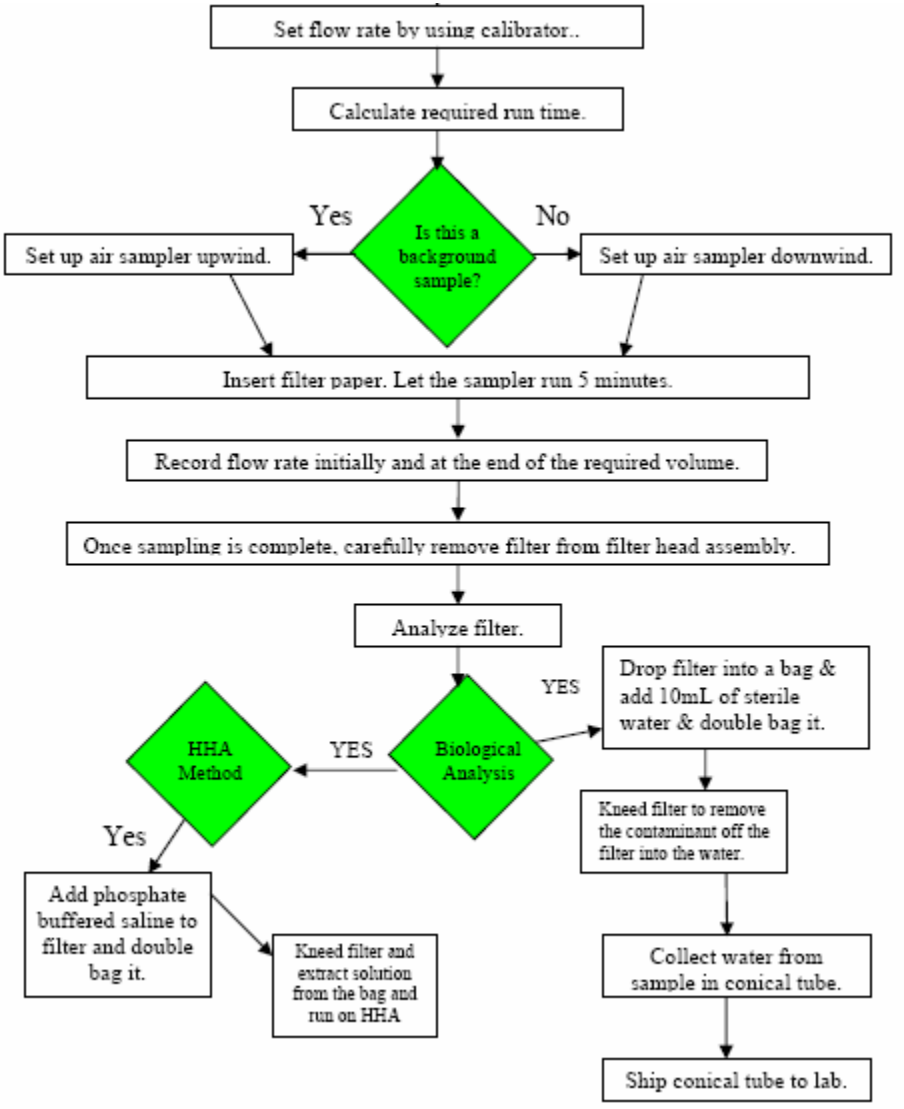


Figure G-2: Sequence of Operation for Biological Sampling Analysis



Appendix H: ADM-300

OPERATIONAL OVERVIEW

There are three methods used to locate radiological contamination: surveying, monitoring, and ground radiological reconnaissance.

Surveying – Determines extent and intensity levels of radiological contamination.

- Ground surveys offer a higher degree of accuracy and can be performed in any type of weather as well as darkness.

Monitoring – Performed to detect and determine the presence (or absence) of radiation, and if present, the intensity of the radiation.

- Area monitoring is done initially and then periodically or continuously to provide early warning and useful radiological data.
- Personnel, equipment and other resources are monitored in order to detect radiological contamination.

Ground Radiological Reconnaissance (GRR) – The process of detecting radiation and measuring it before a unit moves into or through an area.

EQUIPMENT CAPABILITIES

- Locates and measures low and high intensity radioactivity.
- Main unit meters beta or gamma
  - Two G-M detectors
    - Low-range for gamma and beta radiation (Dose rate - 10 uR/h to 5 R/h)
    - High-range only for gamma radiation (Dose rate - 3 R/h to 10,000 R/h)
- Additional probes
  - AP100A = Alpha radiation
  - ABP100 = Alpha/Beta
  - BP100 = Beta
  - XP100 = X-ray
  - NP100 = Neutrons

EQUIPMENT CONTROLS AND INDICATORS

↑ Used to adjust alarm set points and clear dose. Also used to toggle through and select other available rate displays.

DIGITAL DISPLAY

Mode		**Status**	
Operating Mode	Mode Indicator	System Status	Status Indicator
Dose Rate	Rate	Normal (Audio Enabled)	*
Dose	Dose	Normal (Audio Disabled)	(Blank)
Rate Alarm	RaAlm	Rate Alarm	R (Flashing)
Dose Alarm	DoAlm	Dose Alarm	D (Flashing)
		Both Rate & Dose	B (Flashing)

SURVEY AND MONITORING MODES

In the survey or monitoring modes the operator wears the survey meter using the shoulder carrying strap. The ADM-300 must be held in at a consistent angle to assure accuracy and uniformity of readings. If the gun handle is used, the survey meter can be held more comfortably. Do not store batteries in device when not being used.

Main Unit – Beta/Gamma

1. Remove instrument and inspect for damage.
2. Check to ensure the ADM-300 has a valid calibration date annotated on the sticker.
3. Install batteries in the main unit.
4. Press power button for at least 2 seconds, and a self check will be initiated.
5. Check the instrument using the Cs-137 check source.
6. Take background readings for ADM-300 (window open). Annotate readings.

Monitoring for Beta/Gamma

- Approach an area moving the probe in a sweeping motion. Move the probe steadily from left to right.
- As you start to receive indication of contamination, you can close the beta shield (i.e., the window located on the rear panel of the device). If the shield is closed and you still receive the same results, then you have gamma radiation. If you close the shield and the reading goes down, then you have beta. Note: The ADM-300 is intended for beta radiation detection only, and the dose rate indicated is not accurate for beta radiation.

Note: The beta window can be ruptured by sharp objects. Use extreme care to protect the beta window when open.

Alpha Probe

1. Ensure power is off on main unit.
2. Attach cable to main alpha probe and unit.
3. Press power button and hold far at least 2 seconds.
4. System will accomplish self-check and should display “ALPHA PROBE”.
5. Conduct a light leak check, using direct sunlight or a 150 watt incandescent light bulb. A higher reading with the protective cover removed indicates a light leak.
6. Take background readings, holding the probe 1/8 inch from the surface.

Monitoring for Alpha

- Place the alpha probe parallel to the surface and touch the two outside pronged edges on the surface. These two outside edges will be 1/8 inch standoff. DO NOT LAY THE MYLAR ON THE SURFACE.
- If alpha contamination is present, a visual reading will appear within 8 to 12 seconds.

Sampling RADeCO Filters

1. Press the MODE button
   - TO ENTER SCALER PUSH-SET will appear on the screen
2. Push the SET button

- SET-START SCALER, MOD- EXIT SCALER will appear on the screen

3. Place the alpha probe flat on the front of the RADeCO filter (or 3 – 5 cm from the surface being monitored)
4. Push the SET button
   - TIME LEFT will start counting down
   - MAKE SURE IT IS SET FOR 1 MIN. COUNTS
5. DO NOT MOVE THE ALPHA PROBE
   - Moving the alpha probe may create an inaccurate reading
6. When the ADM-300 beeps, remove the alpha probe
   - SCALER DONE will appear on the screen
7. The reading will appear on the screen (e.g., 2 Count Sum)
8. To turn the meter back to the normal survey mode press the MODE button.

NOTE: The procedures listed above should be used to obtain accurate one minute average measurements in counts per minute (cpm) using the ADM 300 summing function. This is ideal for comparing surface contamination readings to charts in the NAPR because they are listed in cpm and for completing *Airborne Alpha Activity Worksheets* because filter readings need to be in cpm in order to calculate airborne activity.

X-ray Probe

1. Ensure power is off on main unit.
2. Connect the cable to the X-ray probe and the unit.
3. Power up the unit. You should get an indication that the X-ray probe is attached.
4. Take background reading by holding probe perpendicular to ground, approximately 18 inches from the ground.

Monitoring for X-rays

- Hold probe perpendicular to surface, approximately 18 inches away. When walking, swing probe vertically in front of shoes.

PROBE VERIFICATION CHECKS

Alpha *Probe (AP100A) Verification Procedure*

1. Remove the Th-232 fixture from the test source container and move the Cs-137 button a few feet away.
2. With the ADM300 turned OFF attach the AP100A and turn on the ADM-300. Press and release the INC (n) until "cpm Alpha" is displayed. Remove the protective cover from the AP100A window.
3. Refer to illustration in the ADM300 Kit E (Test/Verification Kit) manual or on the Th-232 source fixture and place the Th-232 fixture in position on the AP100A window as shown. Make sure that the Th-232 source is facing the AP100A window.
4. Allow the rate reading to settle for approximately 20 seconds. Observe that the displayed rate reading is between the upper and lower limits listed for the current year and correct probe in the expected readings column on the Th-232 fixture label.
5. If the reading is not within the indicated limits, repeat steps 1 - 4. If the reading still fails to fall within the listed limits, return unit to maintenance.

Beta Probe (BP100) Verification Procedure

1. Prepare the GCF200 Test Fixture by inserting the Cs-137 source face-up in the circular inset indicated for testing the BP100.
2. Refer to illustration in the ADM300 Kit E (Test/Verification Kit) manual or on the source container lid and place the BP100 in position on the test fixture as shown.
3. Turn the ADM300 ON. Press and release INC (n) until B+G is displayed. Observe the displayed Rate reading.
4. Allow the rate reading to settle for approximately 20 seconds. Observe that the displayed rate reading is between the upper and lower limits listed for the current year and correct probe/unit on the expected readings label on the inside lid of the TS100 container.
6. If the reading is not within the indicated limits, repeat steps a - d. If the reading still fails to fall within the listed limits, return unit to maintenance.

Beta/Gamma Probe (BGP100) Verification Procedure

1. Prepare the GCF200 Test Fixture by inserting the Cs-137 source face-up in the circular inset indicated for testing the BGP 100.
2. Refer to illustration in the ADM300 Kit E (Test/Verification Kit) manual, or on the source container lid, and place the BGP 100 in position on the test fixture as shown.
3. Turn the ADM300 ON and verify that RaGm is indicated for external gamma probe rate. Allow the rate reading to settle for approximately 20 seconds
4. Observe that the displayed rate reading is between the upper and lower limits listed for the current year and correct probe/unit on the expected readings label on the inside lid of the TS100 container.
5. If the reading is not within the indicated limits, repeat steps 1 - 4. If the reading still fails to fall within the listed limits, return unit to maintenance.

X-ray Probe (XP100) Verification Procedure

1. Remove the Th-232 fixture from the TS100 test source container. Close and move the TS100 with Cs-137 button a few feet away.
2. With the ADM300 turned OFF attach the XP100 and turn on the ADM300.
3. Refer to illustration in the ADM300 Kit E (Test/Verification Kit) manual or on the Th-232 source fixture and place the XP100 on Th-232 fixture in the circle indicated. The XP100 probe face should be flat against the source.
4. Allow the rate reading to settle for approximately 20 seconds. Observe that the displayed rate reading is between the upper and lower limits listed for the current year and correct probe in the expected readings column on the Th-232 fixture label.
5. If the reading is not within the indicated limits, repeat steps 1 - 2. If the reading still fails to fall within the listed limits, return unit to maintenance.

Appendix I: SAM 935 Instructions

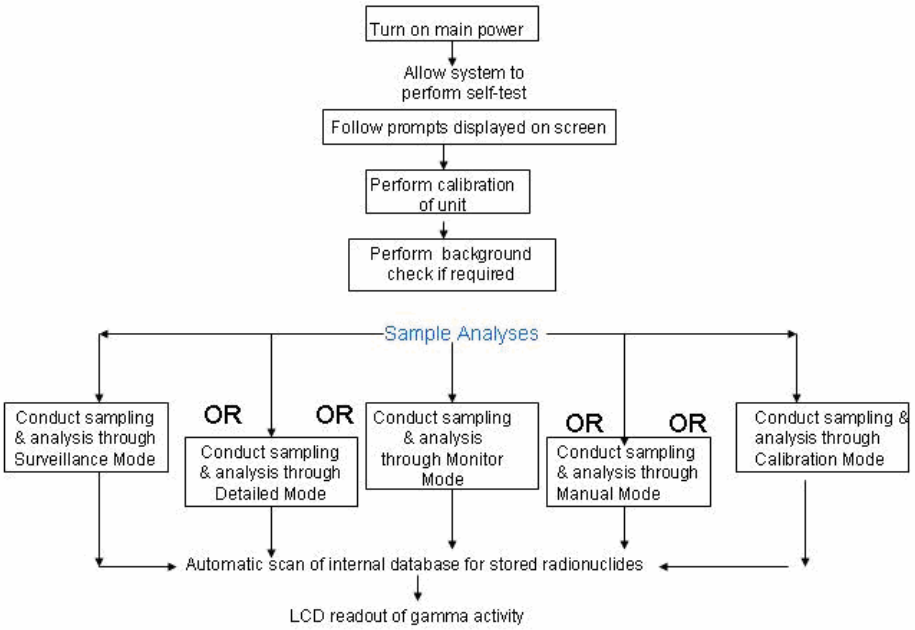
SAM 935 User's Information & Instructions

The SAM 935 is designed and constructed to operate as a portable, self-contained, hand-held radiation surveillance and measurement instrument. Using its internal database, the SAM 935 can detect up to 90 radionuclides (expandable to 128 radionuclides) and present them to the user on the LCD screen. It will detect radiation that has gamma or photon components, not pure beta and/or alpha emitters (i.e. H3). The basic model comes standard with a 1 ½ -inch by 2-inch NaI(Tl) internal detector crystal.

The SAM 935 is normally operated in one of three user-selected modes: Surveillance Mode, Monitor Mode, or the Detailed Mode. When operated in the Surveillance Mode, the SAM 935 alarms in the presence of radionuclides, identifies the alarm, and categorizes the materials accordingly (Medical Isotopes, Nuclear Materials, or Industrial Isotopes). The surveillance mode also contains a dose rate display that gives the user a measured dose rate along with the isotope break-down and individual contributions to the total dose rate. Independent dose rate triggers and display thresholds can be set for each isotope in the library. Operation in the Surveillance Mode is the default operating mode for the instrument.

The SAM 935 has a user function that allows the selection of up to 20 different radionuclides to be "monitored" at a single time (verses allowing the instrument to "self-detect" the radionuclides). These selected radionuclides are referred to as "triggers" and can be loaded in up to three separate and different trigger lists (List A, B, or C). This option allows a user to tell the SAM to identify and quantify only the radionuclides of interest. As an example, if using the SAM to detect nuclear fissionable materials, one might not want to be informed of thorium (in consumer products) or potassium (naturally occurring in most organic materials), so would select only those isotopes which are associated with nuclear weapons and put them in a trigger list to be used. One can then have the SAM search for and identify only those nuclides (ignoring all the rest).

The SAM 935 is powered by an internal nickel-metal hydride (NiMH) battery and recharged with a 120-volt AC power charger or optional 12-volt DC car adapter and charger. A fully charged battery will last approximately 8 hours, and a depleted battery will take approximately 4 hours to recharge (dependent on the battery's physical condition and age).



Getting Started:

- Turn on the SAM 935 and allow a 5 minute warm up if this is a cold start (auto count down is shown on the info line just above the soft keys) otherwise press OK.
- Place Cs 137 check source in front of the probe. Begin cal by pressing F2 button.
- Remove check source; capture background by pressing F2 button (Recal every 30-40 minutes)
- Device automatically begins detection after acquisition of background.
- Press UTIL key & select trigger list:
    - List A – Industrial Isotopes
    - List B – Medical Isotopes
    - List C – Special Nuclear Materials
- Press RETURN (F1) to exit main screen. Radiation measurements will appear on screen
- To capture spectrum press F3 Button (ID). Captured spectrum is displayed on MCA Display screen.

Basic Operation:

The SAM 935 is generally operated in the Dose Rate mode (default screen after turning the instrument on and pressing OK). When a source is found, this real time mode will identify the activity by increased dose rate reading and/or isotope identification on the screen. If the intensity of the source is at background levels or above, the source will be identified in the first second and confirmed in the following second with a confidence

level greater than 97%. If the intensity of the source is well below background levels (as in many environmental samples) the real time indication may or may not be accurate since meaningful statistics may be lacking. In either case identification is verified by pressing F3 (ID) and reading the MCA analysis report which is automatically generated after the ID capture period. Review of the analysis report is the most accurate means of identification. This is because statistics are improved and relative intensities are used in the analysis. Reports produced by the SAM include some quantitative data like dose rate, Sigma levels, integral counts, etc. (complete quantitative results are obtained with Quantum software running on a PC). The analysis report also shows a statistical uncertainty value (UNC) shown next to the isotope identified. If this number is over 10 it means that statistics are poor and more analysis time is required or identification is doubtful. In these cases the isotope will be shown with a question mark (?). Large external detectors can be used to improve the sensitivity and real time confidence level.

Unattended Operation:
For unattended operation the SAM is placed in the Sigma Mode (F1- Bar-graph screen). Isotopes will trigger in this mode by Sigma (standard deviations) above background. Reports are generated in the same manner as attended operation above. In addition, the Export Reports feature may be enabled (UTIL/Setup sub menu). This feature allows data to be exported via the RS232 port automatically when a source is detected.

Specifications:

SPECIFICATIONS	
Functions	Nuclide identification, spectrum analysis, dose rate (rem/Sv) calculation, total dose, audible search tool.
Integrated Electronics	Digital Multi-Channel Analyzer, spectroscopy amplifier, power supply
External Gamma Detector	2" by 2" NaI detector with integral HV supply
	Detector cables available (3 ft. - 100 ft.)
PHYSICAL DIMENSIONS	
Weight	9.5 lbs. with 2" x 2" NaI(Tl) external detector probe, probe adapter cable, and NiMH rechargeable batteries
Dimensions	12" W by 8⅛" H by 2" D
Protection	Water resistant & dust tight
SYSTEM SPECIFICATIONS	
Energy Range	18 KeV - 3 MeV
Temp Operating Range	-20°C to +50°C
SPECIAL FEATURES	
Patented Technology	Quadratic Compression Conversion (QCC) allows for identification of mixed isotopes in one second.
	Hysteresis: Provides 97% I.D. confidence level in 2 seconds.

Customizability	Modifications of isotopes and their associated energy lines can be added, deleted, or changed in the field with no computer needed.
	128 Customizable Isotopes in the library
	400 Customizable Energy Lines
Trigger Lists	Multiple trigger lists for different field applications (Standard trigger lists identified by AFIOH/SDR as attachment 1)
Calibration	Automatic Coarse Calibration with Cs-137
	Dose rate function is indication only – not calibrated.
CONTROLLER	
Display	240 X 128 high contrast black-and-white FSTN graphics with CCFL backlight Monochrome LCD, 10 ½ cm by 5 ½ cm
Clock	Battery backed-up clock and calendar
Controls	10-key custom keypad, utilizing software programmable function keys
Alarm	Audio/Visual
	Gamma - Red LED
BATTERIES (POWER REQUIREMENTS)	
Power	NiMH; Internal battery pack; External, factory supplied, dual mode supply/charger (12w); Continuous 110V Operation Available
Accessories	External battery charger, AC car adapter, Pelican storage case, Check Sources.

Downloading Reports with BNC SAUce

- Connect the SAM to a PC using a null modern RS232 cable
- Open BNC SAUce software
- Turn on SAM. Bypass warm-up – Select Utilities
- Scroll down to "Print Stored Spectra" and hit "enter"
- On PC, font a bottom will change to "waiting for incoming data"
- Files are saved in Word format under Programs
- Files/Berkley/Nucleonics/BNC SAUce files
- Files named by action of user
    - ALA – alarm level exceeded
    - CAP – capture
    - MAN - manual

Appendix J: Reach Back Laboratories

AFIOH **San Antonio, Texas 78235** **Directory Assistance: (210) 536-5454,** **DSN 240-5454** **Toll Free: 1-888-232-ESOH (3764)** http://www.brooks.af.mil/afioh/			**AFIOH (DET 3)** **Kadena AFB** **Unit 5213, Box 10** **APO AP 96368-5213** Comm Tel: 098-1111		
Contact	Commercial	DSN	Contact	Commercial	DSN
Commander FAX: x-6841	(210) 536-2003	240-2003	Commander Fax: 634-1429	098-1111	634-0476
Epidemiology	(210) 536-3471	240-3471	Chief, Readiness & Quality Assurance	098-1111	634-1347
AFRAT	(210) 536-3489	240-3489	Chief, Occupational Health	098-1111	634-2638
Industrial Hygiene EMAIL: IHBranch@Brooks.af.mil	210-536-6137	240-6137	Chief, Public Health	098-1111	634-2648
Chemistry (Technical Analysis Branch) FAX: x-4578	(210) 536-6176/6177	240-6176/6177	Chief, Health Physics	098-1111	634-2636
Chemistry (Support Branch) FAX: x- 4578	(210) 536-6176/6177	240-6176/6177	Chief, Environmental Quality	098-1111	632-7467
Radioactive and Mixed Waste FAX: x- 3726	210-536-1461	240-1461	Analytical Division: Fax: 634-3016	098-1111	632-8349
Health Risk Assessments EMAIL: STINFO@brooks.af.mil	(210) 536-6121	240-6121	Chief, Organics		632-8282
Air Quality	210-536-3305	240-3305	Chemist		632-8282
Hazardous Waste and Pollution Prevention	210-536-3305	240-3305	Inorganic Analyst		632-8287
Water Quality	1-888-232-3764	240-4976	Sample Control		632-8283
Health Physics FAX: x-3189	210-536-3486	240-3486			

USACHPPM South Ft. McPherson, Atlanta, Ga 30330 http://chppm-www.apgea.army.mil/dsa-s/default.aspx			USACHPPM North Fort George Meade MD 20755-5225 http://chppm-www.apgea.army.mil/dsa-n/contact.asp		
Contact	Commercial	DSN	Contact	Commercial	DSN
Entomological Sciences	(404) 464-3460	367-3460	Commander	(301) 677-6200	622-6200
Field Preventive Medicine	(404) 367-2310	367-2310	NCOIC	(301) 677-6205	622-6205
Industrial Hygiene	(404) 464-4161	367-4161	Administration	(301) 677-4252	622-4252
Quality Management and Support	(404) 464-2826	367-2826	Entomological Sciences	(301) 677-3466	622-3466
Environmental Health	(404) 464-3235/3332	367-235/3332	Field Preventive Medicine	(301) 677-3110	622-3110
Industrial Hygiene Division	(301) 677-3426	622-3426	Industrial Hygiene Division	(301) 677-3426	622-3426

USACHPPM West ATTN: MCHB-AW (Bldg. 9030) Box 339500 MS 115 Fort Lewis, Washington 98433-9500 http://chppm-www.apgea.army.mil/dsa-west/			USACHPPM Pacific USA CHPPM-PAC ATTN: MCHB-AJ APO AP 96343-5006 http://www.usarj.army.mil/organization/chppm-pac/index.htm		
Contact	Commercial	DSN	Contact	Commercial	DSN
Commander	(253) 966-0014	347-0014	Commander	81-3117-63-8447 (international)	263-8447
NCOIC	(253) 966-0049	347-0049		0462-51-1520 or 1788, ext. 263-8447 (within Japan)	
Environmental Health	(253) 966-0069	347-0069	Environmental Health	011-81-3117-63-8551	263-8551/8539
Entomology	(253) 966-0073	347-0073	Health Physics and NBC-E	011-81-3117-63-8502	263-8502/8586
Field Preventive Medicine	(253) 966-0063	347-0063	Industrial Hygiene	011-81-3117-63-8493	263-8493/8497
Industrial Hygiene	(253) 966-0052	347-0052	Entomology	011-81-3117-63-4478	263-4478/8595

USACHPPMEUR Europe **CMR 402 (US Mail)** **APO AE 09180**	**Navy Environmental Health Center** **620 John Paul Jones Cir Ste 1100** **Portsmouth, VA 23708** http://www-nehc.med.navy.mil/cmdsuite/index.htm **COM: (757) 621-1967 DSN: 377-1967**

USACHPPMEUR (German Post) Building 3810, Room 236 Kirchberg Kaserne 66849 Landstuhl, Germany http://www.chppmeur.healthcare.hqusareur.army.mil/		
Contact	Commercial	DSN
Commander	011-49-6371-86-8084	314-486-8084
Sergeant Major	011-49-6371-86-8084	314-486-8084
Environmental Health	011-49-6371-86-8542	314-486-8542
Laboratory	011-49-6371-86-8371	314-486-8371
Occupational Health & Epidemiology	011-49-6371-86-8113	314-486-8113
Industrial Hygiene	011-49-6371-86-7243	314-486-7243

NEPMU-2 1887 Powhatan Norfolk, VA 23511-3394 Fax x-1191 http://www-nehc.med.navy.mil/nepmu2/index.htm		
Contact	Commercial	DSN
Commander	(757) 444-7671	564-7671
Entomology	(757) 444-7671	564-7671
Environmental Health	(757) 444-7671	564-7671
Epidemiology	(757) 444-7671	564-7671
Industrial Hygiene	(757) 444-7671	564-7671
BIO Detection	(757) 444-7671	564-7671
Radiation Health	(757) 444-7671	564-7671

NEPMU-5 3235 Albacore Alley San Diego, CA http://www.nepmu5.med.navy.mil/		
Contact	Commercial	DSN
Commander	(619) 556-7070	526-7070
Industrial Hygiene Lab	(619) 556-1427 / 1397	526-1427/1397
Forward Deployable Preventive Medicine	(619) 556-7070	526-7070
Microbiology	(619) 556-7070	526-7070
Pest Management	(619) 556-7070	526-7070
Threat Assessments	(619) 556-7070	526-7070

NEPMU-6 1215 North Road Pearl Harbor, HI 96860 http://nepmu6.med.navy.mil/contact.htm		
Contact	Commercial	DSN
Commander	(808) 473-0555	(315) 473-0555
Entomology	(808) 473-0555	(315) 473-0555
Environmental Health	(808) 473-0555	(315) 473-0555
Industrial Hygiene	(808) 473-0555	(315) 473-0555
Epidemiology	(808) 473-0555	(315) 473-0555
Microbiology	(808) 473-0555	(315) 473-0555

NEPMU-7 PSC 812 Box 3540 FPO AE 09627 http://www.sicily.navy.mil/nepmu7/		
Contact	Commercial	DSN
Commander	39-095-86-9225	314-624-9225
Environmental Health	39-095-86-9232	314-624-9232
Entomology	39-095-86-9232	314-624-9232

Contact	Commercial	DSN
CBRE	39-095-86-9231	314-624-9231
Epidemiology	39-095-86-9232	314-624-9232
Laboratory	39-095-86-9231	314-624-9231
Deployment	39-095-86-9231	314-624-9231
Industrial Hygiene	39-095-86-9232	314-624-9232

Appendix K: Soil Gas Screening Procedures

1. Grid the site location or AOCs into approximately 900 m2 areas. Each grid should be a rough estimate of 30-meter by 30-meter square. The grid layout is dependent on the size of site and professional judgment is necessary in order to collect sufficient data for assessment.
2. Don nitrile gloves
2. Collect soil samples from each corner of the grid and the center of each grid (five samples per grid)
3. Collect the soil samples from the top six to twelve inches of soil using stainless steel tools, or disposable shovels if available.
4. Placed in a plastic bag and seal
5. Gently shake to release soil vapors.
6. Allow the soil to remain in the bag for approximately 30 seconds.
7. Document the temperature and humidity
8. Insert the PID/FID sample probe into the bag and record the results.
9. If the PID/FID reading equals or exceeds 5.0 ppm a contaminant source shall be considered present.
10. If a HAPSITE is available, use it to identify the constituents and estimate the concentration.

Appendix L: OEHSA Evaluations and Report Preparation

1. The report of findings for the OEHSA should generally follow this recommended report format. The report may be presented in a format of CSM diagrams and tables. All reports should include; potential health effects, outcomes, and control measures. The report format is as follows:

    a. *Executive Summary*—The executive summary should be prepared in issue/point paper format including prioritized list of health/mission issues from the OEHSA. The executive summary should contain a concise course of action (COA) that articulates potential impacts and provides recommendations to maximize operations, minimize health threats and negative health outcomes.
    b. *Introduction*—The introduction section should describe the scope of the mission in sufficient detail to permit users to comprehend the work performed. It should describe the purpose, methodology used, limitations, and include any assumptions.
    c. *Site Description*—The report should include sufficient detail on the deployment site and vicinity characteristics such as physical setting information, description of structures, roads, drinking water sources, waste disposal practices, and improvements.
    d. *Information Sources*—The report should include a description of sources used and persons consulted/interviewed during pre-deployment activities and site reconnaissance. The source documentation can be provided in the body of the report or in an appendix.
    e. *Information from Site Reconnaissance and Sampling Activities*—The report should provide description of relevant information gained from the site reconnaissance and sampling activities.
    f. *Findings*—The report shall have a findings section that summarizes known or suspect environmental conditions of health/mission significance associated with the AOC at the deployment site related to complete or potentially complete exposure pathways. Findings are the facts uncovered during the course of the environmental assessment. All findings concerning environmental conditions that may pose an environmental health threat to deployed personnel, affect the intended mission, or both, should be reported. The general guiding principle is that the commander must make a decision about environmental conditions at a specific site that could affect the mission. Findings that will aid in that decision-making process should be reported.
    g. *Conclusions*—The report shall include the environmental health professional's conclusion(s) about known or suspect known or suspect environmental health threat associated with an identified AOC is or is not a complete or potentially complete exposure pathway. The conclusions are based on the evaluation of the findings. They are determinations that potential health risks to deployed forces or potentially mission-compromising environmental conditions exist or do not exist at a site. A conclusion can be a determination that no environmental

conditions exist that pose health risks or could affect the accomplishment of the mission.

h. *Discussion*—The report may include a discussion section to describe the impact of conclusions based on quantitative and qualitative data collected during the OEHSA. It may include information from the screening health risk assessment. Familiarity with service guidance such as the U.S. Army Center for Health Promotion and Preventive Medicine TG 230 and TG 248 are recommended. The BE may consult with others to assist with development of any discussion. The OEHSA discussion section can be a reference to the appropriate ORM documentation or may be a stand-alone description of the known information.

i. *Recommendations*—The report shall include a recommendations section that provides courses of action for reducing, mitigating, and/or eliminating the potential environmental health threat impacts posed by the exposure pathways. Recommended courses of action can range from taking no action to continued monitoring or, if the potential impact is severe enough, relocating of activities or equipment to minimize impacts. A number of options are generally available depending on the mission and associated risk tolerance of the specific commander. The environmental health professional should provide the commander(s) with alternative courses of action instead of a single strategy. This enables the commander to balance health risks with operational risks. Recommended courses of action should be formulated in a mission context and supported by scientifically defensible data.

j. *Assumptions*—Any assumptions that were made in the introduction section should be listed individually and discussed in this section of the report.

k. *References*—The report shall include a reference section to list references used in preparing the environmental health site assessment. Each referenced source shall be adequately annotated in an appendix to the report.

l. *Appendices*—The report shall include an appendix section containing supporting documentation.

Appendix M: Chemical Agent Information

Nerve Agents – Physical Properties					
Chemical Agent	**Tabun**	**Sarin**	**Soman**	**Cyclosarin**	**VX**
Symbol	GA	GB	GD	GF	VX
MW	162.3	140.1	182.18	180.2	267.38
State @ 20ºC	Colorless to brown liquid	Colorless liquid	Colorless liquid	Liquid	Colorless to amber liquid
Odor	Faint fruit, none when pure	Almost none when pure	Fruity; camphor odor when impure	Sweet; musty; peaches; shellac	None
Vapor Density (air = 1)	5.63	4.86	6.33	6.2	9.2
Liquid Density (g/cc) @ 25ºC	1.073	1.0887	1.0222	1.1327	1.0083
Freeze/ Melt (ºC)	-50	-56	-42	-30	Below –51
BP (ºC)	240	158	198	239	298
VP (mm Hg) 20ºC	0.037	2.10	0.4	0.044	0.0007
Volatility (mg/m^3) @ 25ºC	610	22,000	3,900	438	10.5
Decomp Temp (ºC)	150	150	130	---	Half life 36 hours at 150
Eye & Skin Toxicity	Eyes: Direct rapid effect. Skin: Very toxic, liquid penetrates skin readily.	Eyes: Direct rapid effect Skin: Liquid does not injure skin but penetrates rapidly.	Eyes: Direct rapid effect. Liquid does not injure skin but penetrates it rapidly.	Direct rapid effect in eye; penetrates skin readily.	Extremely toxic by skin & eye absorption. Liquid does not injure the skin or eye but penetrates rapidly.
Rate of Action	Very rapid	Very rapid	Very rapid	Very rapid	Very rapid
Stability	Stable - pure form	Stable - pure form	Less stable than GA or GB	Relatively stable in steel	Relatively stable at room temperature

Characteristics of Nerve Agents: Nerve agents are organophosphate ester derivatives of phosphoric acid. To a certain extent, they are volatile, which is to say they volatize or evaporate, and form an often-invisible vapor. The nerve agents are divided into two series: the G series, developed by Germany in the 1930's, and the V series was developed by Britain in the 1950's.

G Series Agents – They are fluorine or cyanide containing organophosphates. G series nerve agents share several common physical and chemical properties. At room temperature, the G series nerve agents are volatile liquids, making them a serious risk for dermal contact with liquid agent and inhalation of agent vapor. The high water solubility of GA and GB allows for water to easily wash them off surfaces, these agents can also easily contaminate water sources, and they will not penetrate the skin as readily as the more fat-soluble agents, such as VX and Soman.

GA - Tabun is the easiest of the nerve agents to manufacture easily contaminates surfaces for a sufficiently long time, which makes it a relevant contact hazard. It is readily soluble in organic solvents and miscible with water. GA evaporates about 20 times more slowly than water.

GB - Sarin is known as the "non-persistent" nerve agent. Its high volatility makes it the most volatile of the nerve agents. GB is very soluble in water whereas other nerve agents are more sparingly soluble. GB evaporates at the same rate as water.

GD - The addition of agent thickeners can greatly increase Soman's persistency while making it a less volatile nerve agent. The solubility of GD in water is moderate. It is the second most volatile nerve agent and is primarily a vapor hazard. GD evaporates about four times slower than water.

GF - Cyclosarin is less stable than the other G agents and it is subject to excessive flashing or burning upon explosive dissemination. GF is the most persistent and least volatile of the G agents. As a slightly volatile liquid it is almost insoluble in water.

V Series Agents - They are sulfur-containing organophosphorous compounds. They are oily liquids with high boiling points, low volatility, and resultant high persistency. V-agents are more persistent than G-agents, and can remain on clothes and other surfaces for longer periods of time; this characteristic makes them exceptionally toxic.

VX – VX is the most common of the V series agents. It is a highly persistent and nonvolatile nerve agent that is substantially more toxic than any known G-agent. It has a low solubility in water that is temperature dependent (higher in cold water) and is hydrolyzed only minimally. VX is soluble in organic solvents. Due to its low volatility, liquid droplets on the skin do not evaporate quickly, thereby increasing absorption. Under certain conditions a disadvantage of VX is that it is highly flammable.

Blister Agents – Physical Properties			
Chemical Agent	Distilled Mustard	Lewisite	Phosgene oxime
Symbol	HD	L	CX
MW	159.08	207.35	113.94
State @ 20ºC	Colorless to pale yellow liquid	Colorless to brownish liquid	Colorless solid or liquid
Odor	Garlic or horseradish	Variable: may resemble geraniums	Sharp, penetrating
Vapor Density (air = 1)	5.9	7.1	3.9
Liquid Density (g/cc) @ 25ºC	1.268	1.89	---
Freeze/ Melt (ºC)	14.45	-18	35-40
BP (ºC)	217	190	53 – 54
VP (mm Hg) 20ºC	0.072	0.394	11.2 @ 25°C (solid); 13 @ 40°C (liquid)
Volatility (mg/m^3) @ 25ºC	610	4,480	1,800 @ 20°C
Decomp Temp (ºC)	149 – 177	> 100	Slowly at normal temperature
Eye & Skin Toxicity	Eyes and lungs very sensitive; Readily damages skin	Eyes highly sensitive; Readily damages skin	Powerful irritant to eyes & nose; liquid corrosive to skin
Rate of Action	Delayed – hours to days	Rapid	Immediate effects on contact
Stability	Stable in steel aluminum	Stable in steel and glass	Decomposes slowly

Characteristics of Blister Agents

Mustards

HD – Distilled mustard reacts with a wide range of biological materials. It irritate cells, causing tissue damage and blistering. It is insoluble in water but soluble in many organic solvents and subject to hydrolysis. Under temperate conditions, mustard evaporates slowly and is primarily a liquid hazard, but its vapor hazard increases with increasing temperature. At 100°F or above, it is a definite vapor

hazard. Mustard freezes at 57°F, and since a solid is difficult to disperse, mustard is often mixed with substances with a lower freezing point (e.g., Lewisite) so that the mixture will remain liquid at lower temperatures. It is used as a delayed-action casualty agent, the duration of which depends upon the munitions used and the weather. Although HD is heavier than water, small droplets will float on water surfaces and present a hazard.

Nitrogen Mustards - Derivatives of ammonia, have nitrogen as the central atom with the hydrogen atoms replaced by various organic groups. Due to their physical properties, mustards are very persistent under cold and temperate conditions. It is possible to increase their persistency even more by dissolving them in thickeners. Mustards are less persistent in hot climates but can reach relatively high concentrations in air because of greater evaporation rate. As a class, the mustards are highly reactive and the damage they inflict on body tissues can be considered cumulative.

HN-1 is similar to mustard in its properties and effects; however, it is more volatile and less persistent than mustard but only one-fifth as damaging and not as stable. HN-1 is a colorless liquid with a faint, fishy or musty odor. It is used as a delayed-action casualty agent that has a delay of 12-hours or more before skin-damaging symptoms are felt.

HN-2 is a liquid with a fruity odor in high concentrations. It is rated more toxic than HN-1. HN-2 affects the eyes in lower doses than do the other mustards. HN-2 has the greatest blistering power of the nitrogen mustards in vapor form but is intermediate as a liquid blistering agent. Skin effects are delayed 12-hours or longer after exposure. HN-2 is highly unstable and is not presently considered seriously as a chemical agent.

HN-3 is the principal nitrogen mustard because its properties are almost equal to those of HD. It also is the most stable in storage of the three nitrogen mustards. Because of its low volatility, HN-3 does not constitute a grave vapor hazard to the skin in open air. HN-3 is a liquid that has no odor in its pure form. It is used as a delayed-action casualty agent that has a persistency that is considerably longer than HD.

HT Mustard – A clear, yellowish, highly viscous liquid. It has a garlic-like odor similar to HD. It is a mixture of 60% HD and 40% T. T is a sulfur, oxygen, and chlorine compound similar in structure to HD. HT is used as a delayed-casualty agent, the persistency of which depends on the munitions used and the weather. Properties are essentially the same as HD but HT is more stable, has a longer duration of effectiveness, and has a lower freezing point than HD. Its low volatility makes effective vapor concentrations in the field difficult to obtain. HT has a strong blistering effect.

CX- Phosgene oximeis **o**ne of the most violently irritating substances known. Due to its extreme instability, pure CX is not likely to be used in military operations. By the addition of certain compounds it is possible to liquefy phosgene oxime at room temperature. It is fairly soluble in water and in organic solvents. In aqueous solution phosgene oxime hydrolyzes fairly rapid, especially in the presence of alkali. As a dry solid, phosgene oxime decomposes spontaneously; it must be stored at low temperatures.

L – Organic arsenical agents pose a difficult problem because the arsenic remains toxic after the organic portion of the molecule is converted to nontoxic products. Lewisite is the principal arsenical of military interest. It is used as a moderately delayed-action casualty agent with a persistency somewhat shorter than that of HD. It hydrolyzes faster than other arsenical compounds and has a low solubility in water. When humidity is high, L hydrolyzes so rapidly that it is difficult to maintain a concentration sufficient to blister bare skin.

Agent – Chemical Name	Degradation Products
A. Mustard	
1. Sulfur Mustard – HD Bis-(2-chloroethyl)sulfide 2,2'-dichloroethyl sulfide 1,1'-thiobis(2-chloroethane)	1,4-Dithiane Divinyl Sulfide Divinyl Sulfone 1,4-Oxathiane (1,4-Thioxane) Divinyl Sulfoxide Thiodiglycol – found in the body
B. Nerve Agents	
1. GA (Tabun) Ethyl N,N-dimethylphosphoroamidocyanidate	Dimethylamine Ethyl Cyanophosphonic Acid CN (present in environment as sodium cyanide)* Ethylphosphoric Acid* Ethyl dimethylphosphoramidic Acid* Dimethylphosphoramidic Acid*
2. GB (Sarin) Isopropyl methylphosphonofluoridate Isopropyl methylfluorophosphate Isopropoxymethylphosphoryl fluoride	Isopropyl methylphosphonic Acid [IMPA]* Methylphosphonic Acid [MPA]* Diisopropyl methylphosphonate [DIMP] Methylphosphonofluoridic Acid [MPFA]* Hydrofluoric Acid [HF]* Isopropyl Alcohol
3. GD (Soman) Pinacolyl methylphosphonofluoridate 3,3-dimethyl-n-but-2-yl methylphosphonofluoridate Methyl pinacolyl phosphonofluoridate Pinacolyl methylfluorophosphonate	Pinacolyl methylphosphonic Acid [PMPA]* Pinacolyl Alcohol Methylphosphonic Acid [MPA]* Methylphosphonofluoridic Acid [MPFA]* Hydrofluoric Acid [HF]*
4. GF Cyclohexyl methylphosphonofluoridate O-Cyclohexyl methylfluorophosphonate	O-cyclohexyl methylphosphonic Acid* Methyl phosphonic acid [MPA]*
5. VX* O-ethyl-S-(2-diisopropylaminoethyl)methyl phosphonothiolate (US)	Ethyl methylphosphonic Acid [EMPA]* Ethyl methylphosphonothioic Acid [EMPTA]* 2-(diisopropylamino)ethanethiol Diisopropylaminoethanol [DIPAE] S-2(diisopropylaminoethyl)methylphosphonic Acid* Ethyl Alcohol Methylphosphonic Acid [MPA]* Bis(2-diisopropylaminoethyl)disulfide*

***Compounds cannot be analyzed with this technology.**

Appendix N: Water System Certification Process

1. **Categorized the system**
   Name _____
   Location_____
2. **Determine size**
   Population served _____
3. **Determine source water type**
   - Surface or GWUDI
   - Ground Water
4. **Determine water system category**
   - Community water system
   - Non-transient, non-community water system
   - Transient non-community water system
5. **Implement Treatment and Disinfection**
   - Conventional filtration
   - Direct filtration
   - Slow sand filtration
   - Diatomaceous earth filtration
   - Membrane filter
   - Bag or cartridge filtration

(Check all treatment processes that apply)

   - Chlorine
   - Chloramines
   - Chlorine dioxide
   - Ozone
   - UV disinfection
   - Aeration
   - Lime/aoda ash softening
     a. Corrosion control (chemical) _____
     b. Fluoride Yes/No
6. **Set Monitoring for Coliforms**
   - Establish routine sampling plan
     - Sample sites representative of water quality throughout the distribution system according to a written sample plan
     - Samples must be collected at regular time intervals throughout the month except groundwater systems serving 4,900 persons or fewer may collect them on the same day.
     - Monthly sampling requirements are based on population served (see table on next page for the minimum sampling frequency).
     - A reduced monitoring frequency may be available for systems serving 1,000 persons or fewer and using only ground water if a sanitary survey within the

past 5 years shows the system is free of sanitary defects (the frequency may be no less than 1 sample/quarter for community and 1 sample/year for non-community systems).
    - Each total coliform-positive routine sample must be tested for the presence of fecal coliforms or *E. coli*.
    - If any routine sample is total coliform-positive, repeat samples are required.
- Establish REPEAT sampling requirements
    - Within 24 hours of learning of a total coliform-positive ROUTINE sample result, at least 3 REPEAT samples must be collected and analyzed for total coliforms:
        - Collect one REPEAT sample from the same tap as the original sample.
        - Collect one REPEAT sample within five service connections upstream.
        - Collect one REPEAT sample within five service connections downstream.
            - Systems that collect 1 ROUTINE sample per month or fewer must collect a 4th REPEAT sample.
            - If any REPEAT sample is total coliform-positive:
                - The system must analyze that total coliform-positive culture for fecal coliforms or *E.coli*.
                - The system must collect another set of REPEAT samples, as before, unless the MCL has been violated and the system has notified the state.
- Other requirements
    - Systems collecting fewer than 5 ROUTINE samples per month must have a sanitary survey every 5 years (or every 10 years if it is a non-community water system using protected and disinfected ground water).**
    - Systems using surface water or ground water under the direct influence of surface water (GWUDI) and meeting filtration avoidance criteria must collect and have analyzed one coliform sample each day the turbidity of the source water exceeds 1 NTU. This sample must be collected from a tap near the first service connection.

7. Establish Compliance Criteria

- Compliance is based on the presence or absence of total coliforms.
- Compliance is determined each calendar month the system serves water to the public (or each calendar month that sampling occurs for systems on reduced monitoring).
- The results of ROUTINE and REPEAT samples are used to calculate compliance.

8. Establish Monthly MCL Triggers

- A system collecting fewer than 40 samples per month:
    - Has greater than 1 ROUTINE/REPEAT sample per month which is total coliform-positive.

- A system collecting at least 40 samples per month:Has greater than 5.0 percent of the ROUTINE/REPEAT samples in a month total coliform-positive.

9. Establish Acute MCL Triggers

- Any public water system:
  - Has any fecal coliform- or *E. coli*-positive REPEAT sample *or* has a fecal coliform- or *E. coli*-positive ROUTINE sample followed by a total coliform-positive REPEAT sample.

10. Establish Treatment Procedures

- Implement specific microbial pathogen control procedures for protozoan Cryptosporidium to meet maximum Contaminant Level Goal (MCLG) of zero
- Surface water systems serving 10,000 or more people that are required to filter and must;
  - Achieve at least 2 log removal of Cryptosporidium
  - Systems that use conventional or direct filtration:
    Meet the 2 log removal requirement if they comply with strengthened turbidity performance standards for combined filter effluent (described below)
  - Systems that use slow sand filtration or diatomaceous earth
    Meet the 2 log removal requirement if they are in compliance with existing turbidity performance standards under the SWTR (less than or equal to 1 NTU in at least 95% of measurements taken each month or, for slow sand, alternative criteria as approved by the State; and a maximum of 5 NTU).
  - Strengthen turbidity performance requirements:
    - Surface water or GWUDI systems that use conventional treatment or direct filtration, serve 10,000 or more people, and are required to filter:
      - The turbidity level of a system's combined filtered water at each plant must be less than or equal to 0.3 NTU in at least 95 percent of the measurements taken each month
      - The turbidity level of a system's combined filtered water at each plant must at no time exceed 1 NTU. For both the maximum and the 95th percentile requirements, compliance is determined based on measurements of the combined filter effluent at four-hour intervals.

11. Conduct sanitary surveys

- For water systems using surface water or ground water under the direct influence of surface water, regardless of system size sanitary surveys are required no less frequently than every three years

12. Establish Total Trihalomethane (TTHM) monitoring

- The MCL for total trihalomethanes (TTHM) of 0.10 mg/L as an annual average.
- Compliance is defined on the basis of a running annual average of quarterly averages of all samples. The value for each sample is the sum of the measured

concentrations of chloroform, bromodichloromethane, dibromochloromethane and bromoform.

13. **Establish Nitrate and Nitrite monitoring and treatment**
    - Collect water samples at least once a year and analyze them to find out if nitrates/nitrites are present above 50 percent of their MCLs.
    - If it is present above this level, the system must continue to monitor this contaminant every 3 months.
    - If contaminant levels are found to be consistently above MCLs, take steps to reduce the amount of nitrates/nitrites so that they are consistently below that level. The following treatment methods have been approved by EPA for removing nitrates/nitrites:
        - Ion exchange, Reverse Osmosis
        - Electrodialysis
    - The MCL for nitrates has been set at 10 ppm, and for nitrites at 1 ppm
14. **Establish VOC monitoring procedures for the following chemicals**

Acrylamide	Epichlorohydrin
Benzene	Ethylbenzene
Carbon tetrachloride	Styrene
Chlorobenzene	Tetrachloroethylene
o-Dichlorobenzene	Toluene
p-Dichlorobenzene	1,2,4-Trichlorobenzene
1,2-Dichloroethane	1,1,1-Trichloroethane
1,1-Dichloroethylene	1,1,2-Trichloroethane
cis-and trans- 1,2-Dichloroethylene	
Dichloromethane	Trichloroethylene
1,2-Dichloropropane	Vinyl Chloride
Xylenes (Total)	

BOTTLE WATER PLANT COMPLIANCE CHECKLIST		OPR	DATE
FACILITY INSPECTED *(Name and Address)*:		**PHONE NUMBER:**	
ACCOMPANYING INDIVIDUAL(S) *(Name and Title)*:			
#	**ITEM**	**ASSIGNED DEFECT POINTS**	**INSPECTOR DEFECT POINTS**
1	**PLANT CONSTRUCTION AND DESIGN**		
	A Properly stored equipment, waste and refuse/litter.	3	
	B Road, yard and parking lot dust controlled.	3	
	C Grounds adequately drained.	3	
	D Sufficient space for placement of equipment and storage of materials; aisles and working spaces unobstructed, sufficient width.	4	
	E Proper construction: floors, walls and ceilings; clean.	4	
	F Fixtures, ducts and pipes placed to preclude dripage or condensate contamination product.	5	
	G Bottling room separate from other plant operations or storage; tight walls, ceilings; self-closing doors; size of conveyor opening.	5	
	H Adequate lighting; work stations (50 foot candles minimum), hand washing areas, dressing or locker rooms, toilet room and storage areas.	4	
	I Light fixtures over processing areas safety type or otherwise protected.	5	
	J Adequate ventilation provided to minimize odors, noxious fumes or vapors and condensate in processing, bottling, container washing and sanitizing rooms; ventilation equipment clean.	5	
	K Effective screening or other protection against birds, animals and vermin.	4	
	L Product in process in sealed piping system under pressure; free of excessive leaks or other sources of contamination.	Critical	
	M Bottle washing and sanitizing in an enclosed room and so positioned to minimize post-sanitation contamination.	5	
	N Processing, washing and storage rooms not directly connected to room(s) used for domestic household purposes.	4	
2	**SANITARY FACILITIES AND CONTROL**		
	A Product water supply from approved, properly located, protected, operated and accessible source; safe, sanitary quality; conforms at all times with applicable laws and regulations.	Critical	
	B Operations water meets same requirement as number 2A above.	5	
	C Source waters analyzed annually for chemical, physical parameters; once every four years for radiological parameters. Source waters, other than municipal sources analyzed weekly for microbiological quality.	Critical	
	D Product water separate from operations water to preclude contamination of product; either separate piping system or suitable backflow prevention.	Critical	
	E Dispensing equipment refurbishing: Acceptable coating used; water dispensing reservoirs and valves adequately sanitized and protected prior to reuse.	5	
3	**PROCESSES AND CONTROLS**		
	A Treatment methods accomplish intended purpose: Records maintained for type and date of treatment equipment physical inspections; conditions found, performance and effectiveness noted.	Critical	
	B Treatment equipment processes and substances used, preclude contamination or adulterations of product.	Critical	

	C Product water samples taken after processing prior to bottling to assure uniformity and effectiveness of treatment process. Analysis methods approved by government agency having jurisdiction.	5	
	D All unsanitary or defective containers reprocessed or rendered unusable and discarded. Multi-service primary containers cleaned, sanitized and inspected just prior to being filled, capped and sealed.	Critical	
	E Containers checked for caustic carryover; records maintained.	4	
	F Mechanical washers inspected and records of physical maintenance, inspections, conditions found and performance maintained.	4	
	G Multi-service shipping cases maintained to assure they will not contaminate primary container or product.	4	
	H Sanitizing operation: Records maintained of concentration of sanitizing agent and time agent was in contact with surface being sanitized.	5	
	I Each unit package identified by production code. Code identifies particular batch or segment of continuous run and day produced.	5	
	J Records maintained for product volume produced, date produced, lot code used and distribution to wholesale and retail outlets.	4	
	K Containers and closures non-toxic; comply with FDA standards.	Critical	
	L Filling, capping and sealing monitored. Filled containers visually or electronically inspected.	4	
	M Swab and/or rinse bacterial count of four (4) containers and closures just prior to filling done quarterly.	5	
	N Representative bacteriological sample taken once per week of each type of product water produced during a day's production.	Critical	
	O Representative chemical, physical, radiological sample analyzed once a year for each product water.	Critical	
	P Records maintained of date of sampling, type of product, production code and results of analysis.	4	
	Q All records retained for two (2) years. Current certificates or notifications of approval authority for source and supply of product and operations water on file.	3	
4	**PERSONNEL**		
	A Overall sanitation of plane and personnel under supervision of assigned individual.	5	
	B Personnel with disease in communicable form excluded from work in any capacity where there is reasonable possibility of product contamination or transmittal to other individuals.	Critical	
	C Personnel practices: Clean outer garments worn; high degree of personal cleanliness exhibited; hand washing practices adequate; un-cleanable jewelry not worn on hands; effective hair restraints used; tobacco not used in any form; no eating at work stations.	5	
5	**CALCULATIONS**		

TOTALS: 209

MINUS NON-APPLICABLE DEFECT POINTS: _____

NET TOTAL DEFECT POINTS: _____

$$SRC = \frac{\text{Net Total Defect Points - Inspector Defect Points}}{\text{Net Total Defect Points}} \times 100 = \frac{209 \text{ -}}{} \times 100 =$$

SRC COMPUTATION:	SRC ASSIGNED	NUMBER OF CRITICAL DEFECTS:

Appendix O: Initial Entry Plan - Example

Date: **Plan Number:**

1. OPERATIONAL OBJECTIVES:

2. DETAILED PROCEDURES:

3. SPECIAL INSTRUCTIONS:

4. HAZARDS AND PERSONNEL PROTECTIVE EQUIPMENT

5. DETECTION EQUIPMENT:

EQUIPMENT NAME	SERIAL NUMBER

6. PERSONNEL:

NAME	ORGANIZATION	FUNCTION

7. ACTIVITY CHECKLIST:

Expected duration of activities: _____

Expected start time of entry _____

Actual time of completion _____

Appendix P: Clinical Sample Info/Biological
Source: Bluebook

Bacteria and Rickettsia

Early Post-Exposure	Clinical	Terminal/Postmortem
Anthrax *Bacillus anthracis*		
0 – 24 h Nasal and throat swabs, induced respiratory secretions for culture, FA, and PCR	24 to 72 h Serum (TT, RT) for toxin assays Blood (E, C, H) for PCR. Blood (BC, C) for culture	3 to 10 days Serum (TT, RT) for toxin assays Blood (BC, C) for culture. Pathology samples
Plague *Yersinia pestis*		
0 – 24 h Nasal swabs, sputum, induced respiratory secretions for culture, FA, and PCR	24 – 72 h Blood (BC, C) and bloody sputum for culture and FA (C), F-1 Antigen assays (TT, RT), PCR (E, C, H)	>6 days Serum (TT, RT) for IgM later for IgG. Pathology samples
Tularemia *Francisella tularensis*		
0 – 24 h Nasal swabs, sputum, induced respiratory secretions for culture, FA and PCR	24 – 72 h Blood (BC, C) for culture Blood (E, C, H) for PCR Sputum for FA & PCR	>6 days Serum (TT, RT) for IgM later for IgG. Pathology samples
Glanders *Burkholderia mallei*		
0 – 24 h Nasal swabs, sputum, induced respiratory secretions for culture and PCR.	24 – 72 h Blood (BC, C) for culture Blood (E, C, H) for PCR Sputum & drainage from skin lesions for PCR & culture.	>6 days Blood (BC, C) and tissues for culture. Serum (TT, RT) for immunoassays. Pathology samples.
Brucellosis *Brucella abortus, suis, & melitensis*		
0 – 24 h Nasal swabs, sputum, induced respiratory secretions for culture and PCR.	24 – 72 h Blood (BC, C) for culture. Blood (E, C, H) for PCR.	>6 days Blood (BC, C) and tissues for culture. Serum (TT, RT) for immunoassays. Pathology samples
Q-Fever *Coxiella burnetii*		
0 – 24 h Nasal swabs, sputum, induced respiratory secretions for culture and PCR.	2 to 5 days Blood (BC, C) for culture in eggs or mouse inoculation Blood (E, C, H) for PCR.	>6 days Blood (BC, C) for culture in eggs or mouse inoculation Pathology samples.
BC: Blood culture bottle	**E: EDTA (3-ml)**	**RT: Red top if no TT**
C: Citrated blood (3-ml)	**H: Heparin (3-ml)**	**TT: Tiger-top (5 – 10 ml)**

Toxins

Early Post-Exposure	Clinical	Terminal/Postmortem
Botulism Botulinum toxin from *Clostridium botulinum*		
0 – 24 h	24 to 72 h	>6 days
Nasal swabs, induced respiratory secretions for PCR (contaminating bacterial DNA) and toxin assays. Serum (TT, RT) for toxin assays	Nasal swabs, respiratory secretions for PCR (contaminating bacterial DNA) and toxin assays.	Usually no IgM or IgG Pathology samples (liver and spleen for toxin detection)
Ricin Intoxication Ricin toxin from Castor beans		
0 – 24 h	36 to 48 h	>6 days
Nasal swabs, induced respiratory secretions for PCR (contaminating castor bean DNA) and toxin assays. Serum (TT) for toxin assays	Serum (TT, RT) for toxin assay. Tissues for immunohisto- logical stain in pathology samples.	Serum (TT, RT) for IgM and IgG in survivors
Staph enterotoxicosis *Staphylococcus* Enterotoxin B		
0 – 3 h	2 - 6 h	>6 days
Nasal swabs, induced respiratory secretions for PCR (contaminating bacterial DNA) and toxin assays. Serum (TT, RT) for toxin assays	Urine for immunoassays Nasal swabs, induced respiratory secretions for PCR (contaminating bacterial DNA) and toxin assays. Serum (TT, RT) for toxin assays.	Serum for IgM and IgG Note: Only paired antibody samples will be of value for IgG assays…must adults have antibodies to staph enterotoxins.
T-2 toxicosis		
0 – 24 h postexposure	1 to 5 days	>6 days postexposure
Nasal & throat swabs, induced respiratory secretions for immunoassays, HPLC/ mass spectrometry (HPLC/MS).	Serum (TT, RT), tissue for toxin detection	Urine for detection of toxin metabolites
BC: Blood culture bottle	**E: EDTA (3-ml)**	**RT: Red top if no TT**
C: Citrated blood (3-ml)	**H: Heparin (3-ml)**	**TT: Tiger-top (5 – 10 ml)**

Viruses

Early Post-Exposure	Clinical	Terminal/Postmortem
Equine Encephalomyelitis VEE, EEE and WEE viruses		
0 – 24 h	24 to 72 h	>6 days
Nasal swabs & induced respiratory secretions for RT- PCR and viral culture	Serum & Throat swabs for culture (TT, RT), RT-PCR (E, C, H, TT, RT) and Antigen ELISA (TT, RT), CSF, Throat swabs up to 5 days	Serum (TT, RT) for IgM Pathology samples plus brain
Ebola		
0 – 24 h	2 to 5 days	>6 days
Nasal swabs & induced respiratory secretions for RT- PCR and viral culture	Serum (TT, RT) for viral culture	Serum (TT, RT) for viral culture. Pathology samples plus adrenal gland.
Pox (Smallpox, monkeypox) *Orthopoxvirus*		
0 – 24 h	2 to 5 days	>6 days
Nasal swabs & induced respiratory secretions for PCR and viral culture	Serum (TT, RT) for viral culture	Serum (TT, RT) for viral culture. Drainage from skin lesions/ scrapings for microscopy, EM, viral culture, PCR. Pathology samples
BC: Blood culture bottle	**E: EDTA (3-ml)**	**RT: Red top if no TT**
C: Citrated blood (3-ml)	**H: Heparin (3-ml)**	**TT: Tiger-top (5 – 10 ml)**

Disease	CDC List Type (A, B or C)	HHA Detection	JBAIDS Detection	HazMatID Detection	M1M Detection
Bacteria					
Anthrax (inhalation, cutaneous and digestive) *Bacillus Anthracis*	**A**	1.5E5 – 3E5 iu/ml 1 ng/mL	1,000 CFU/ml	See note 1:	500 CFU/ml 50 pg/mL
Brucellosis *Brucella*	**B**	3E6 – 3.9E6 iu/ml	1,000 CFU/ml	See note 1:	See note 2:
Cholera *Vibrio cholerae*	**B**	No	No	See note 1:	See note 2:
Escherichia coli O157:H7	**B**	No	No	See note 1:	500 CFU/ml
Glanders *Burkholderia mallei*	**B**	No	1,000 CFU/ml	See note 1:	See note 2:
Melioidosis; Whitmore dieases *Burkholderia pseudomallei*	**B**	No	No	See note 1:	See note 2:
Microcystins	**C**	No	No	See note 1:	See note 2:
Pneumonic Plague *Yersinia pestis*	**A**	1.4E4 – 4.4E4 iu/ml	1.000 CFU/ml	See note 1:	See note 2:
Psittacosis (*Chlamydia psittaci*)	**B**	No	No	See note 1:	See note 2:
Shigella Flexneri *Shigella Dysenteriae*	**B**	No	No	See note 1:	See note 2:
Tularemia *Francisella tularensis*	**A**	4.9E4 – 1.1E5 iu/ml	1,000 CFU/ml	See note 1:	See note 2:

Disease	CDC List Type (A, B or C)	HHA Detection	JBAIDS Detection	HazMatID Detection	M1M Detection
Typhoid Fever *Salmonella Typhi*	**B**	No	No	See note 1:	See note 2:
Viruses					
Congo-Crimean Hemorrhagic Fever *Bunyaviridae*	**B**	No	No	See note 1:	See note 2:
Eastern Equine Encephalitis *Togaviridae, genus Alphavirus*	**B**	No	10,000 PFU/ml	See note 1:	See note 2:
Ebola Hemorrhagic Fever *Filoviridae virus family*	**A**	No	10,000 PFU/ml	See note 1:	See note 2:
Hanta Virus *hantavirus pulmonary syndrome*	**C**	No	No	See note 1:	See note 2:
Kyasanur Forest Disease *Flaviviridae*	**C**	No	No	See note 1:	See note 2:
Lassa Fever *Arenaviridae virus family*	**A**	No	No	See note 1:	See note 2:
Marburg Hemmorrhagic Fever *Filoviridae virus family*	**A**	No	10,000 PFU/ml	See note 1:	See note 2:
Omsk Hemorrhagic Fever	**C**	No	No	See note 1:	See note 2:

Disease	CDC List Type (A, B or C)	HHA Detection	JBAIDS Detection	HazMatID Detection	M1M Detection
Flaviviridae					
Rift Valley Fever *Bunyaviridae virus family*	**C**	No	No	See note 1:	See note 2:
Smallpox *variola virus (an orthopoxvirus)*	**A**	2.5E7 – 3.2E7 iu/ml	10,000 PFU/ml	See note 1:	See note 2:
Venezuelan Equine Encephalitis *Togaviridae: Alphavirus*	**B**	3E8 – 4.4E8 iu/ml	10,000 PFU/ml	See note 1:	See note 2:
Yellow Fever *Flaviviridae Flavivirus*	**C**	No	No	See note 1:	See note 2:
Western Equine Encephalitis T*ogaviridae: Alphavirus*	**B**	No	10,000 PFU/ml	See note 1:	See note 2:
Toxins					
Botulism *Clostridium botulinum*	**A**	10 – 20 ng/ml	No	See note 1:	Test (A) 3.2 pg/ml Test (B) 12 pg/ml
Staphylococcal Enterotoxin B (SEB)	B	287 – 505 pg/ml	No	See note 1:	Test (A) 4.0 pg/ml Test (B) 2.0 pg/ml
Ricin	B	80 – 236 ng/ml	No	See note 1:	5.0 pg/ml
Mycotoxins (T-2) *Yellow rain*	B	No	No	See note 1:	See note 2:
Rickettsiae					
Q-Fever *Coxiella burnetii*	B	7.4E6-1.7E7 iu/ml	1000 CFU/ml	See note 1:	See note 2:

Disease	CDC List Type (A, B or C)	HHA Detection	JBAIDS Detection	HazMatID Detection	M1M Detection
Rickettsia Typhi *Endemic Typhus*	B	No	1000 CFU/ml	See note 1:	See note 2:
Parasite					
Cryptosporidium parvum	B	No	No	See note 1:	See note 2:

Routes of exposure: S - skin, D- Digestive, R - respiratory, V - vector, DC - direct contact, I - injection.

Note 1: HazMatID has ability to detect organic compounds that consists of amino acids joined by peptide bonds (cell and virus proteins). It can not differentiate or identify biological agents or toxins.

Note 2: See M1M Critcial Reagents Program Listing more more information.

Appendix Q: Chemical Hazard Estimation Method and Risk Assessment Tool (CHEMRAT)

Why we use it

To provides the information necessary to advise the Installation Commander on risk associated with chemical exposure over time, reduction in Mission Oriented Protected Postures (MOPP), and hazard duration. Use in preplanning and post-attack assessment actions to estimate:

- Persistency of chemical agent vapors
- Hazardous exposure risks
- Hazard duration
- Percentage of casualties

Operational Checklist

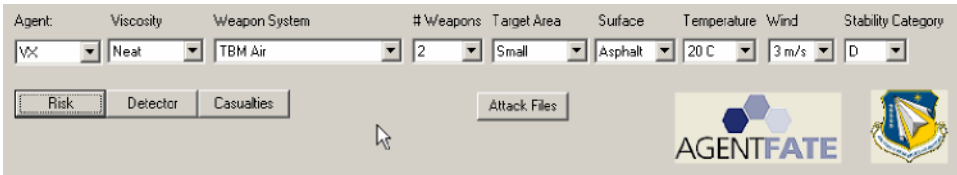
1. Select the agent(s) used in the attack. If multiple agents are used, examine each case and result separately. Use VX or GD for worst case scenarios if agent is unknown. Also, utilize intelligence and initial detection data. Select whether the agent is "Neat" or "Thickened". If the viscosity is unknown or cannot be determined, evaluate both conditions. "Thickened" will yield worst case persistency.

2. Enter weapon system by selecting TBM Air, TBM Ground, or a specific TBM that may target the operating area. In general select weapons with a CEP=0. This assumes that the weapon is on target and will not incorporate a probabilistic average into the calculations. This is worst-case scenario.

3. Enter number of weapons by selecting the estimated number of in-bound TBMs or TBMs causing agent deposition.

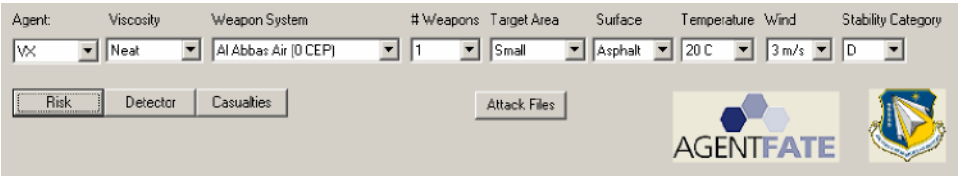
a. Where the number of TBMs successfully reaching the selected target area is unknown, but the potential number is known, select the estimated number of weapons and the appropriate weapon system without the 0 CEP (Example 1).

Example 1: Given a scenario of two in-bound Scuds (type unknown), select the number of weapons (2) and TBM Air



b. When the number of TBMs causing agent deposition in the selected target area is known, select the number of weapons and a weapon system with 0 CEP (Example 2).

Example 2: Post-attack assessment reveals the chemical attack was an airburst from one TBM (type Al Abbas). Knowing this information, select the number of weapons (1) and Weapon System (type Al Abbas Air 0 CEP)



4. Establish target area by selecting area size or specific air base. This option can be used for pre-attack modeling. However, during an attack, "Small Base" should be selected. Refer to the CWA HRA for a more detailed explanation.

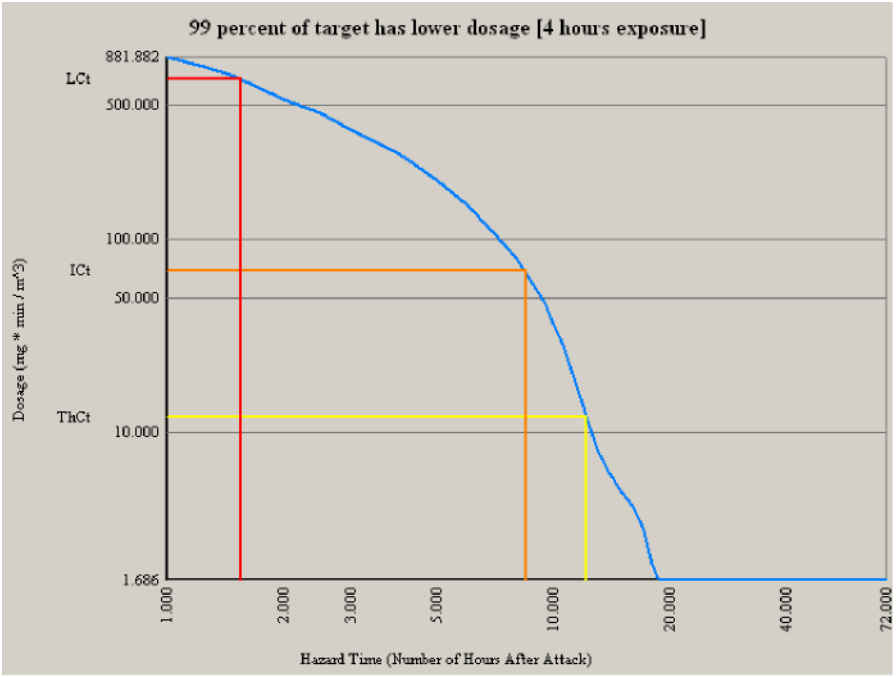
Small base = 3 km (downwind) × 1 km (crosswind)
Large base = 5 km (downwind) × 3 km (crosswind)

5. Enter surface by selecting asphalt, concrete, or sand. If contamination is present on multiple surface areas, examine each area separately and compare the results. Consider where critical mission occur (i.e., security forces may be in contact with ground on the grass, bomb loaders on the concrete ramp, etc.)

6. Select the temperature closest to forecast or actual conditions. If not certain, select the temperature that presents the worst-case results.

7. Select the wind speed closest to forecast or actual conditions. If the current wind speed falls between two wind speed ranges, evaluate both wind speeds and compare the results. Select the wind speed that presents the worst-case results. 1m/s is approximately 2 knots

8. View data using RISK Category
Example : The Risk view, shows a dosage curve (blue line) over time. The Y-axis (vertical axis) shows the dosage values, and the X-axis (horizontal axis) shows the hazard time (Number of Hours After the Attack). The intersection of the threshold (yellow), incapacitating (orange), and lethal (red) lines with the dosage line is the estimated dosage over time starting at 0.00 hours after an attack. Other views, while also based on log scales, will contain different information.



Example Log Graph

9. The Risk View

In the Risk view, the user can examine the estimated vapor dosages to personnel. The user may adjust the risk level according to the operational mission. The Risk view contains the following drop-down menus from which the user selects the appropriate information:

Exposure Type

Select Inhaled or PercVapor. CHEMRAT only evaluates risk from one exposure type in a given scenario.

a. Inhaled – the chemical vapor that exists after the contact hazard has dissipated to operationally insignificant levels

b. PercVapor – the chemical vapor present that can penetrate unprotected skin (percutaneous vapor)

Exposure Duration

Select the length of time the individual(s) will be exposed to the chemical agent vapors.

Protection

Select Full or None from the drop-down menu. For Inhaled exposures, personnel are assumed to be unmasked (None) or masked (Full). For PerVapor exposures, personnel are assumed to be wearing Battle Dress Uniform (BDU) which is (None) or protective over-garment (Full). To estimate the inhaled exposure risk to personnel if the MOPP level is reduced to MOPP 0, MOPP 1, or MOPP 2, select an "Inhaled" exposure and "None" for protection. To estimate the percutaneous exposure risk in the ventilation option, select "PercVapor" exposure and "None" for protection.

Coverage

Select the percent of target area having a vapor concentration equal to or less than the concentration associated with the area coverage percentile level. Typically, peak, 99%, and 95% are selected when using a Small base. Peak represents the 30,000 m2 grid with the worst/highest coverage of agent. 99% represents the next highest agent deposition area between 30-150,000 m2. 95% can be applied to the remaining area of agent coverage.

> If the user selects 99% area coverage, this means that 99% of the base has a vapor concentration less than the vapor concentration associated with the 99% coverage level. Alternatively, only 1% of the target area has a vapor concentration higher than the concentration associated with the 99% coverage level. Therefore, the probability or chance that a person would be exposed to a vapor concentration higher than the 99^{th} percentile area coverage is only 1%. If the 90^{th} percentile was selected, there would be a 10% chance that an individual would be exposed to a vapor concentration higher than the selected 90% area coverage concentration.

Risk Scale

The risk scale may be adjusted to examine the percentage of personnel that may experience threshold, incapacitating, and lethal effects. As the ruler is adjusted on the scale, the percentage and hazard duration times will change. Risk percentages outside the + or -1 standard deviation have limited accuracy. Therefore, the risk level should only be adjusted between the 16^{th} and 84^{th} percentile.

Percentile

This value represents a calculation of the percentage of personnel that may receive the

contamination dosages listed in the threshold (ThCt), incapacitating (ICT) and lethal concentration (LCT) windows. This value is equal to the Risk Scale.

Dosage

Dosage is the amount of agent ($mg^{*}min/m^{3}$) required to cause threshold, incapacitating, or lethal effects for a given exposure time and specified casualty risk percentile level.

10. Risk View Graph Display

The graph visually displays the results contained in the risk table using four colored curve lines.

Blue Line	The blue line represents the overall dosage curve.
Dotted Blue Lines	The dotted blue lines represent the standard deviation from the overall dosage curve.
Yellow Line	The yellow line represents threshold values.
Orange Line	The orange line represents the incapacitating values.
Red Line	The red line represents the lethal values.

Applications

1. Immediately after an attack, BE can estimate the hazard persistency. The software has a limitation of 72 hours based on the data files.

2. BE can also estimate hazard effects on personnel based modeled concentration and exposure time at various points in time after the attack.

3. In conjunction with CHART and HAPSITE measurements, can compare predicted concentration/dose with actual. Plotting the actual concentration/dose at various points in time and using the decay curves in ChemRAT, BE can adjust the prediction for persistency based on measurements and interpolation.

Appendix R: Chemical Health Assessment and Risk Tool (CHART)

Overview: Use the CHART program to estimate human health effects from exposure to chemical warfare agents when the concentration is estimated or known. Based on the user inputs of agent, temperature, equipment limit of detection or known/predicted concentration, and exposure time, the program calculates the equivalent dose and identifies the percentile range of the population expected to suffer from the three different identified health effects (threshold, severe, death). The program also accounts for work/activity levels.

Operational Checklist

1. Select agent of interest
2. Input temperature Note: Check box if your temperature measurement is in degrees Fahrenheit. Degrees Celsius is the default unit for this entry
3. Enter measured concentrations Note: Select the appropriate unit button to match your concentration measurement. This can be derived from several sources.
    a. LOD for initial detection equipment (i.e., M256, CAM, M22, etc.) when agents are present/absent. This provides one boundary point for exposure effects and can be used to initiate the HRA.
    b. LOD for advanced surveillance equipment (i.e., CDS kit, Hazcat kit, or other non-quantitative equipment)
    c. Actual concentration from HAPSITE or other quantitative instruments
    d. Predicted concentration, calculated from ChemRAT at a future point in time to estimate effects.
    e. Predicted concentrations from plume models such as HPAC or VLSTRAK immediately following an attack to predict casualties or risks.
4. Input estimated exposure duration Note: Enter your time unit in minutes. This parameter can be used for several purposes:
    a. Known time to complete a critical mission without MOPP-gear
    b. Estimating imminent effects from a recent exposure
    c. Determining the point at which de-MOPPing poses minimal risk (trial and error iteration)

Sample Program Data Entry Sheet

	Light Work Level		
	Risk Assessment of Nerve Agent Exposure and Effect		
	Threshold Risk (Th)	Incapacitation Risk (EC)	Lethal Risk (LC)
Risk @ Calculated Dosage	<16%	<16%	<16%
Dose Required for Percentile Response	Th16 Dose (mg-min/M3) 0.2725	EC16 Dose (mg-min/M3) 19.86	LC16 Dose (mg-min/M3) 28.89
Calculated Dosage (mg-min/M3)	0.2700	0.2700	0.2700

	Moderate Work Level		
	Risk Assessment of Nerve Agent Exposure and Effect		
	Threshold Risk (Th)	Incapacitation Risk (EC)	Lethal Risk (LC)
Risk @ Calculated Dosage	>70%<84%	<16%	<16%
Dose Required for Percentile Response	Th84 Dose (mg-min/M3) 0.2936	Th16 Dose (mg-min/M3) 9.93	Th16 Dose (mg-min/M3) 14.44
Calculated Dosage (mg-min/M3)	0.2700	0.2700	0.2700

	Heavy Work Level		
	Risk Assessment of Nerve Agent Exposure and Effect		
	Threshold Risk (Th)	Incapacitation Risk (EC)	Lethal Risk (LC)
Risk @ Calculated Dosage	>84%	<16%	<16%
Dose Required for Percentile Response	Th84 Dose (mg-min/M3) 0.1957	Th16 Dose (mg-min/M3) 6.62	Th16 Dose (mg-min/M3) 9.63
Calculated Dosage (mg-min/M3)	0.2700	0.2700	0.2700

5. Take note of the different work levels and the three different estimated physiological risk associated with an expected exposure.
6. The light, moderate and heavy work levels are associated with ventilation rates of 15 lit/min, 30 lit/min and 45 lit/min respectively.

Guide to Determination of Workload

• Walking on hard surface @ 2.5 mph with $\leq$ 30 lb load • Weapon Maintenance • Manual of Arms • Marksmanship Training • Drill and Ceremony	• Walking on hard surface @ 3.5 mph with < 40 lb load • Walking loose sand @ 2.5 mph with no load • Patrolling • Low crawl, high crawl • Defensive position construction • Field Assaults	• Walking on hard surface @ 3.5 mph with $\geq$ 40 lb load • Walking on loose sand @ 2.5 mph with load

Appendix S: HazCat Kit

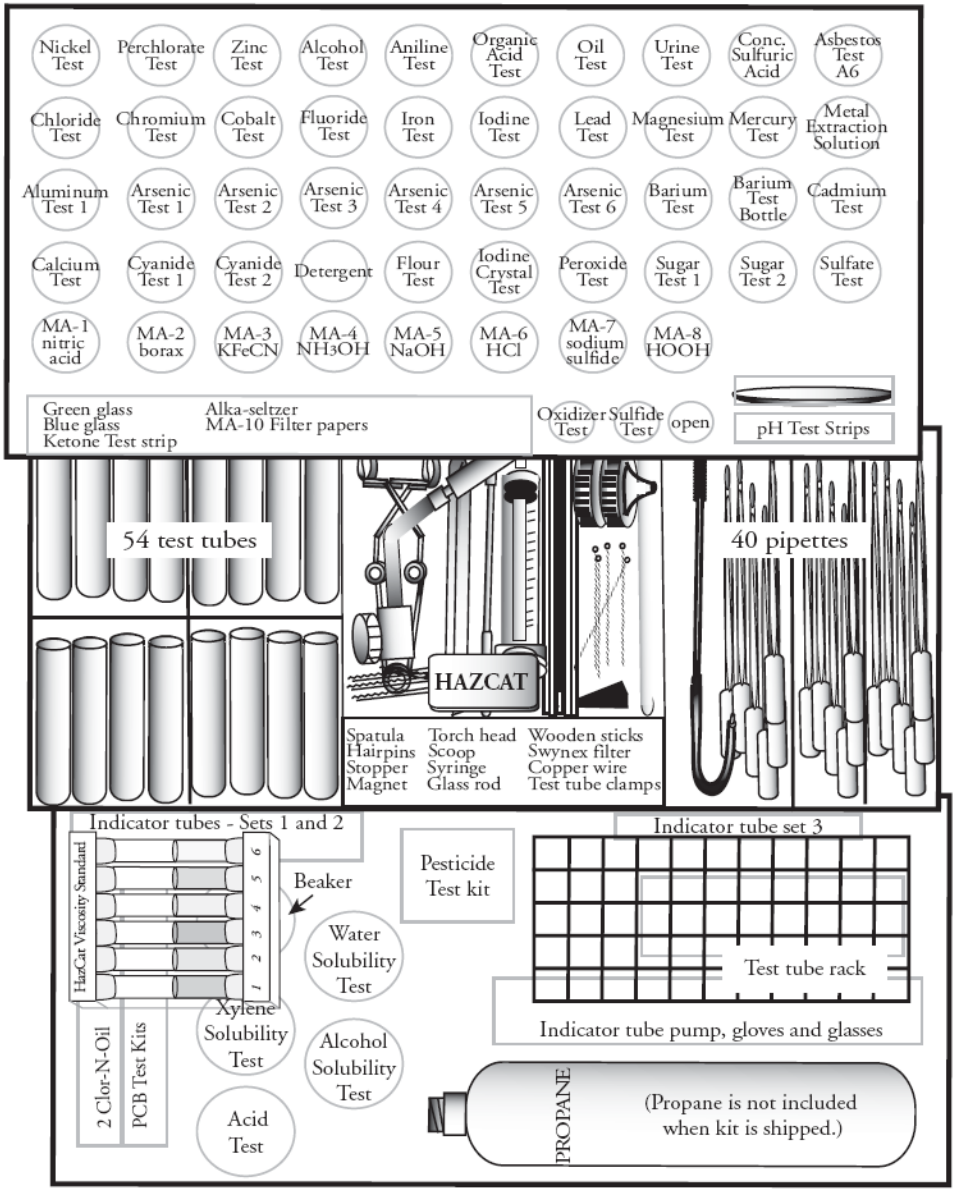
The HazCat System can identify the following substances:

Acetaldehyde	Diesel fuel	Phenol
Acetic Acid	Dimethyl sulfate	Phosphoric acid
Acetone	Ether	Phosphorous pentoxide
Aluminum	Ethylene glycol	Picric acid
Ammonia	Fiberglass	Potassium cyanide
Ammonium nitrate	Flour	Potassium hydroxide
Ammonium perchlorate	Formaldehyde	Potassium metal
Aniline	Gasoline	Propyl chloride
Arsenic	Hydrazine	Pumice
Arsenic acid	Hydrofluoric acid	Salicyclic acid
Asbestos	Hydrogen peroxide	Silica
Benzoyl peroxide	Hydroiodic acid	Silver
Bleach	Iodine	Sodium cyanide
Boric acid	Iron	Sodium hydroxide
Boron	Kerosene	Sodium metal
Cadmium	Latex paint	Strychnine
Calcium carbide	Lead	Sugar
Calcium hydroxide	Lime	Sulfur
Calcium metal	Lithium hydroxide	Sulfuric acid
Calcium sulfate	Lithium metal	Tetrahydrofuran
Carbon disulfide	Magnesium	Thionyl chloride
Carbonated water	Mercury	Thiophene
Cement	Methyl ethyl ketone	Turpentine
Chlorobenzene	Methyl ethyl ketone peroxide	Urea
Chrome	Nitric acid	Urethane plastic
Chromic acid	Oxalic acid	Urine
Chromium trioxide	Paint stripper	Wax
Cobalt	PCBs	Zinc
Detergent	Perchloric acid	

HazCat also characterizes chemicals by “families.”

Acetates	Glycols	Acrylates	Isocyanates
Alcohols	Ketones	Aldehydes	Mercaptans
Amines	Nitriles	Animal feed	Organo-metals
BTEX	Organophosphates	Chlorinated	Wood and wood
hydrocarbons	Carbamates	hydrocarbons	products
Carbonates	Thionated pesticides	Plastics/plastic resins	Chlorocyanurates
Polyols	Cellosolves	Shellacs	

Figure S-1: HazCat Kit Reagent Locations by Tray



Appendix T: HazMat ID

Figure T-1: IR Analyzer Sequence of Operation

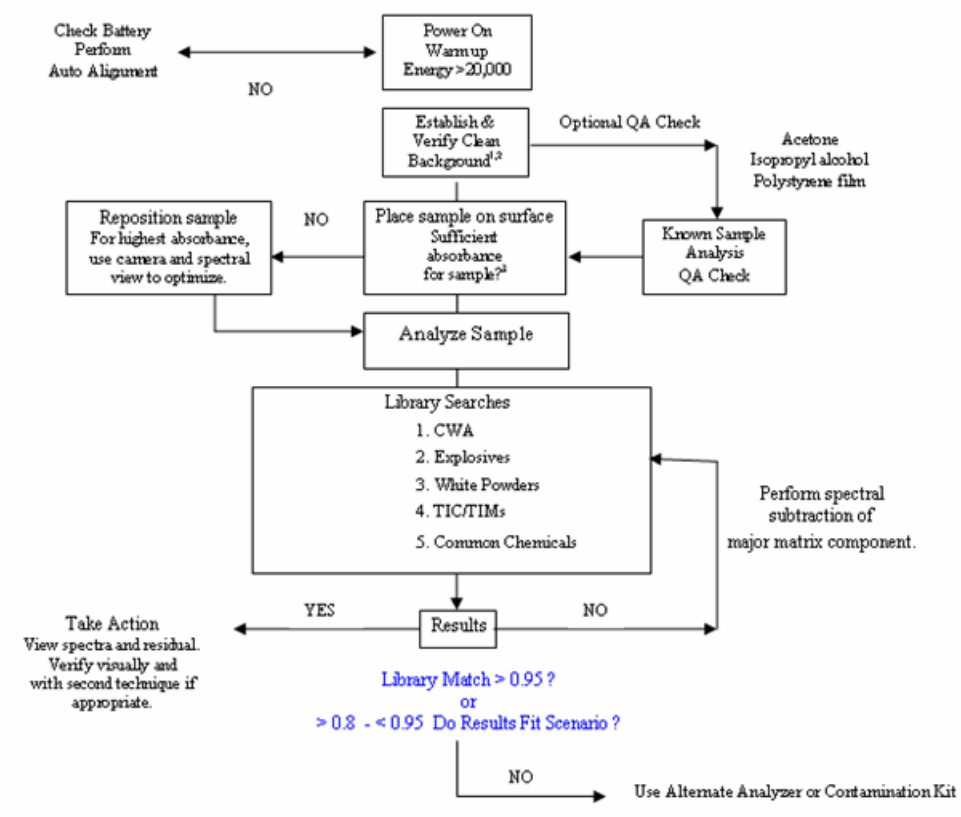


Figure T-2: Sample Optimization and Mixture Identification Sequence

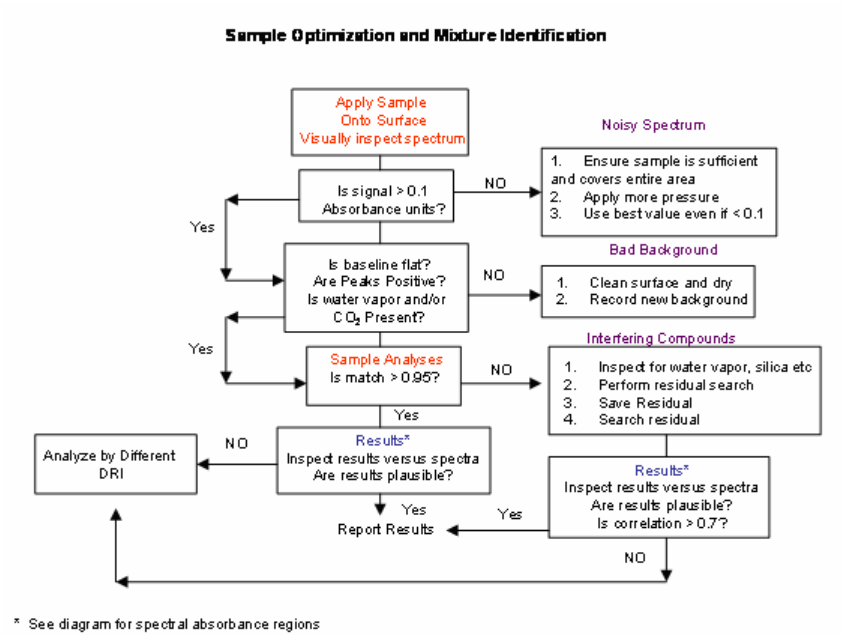
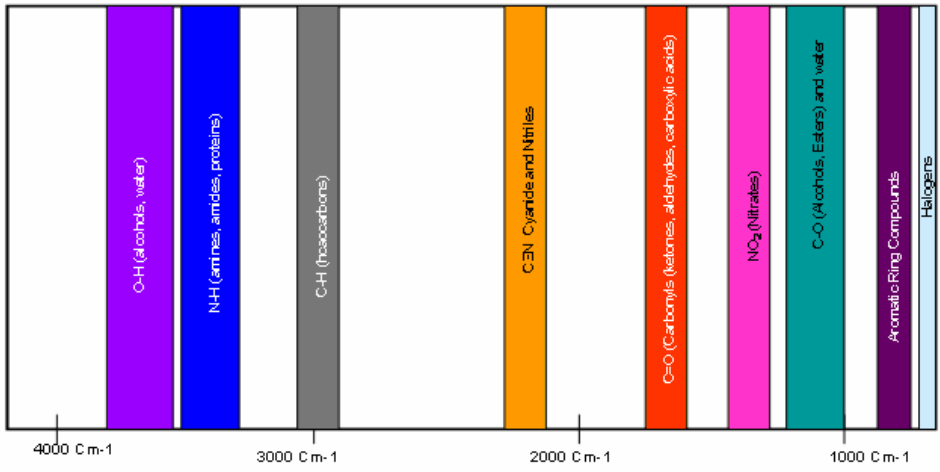


Figure T-3: IR Spectrum Functional Group Absorbance Regions



Appendix U: XMX

General Information

The XMX liquid impinger is capable of collecting aerosolized samples of 1-10 microns in size to replicate the aerosol size that WMD agents must have to be adsorbed on the lung. Aerosolized samples can be collected directly in either an impinger containing 5-7 milliliters of liquid (e.g., DI water) or a dry cassette. The identification of the unknown substances must be made using another instrument or through chemical analysis.

XMX Specifications

Dimensions	Width: 46 cm, Height: 58 cm (with stack), Depth: 33 cm
Weight	Approximately 17 kilograms
Power Requirements	110V AC or 220V AC
Power Consumption	10 A @ 110V AC, 5A @ 220V AC (optional)
Intake Flow Rate	530 Standard LPM +- 25 SLPM, at 1 atm = 101325Pa, 25°C
Secondary Flow Rate	12 liters per minute
Particle Size Range	Between 1 – 10 microns
Operating Temperature Range	0 to +50°C -10 to +50°C (With heater and dry filter)
Decontamination	Air Purge – 5 minutes
Collection Vials	Fisher commercial-off-the-shelf 50ml centrifuge tube
Setup/Teardown Time	5 minutes
Collection Medium	Liquid – includes sterile water, PBS solution, surfactant solution OR Dry Filter – COTS filter
Collection Medium Volume	Fixed at 5ml (liquid) ; minimizes dilution for integrated collection period
Ingress Protection (Environment)	NEMA-3 Rating

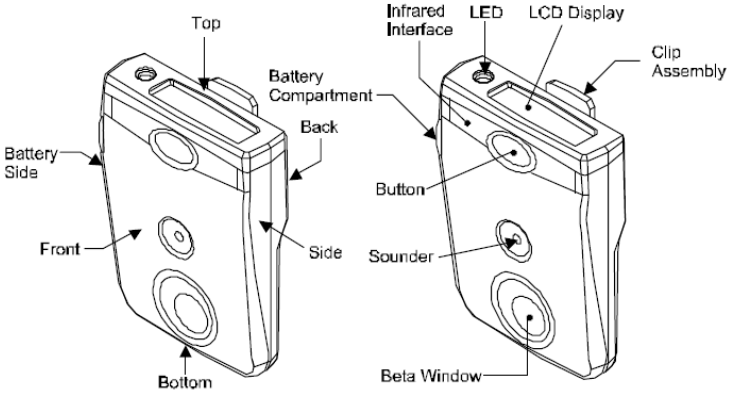
Sampling Checklist

1. Turn the instrument on and warm up for 5 minutes
2. To set up the sampler, turn the XMX off once it's warmed up
3. Install the liquid impingement nozzle.
4. Fill the collection via with 5-7 ml of liquid and reinstall in the LIM body
5. Set the operation mode of the run-time timer to "H"
6. Set the time amount (usually 5 minutes) and interval of the timer (seconds, minutes, hours)
7. At the sampling location, turn the sampler on. (ensure the exhaust is located in a area which doesn't blow the sample into the air)
8. Take GPS coordinates of the sampling location
9. Fill out required chain of custodies.
10. Place sample in plastic bag for further analysis.

Appendix V: EPD's

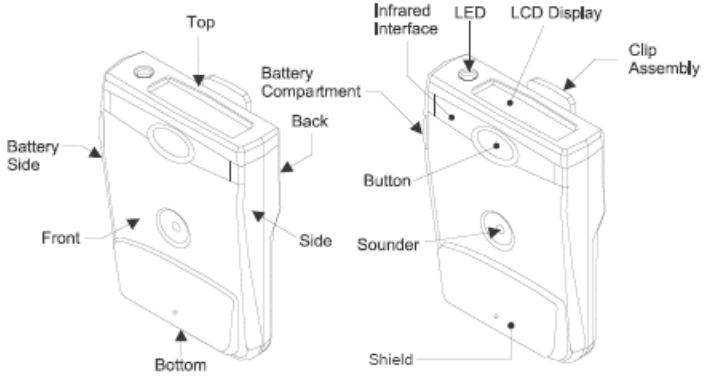
MK2 General Information

- Gamma, x-ray: 15 keV to 10 MeV
- Beta: 250 keV to 1.5 MeV (mean energy)



N2 General Information

- Gamma, x-rays: 20 keV to >7 MeV
- Neutrons: Thermal to >15 MeV



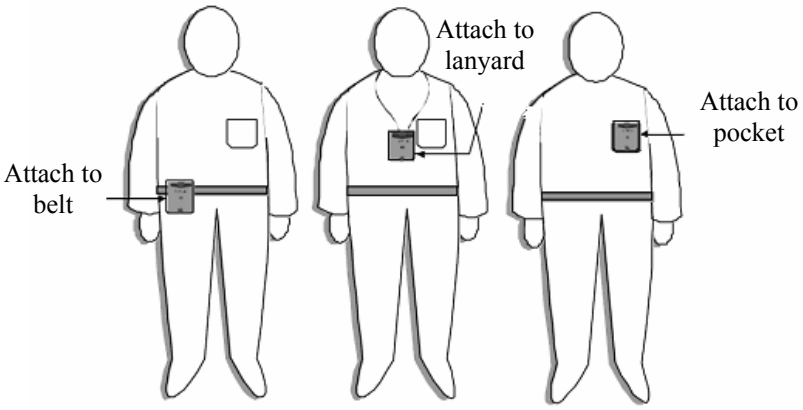
EPD Easy Software

1. Power on Computer/open up Easy EPD Software Program
2. Place EPD in front of IR Reader
3. Update Name and ID of responder
4. Verify AFIOH WMD default Alarm set points or update alarm set points as needed

EPD Mk2 (Gamma-Beta)				
Dose Alarm Thresholds			**Rate Alarm Thresholds**	
			On	**Off**
Hp10 (1)	2,500 mrem		10 mrem/hr	8 mrem/hr
Hp10 (2)	25,000 mrem		5,000 mrem/hr	4,990 mrem/hr
Hp07	250,000 mrem		10,000 mrem/hr	9,990 mrem/hr
EPD N2 (Neutron-Gamma)				
Dose Alarm Thresholds			**Rate Alarm Thresholds**	
			On	**Off**
HpG (1)	2,500 mrem		10 mrem/hr	8 mrem/hr
HpG (2)	N/A		5,000 mrem/hr	4,990 mrem/hr
HpN	500 mrem		100 mrem/hr	90 mrem/hr
HpG+HpN	5,000 mrem			

(1) Continuous Single Tone
(2) Continuous Dual Tone

5. To update or set, click disable all… under visable displays check the cell blocks that apply (2nd row, 2nd and 3rd columns). Blocks will turn grey
6. Set "Display Settings" to rem
7. Enable "Backlight" if needed
8. "Close" screen
9. Click "Write to EPD"
10. Program next EPD or "Close" Program
11. Wear EPD as shown below. Note: Wear EPD outside of protective clothing and the beta window should be facing outwards.



Appendix W: Radio Codes

Table 1 – CHEMICAL CODES						
Item	Equipment		A	B	C	D
1	4 Gas meter		LEL >10%	LEL <10%	>23.5% 02	<19.5% O2
2	M8		Gold	Green	Blue	Red
3	M9		Pos	Neg		
4	M22	H	1 2	3 4	5 6	7 8
4.1	M22	G	1 2	3 4	5 6	7 8
5	CAM	H	1 2	3 4	5 6	7 8
5.1	CAM	G	1 2	3 4	5 6	7 8
6	Hapsite		CWA	TIC/TIM	Below LOD	Other chemical
7	TVA 1000		PID	FID		
8	M256		Lewisite Tab	Blister	Blood	Nerve
8.1		Pos	Olive	Purple Blue	Pink	Peach
8.2				Red	Blue	Colorless
8.3		Neg	Tan	Colorless	Colorless	Blue
9	M272		Lewisite	Nerve	Cyanide	Mustard
9.1		Pos	Yellow	White	Blue Yellow	Purple
9.2		Neg	White	Blue	White	White
10	CDS kit	Pos	Thioether	Phosgene	Hydrocyanic Acid	Organic Arsenic
			Organic Basic Nitrogen	Cyanogen Chloride	Chlorine	Phosphoric Acid Ester
10.1	CDS kit	Neg	Thioether	Phosgene	Hydrocyanic Acid	Organic Arsenic
			Organic Basic Nitrogen	Cyanogen Chloride	Chlorine	Phosphoric Acid Ester

Reporting Instructions: Match the column to the Row (i.e. "Table 1 – 2=Alpha" for positive M-9 tape) DO NOT REPORT ACTUAL COLORS OR NUMBERS

Table 2 – BIOLOGICAL CODES					
		A	B	C	D
1	Bio Signs	Dead Animal	Discolored Vegetation	Unusual Smells	Reported Epidemic
2	Hazmat ID	Protein based unkn	Not Hazardous	TIC (Single Chemical)	TIM (Multiple Chemicals)
2.1		Explosive	Drug/Precursor	CWA	Unknown poor similarity
3	HHA	Tray 1: N	Tray 2: LE	Tray 3: W	Tray 4: XR
3.1		Tray 5: UC	Tray 6: UL	Tray 7: AB	Tray 8: OS
3.2		All negative			

Table 3: RADIOLOGICAL CODES						
			A	B	C	D
			Nano-R/hr	Micro-R/hr	Milli-R/hr	R/hr
1	SAM 935		1 - 999	1 - 999	1 - 999	1 - 999
	ADM 300		Nano-R/hr	Micro-R/hr	Milli-R/hr	R/hr
2		Alpha	1 – 10 cpm	11 – 100 cpm	10 – 1000 cpm	>1000 cpm
2.1		Beta	1 - 999	1 - 999	1 - 999	1 - 999
2.2		x-ray	1 - 999	1 - 999	1 - 999	1 - 999
			Nano-R/hr	Micro-R/hr	Milli-R/hr	R/hr
3	Victoreen		1 - 999	1 - 999	1 - 999	1 - 999
4	EPD		1st alarm	2nd alarm	3rd alarm	
5	RADECO		Nano-R/hr	Micro-R/hr	Milli-R/hr	R/hr
		Alpha	1 – 10 cpm	11 – 100 cpm	10 – 1000 cpm	>1000 cpm
		Beta	1 - 999	1 - 999	1 - 999	1 - 999
		Gamma	1 - 999	1 - 999	1 - 999	1 - 999

Table 4: PERSONNEL/EQUIP CODES						
			A	B	C	D
1	Team		Missing	Lost Team	Hurt	Dead
2	Casualty		Ambulatory	Minor	Serious	Dead
3	UXO		Found	Marked	Safe	
4	Decon		CCA	Bleach	M291	M295
4.1	Item/person		Contaminated	Clean		
5	Mark 1		1 kit	2 kit	3 kit	CANA
6	Equip		Operational	Non-operable	No power/low battery	Broken/ unusable
7	SCBA		Full	Half	Low	

Reporting Instructions: Match the column to the Row (i.e. "Table 1 – 2=Alpha" for positive M-9 tape) **DO NOT REPORT ACTUAL COLORS OR NUMBERS**

Appendix X: Conversion Factors

US	Metrics/US
1 ft^3	28,317 cc
	1,728 in^3
	0.0283 m^3
	7.48 gallons
	28.32 liters
	29.92 quarts
	62.5 lbs of water
1 in^3	16.39 cc
	5.79 x 10^{-4} ft^3
	1.64 x 10^{-5} m^3
	4.33 x 10^{-3} gal
	0.0164 liters
1 ft	0.3048 m
	30.48 cm
1 gallon	3,785 cc
	0.134 ft^3
	3.785 liters
1 inch	2.54 cm
1 lbs	453.59 g
1 quart	946.4 cc
	57.75 in3
	0.946 liters

Metrics	US/Metrics
1 cm	0.0328 feet
	0.394 inches
	10,000 microns
1 cc	3.53 x 10^{-5} ft^3
	2.64 x 10^{-4} gallons
	0.001 liters
	1.00 ml
1 m^3	35.31 ft^3
	264.17 gallons
	1,000 liters
1 gram	2.205 x 10^{-3} lbs
1 gram/cc	62.43 lbs/ft^3
	8.345 lbs/gal
1 liter	1,000 cc
	0.0353 ft3
	1,000 ml
	0.264 gallons
	1.057 quarts
1 meter	3.28 ft
1 kg	about 2.2 pounds

Radiation:

millicurie (mCi)	1 x 10^{-3} Ci
microcurie (mCi)	1 x 10^{-6} Ci
nanocurie (nCi)	1 x 10^{-9} Ci
picocurie (pCi)	1 x 10^{-12} Ci
100 rem	1 sievert (Sv)
1 rem	10 mSv
1 mrem	10 µSv
1 µrem	10 nanosievert (nSv)
1 Ci	3.7x10^{10} Bq

Becquerel (Bq)	1 dps
Kilobecquerel (kBq)	1000 dps
Megabecquerel (MBq)	1,000,000 dps
100 rad	1 gray (Gy)
1 rad	1 centigray
1 rad	10 milligray (mGy)
1 millirad (mrad)	10 microgray (µGy)
1 microrad (µrad)	10 nanogray (nGy)
1 Ci/ml	2.22x10^{12} dpm/m^3

Miscellaneous:

Weight of water = 8.34 lb/gal	1 ug/l = 1 part per billion
1 mg/kg = 1 part per million	1 mg/l = 1 part per million

Appendix Y: Radiation Dose Rate and Dose Guidance

Dose Rate Recommendations	Actual Values	Exercise Values for Training
Contaminated Person[1]	2 x Background Reading (cpm or µR/hr or mR/hr)	2 x Background Reading (cpm or µR/hr or mR/hr)
Limit of Radioactive "Plume" on the Ground or Air[2]	5 x Background Reading (cpm or µR/hr or mR/hr)	5 x Background Reading (cpm or µR/hr or mR/hr)
Establish Hot Line[3] CAUTION	1-10 mR/hr (0.001 – 0.01 R/hr)	100 µR/hr (0.1 – 1 mR/hr)
Work in Hot Zone CAUTION – DANGER	1 – 10,000 mR/hr 0.001 – 10 R/hr)	100 – 1,000 µR/hr (0.1 – 1 mR/hr)
Turn Around Dose Rate for Non-Life-Saving[4] DANGER	10 R/hr	1000 µR/hr (1 mR/hr)
Turn Around Dose Rate for Life-Saving[5] DANGER	200 R/hr	4000 µR/hr (4 mR/hr)
Only Volunteers Fully Informed of the Risk May Proceed[5] GRAVE DANGER	More than 200 R/hr	Not Allowed For Training

[1]EPA Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, EPA 400-R-92-001

[2]DOE FMRAC Monitoring and Analysis Manual Radiation Monitoring and Sampling. DOE/NV/11718-181-VOL.1

[3]See guidance from local or state authorities. Many jurisdictions use 2 mR/hr.

[4]NCRP Management of Terrorist Events Involving Radioactive Material, NCRP Report No. 138

DOE FMRAC uses 1.5 R/hr for turn-around unless otherwise directed. DOE/NV/11718-181-VOL.1

[5]Adapted from DOE Los Alamos National Laboratory Emergency Responder Radiological Training. See guidance from local and state authorities for maximum dose *rate* that can be entered for life-saving activities.

Gamma Dose Rate Stay Time Tables

Gamma Dose Rate on Meter		Time To Receive This Dose (Times rounded off. Table only calculates from external sources.)									
		All Emergency Responder Activities Under the Emergency Conditions				Protect Property	Life-Saving	Life-Saving Volunteers Only		Potentially Lethal	
		0.1 rem	1 rem	2 rem	5 rem	10 rem	25 rem	50 rem	100 rem	300 rem	500 rem
	10 µR/hr	1 yr									
	100 µR/hr	6 wk	1 yr								
	500 µR/hr	8 day	12 wk	24 wk	1 yr						
Set –up Hot Line Caution	1 mR/hr	4 day	6 wk	12 wk	30 wk	1 yr					
	5 mR/hr	20 hr	8 day	16 day	6 wk	12 wk	30 wk	1 yr			
	10 mR/hr	10 hr	4 day	8 day	3 wk	6 wk	15 wk	30 wk	1 yr		
Work in Hot Zone Caution	20 mR/hr	5 hr	2 day	4 day	10 day	3 wk	7 wk	15 wk	30 wk	2 yr	
	50 mR/hr	2 hr	20 hr	40 hr	4 day	8 day	3 wk	6 wk	12 wk	35 wk	1 yr
Danger	100 mR/hr	1 hr	10 hr	20 hr	2 day	4 day	10 day	3 wk	6 wk	18 wk	30 wk
	500 mR/hr	12 min	2 hr	4 hr	10 hr	19 hr	2 day	4 day	8 day	25 day	40 day
	1 R/hr	6 min	1 hr	2 hr	5 hr	10 hr	25 hr	50 hr	4 day	12 day	3 wk
	2 R/hr	3 min	30 min	1 hr	2.5 hr	5 hr	13 hr	25 hr	2 day	6 day	11 day
	5 R/hr	72 sec	12 min	24 min	1 hr	2 hr	5 hr	10 hr	20 hr	2.5 day	4 day
Life-Saving Only Danger	10 R/hr	36 sec	6 min	12 min	30 min	1 hr	2.5 hr	5 hr	10 hr	30 hr	50 hr
	50 R/hr	7 sec	72 sec	80 sec	6 min	12 min	30 min	1 hr	2 hr	6 hr	10 hr
	100 R/hr	4 sec	30 sec	1 min	3 min	6 min	15 min	30 min	1 hr	3 hr	5 hr
Volunteer Grave Danger	300 R/hr	1 sec	10 sec	20 sec	1 min	2 min	5 min	10 min	20 min	1 hr	100 min
	500 R/hr	1 sec	7 sec	15 sec	30 sec	72 sec	3 min	6 min	12 min	36 min	1 hr
	1000 R/hr	1 sec	3 sec	7 sec	18 sec	36 sec	90 sec	3 min	6 min	18 min	30 min

Natural background: ~ 10 µR/hr = 0.01 mR/hr = 0.00001 R/hr = 0.25 mR/day

Appendix Z: Select Chemical and Biological Detectors Fact Sheet

Select Chemical and Biological Detectors Fact Sheet – individual equipment fact sheets can be viewed in their entirety at https://kx.afms.mil/esoh, CBRNE Documents under the Readiness (CBRNE) tab.

Equipment	M9 Paper	M8 Paper	M256A1
Chemicals Agent	GA, GB, GD, H, VX	G - yellow (30 sec); V - dark green (30 sec); H - pink/red (30 sec); 25 sheets in M256A1 kit, Quicksilver Kit	GB, GD, H, HD, AC, CK, L, VX
Does Not Detect	Does not detect agent type, only presence; does not respond if paper is wet	Agent vapor and must come in contact with liquid chemical agent	Choking agents, DP (diphosgene), GA
Detection State	Liquid	Liquid	Vapor, liquid (droplet/aerosol)
Sensitivity	100 drops	Responds to droplets of 100 microns or larger	HD – 2.0 mg/m^3; G – 0.005 mg/m^3 VX – 0.02 mg/m^3 L – 9.0 mg/m^3 AC – 8.0 mg/m^3 CK – 8.0 mg/m^3
ID Criteria	Color change	Color change	Color change indicates agent is present or danger; *Lewsite* -present: rub mark on paper tab turns olive green; not present: tab is tan; *Nerve agent* - present: colorless; not present: blue-green or darker; *Blister agent* - present: purple/blue (H), red/purple (CX); not present: colorless; *Blood agent* - present: pink or blue; not present: colorless
Response Time	$\leq$ 20 sec	< 30 sec	15 – 25 min
Interferents	Petroleum products; insecticides; anti-freeze	Numerous false positives for both H-blister and G-nerve	Some smokes, high temperatures, petroleum products may cause false readings
Intrinsically Safe?	Y, avoid direct contact	Y	N, always wear complete chemical PPE when using

Nerve Agents
GA – tabun
GB – sarin
GD – soman
GF – cyclosparin

Blister Agents
H – sulfur mustard
HD – distilled mustard
HN-1 – nitrogen mustard
L – Lewisite

Blood Agent
AC – hydrogen cyanide
CK–cyanogens chloride

Lung Agent
CG – phosgene

Equipment	CDS Kit		
Chemicals Agent	**Agent**	**Drager Tube**	
	Nerve		
	GB, GA, GD; Pesticides (DFP, Metasystox, & DDVP)	Phosphoric acid esters	
	Blister		
	Sulfur Mustard	Thioether	
	H, HD, S-Mustard	Thioether (sulfur mustard)	
	HN, N-Mustard	Organic basic nitrogen compounds	
	Lung Agents		
	CG	Phosgene	
	Blood Agents		
	AC	Hydrocyanic acid	
	CK	Cyanogen chloride	
	Hydrogen Arsenide	Organic arsenic compounds & arsine	
	Nose & Throat Irritating Agents		
	Clark I (DA, DX), Clark II (DC), & Adamsite (DM)	Organic arsenic compounds & arsine	
CDS Simultaneous Set I	**Drager Tube**	**Color Change**	**Sensitivity**
	Thoiether (sulfur mustard)	yellow to orange	1 mg/m^3
	Phosgene	yellow to blue-green	0.2 ppm; ~20 min pale green
	Hydrocyanic acid (HCN)	yellow to red	1 ppm
	Organic arsenic compounds and arsine	yellow to grey	0.1 ppm arsine (3 mg/m^3 organic arsenic compounds)
	Organic basic nitrogen compounds	yellow to orange-red	1 mg/m^3
CDS Simultaneous Set V	**Drager Tube**	**Color Change**	**Sensitivity**
	Cyanogen chloride	white to pink	0.25 ppm
Does Not Detect	Inorganic compounds		
Bio Agents	NA		
Detection State	Vapor, aerosol		
Sensitivity	GA, GB at 0.025 ppm (< IDLH) HD at 0.15 ppm (No IDLH) Hydrogen cyanide at 1 ppm (No IDLH) Arsine at 0.1 ppm (< IDLH) Cyanogen chloride at 0.25 ppm (No IDLH)	GD at 0.025 ppm (> IDLH) Phosgene at 0.2 ppm (< IDLH) L at 0.1 ppm (No IDLH) Chlorine at 0.2 ppm (< IDLH)	
ID Criteria	Color change		
Response Time	5 min		
Interferents	Water aerosols can produce minus errors		
Intrinsically Safe?	Y		

Equipment	TVA 1000	HazMatID	XMX
Chemicals Agent	G-series; PID – detector of choice for measuring high vapor concentrations; FID – organic compounds; dilutor kit can be used to reduce very high VOC concentrations to within dynamic range	Half mustard, VX, GA, GB, GD, GF, HD	Collects aerosol samples 1-10 microns, to include GA, GB, VX, TIC/TIMs
Does Not Detect	PID – methane; FID – ammonia, carbon disulfide, carbon tetrachloride, chloroform, ethylamine, hydrogen sulfide	Elemental substances (iron, aluminum, etc.); non-metals (sulfur, phosphorous); dilute water-based solutions; individual components of a mixture >10% concentration	Gaseous or particulates < 1 micron
Bio Agents	NA	Protein will appear for substance that has spectrum consistent with biological material	Anthrax
Detection State	Vapor, aerosol	Solids, liquids, pastes	Liquid & dry impingers
Sensitivity	GA 0.61 ppm (above IDLH); HD at 0.29 ppm (no IDLH)	NA	Particle size 1-10 microns; primary flow rate 800 l/min (airborne particles); secondary flow rate 12 L/min (air drawn through liquid impingement)
ID Criteria	Minimum detection limit – 100 ppb benzene (PID); 300 ppb hexane (FID)	Quality index over 0.95 (95%); sample and library match visually; physical properties match	Sample collection for subsequent analysis
Response Time	4 sec (without telescoping wand or charcoal filter adaptor)	15-20 min warm-up	5 min
Interferents	PID – water vapor; FID – low oxygen (16% required)	Sample mix (water & alcohol O-H bonds – near 3600 & 1600	Extreme weather conditions
Intrinsically Safe?	Y	N	N

Equipment	HHA	Hapsite GC/MS	Hapsite V to G tubes
Chemicals Agent	NA	GA, GB, GD, GF, HD; VX, R-33 (V to G tubes)	VX or R-33
Does Not Detect	Cannot be used on soil or very dirty/dusty surfaces	L, hydrogen cyanide, inorganics (ammonia, arsine, phosgene hydrogen chloride, surfuric acid)	Sulfur mustard when conversion tube installed
Bio Agents	Presumptive ID of 10 BW threat and 4 simulants agents (used only on non-porous surfaces)	NA	NA
Detection State	Visible powders (or suspensions); suspected liquids	Vapor	Vapor
Sensitivity	Kit indicators	SIM Method, Tenax tube required: GA – 0.001 mg/m^3 GB – 0.0002 mg/m^3 GD – 0.0002 mg/m^3 GF – 0.0002 mg/m^3 HD – 0.0003 mg/m^3	VX – 0.0003 mg/m^3 R-33 – 0.0008 mg/m^3
ID Criteria	Presumptive	GA – RT – 12:13 GB – RT – 6:10 GD – RT – 11:23 GF – RT – 13:47 HD – RT – 12:54	VX – Tenax RT – 4:39 Tri-bed RT – 5:21 R-33 – Tenax RT – 9:03 Tri-bed RT – 9:43
Response Time	15 min	30 min	
Interferents	Matrix effect – something in biological agent sample prevents antibodies form bonding to antigen	Co-elution	Extreme sunlight and excess heat
Intrinsically Safe?	Y	N	Y

Appendix AA: Field Analytical Methods

AF CBRN Method	Description
CBRN-B-B-1, V1 2007	Bulk Sample Collection and Swab Sample Collection of Visible Powders Suspected of Being Biological Agents from Nonporous Surfaces

1. Method Overview

The following methods were developed using 886H supplies and are consistent with the ASTM Standard for *Standard Practices for Bulk Sample Collection and Swab Sample Collection of Visible Powders Suspected of Being Biological Agents from Nonporous Surfaces*. The procedures are somewhat simplified and utilize supply terminology consistent with existing items in the Quicksilver Sampling kit and the DoD Hand-Held Assay.

2. Target Analyte(s):

Visible powders suspected of being biological agents from nonporous surfaces. Refer to DoD Hand-held assay codes for analytical capability.

3. Equipment Required

The HHA and Quicksilver kit: drop cloth, marker, zip lock bags, and containers.

4. Site Prescreening

Use the HazmatID to prescreen bulk powders for protein.

5. Sample Collection – Method A

1. Identify 2 trained individuals as ***Facilitator*** and ***Sampler*.**
2. *Facilitator* lays drop cloth and removes all kit contents; assign unique sample ID number to sample collection containers.
3. Perform basic field screening on material prior to sample collection to assess explosive, radiological, or acute chemical hazards. Record results on screening form.
4. *Facilitator* completes the Chain of Custody form.
5. If a source of the powder is present (i.e. letter or small package), ***Facilitator*** holds open and positions pre-labeled "PRIMARY SOURCE" bag next to the source.
6. *Sampler* gently places the source into the plastic bag, making sure all writing and markings are visible through the bag. **Note:** Take digital photograph of the source.
7. *Facilitator* seals bag and places it into another plastic bag, then puts that bag into a sample transport container (i.e. 1 gal sealable bag or container) for decontamination.


8. ***Facilitator*** removes and hands HHA kit laminated card to ***Sampler.***
9. The ***Facilitator*** opens the swab container; ***sampler*** removes swab from container while the facilitator holds the swab container.
10. ***Sampler*** holds the laminated card at an angle on the surface next to the powder. **Note 1:** Smooth surface, use card to make pile on surface. **Note 2:** Rough surface, use swab to pile powder on laminate card.
11. ***Sampler*** places swab into the HHA aqueous solution, breaks off the swab tip, and closes the container.

12. ***Facilitator*** opens sample container labeled "POWDER SAMPLE" and hands it to ***sampler*** for later use.
13. ***Facilitator*** places sealed swab container into plastic bag labeled "DRY SWAB"; ***facilitator*** seals bag and places it into the sample transport container for decontamination.

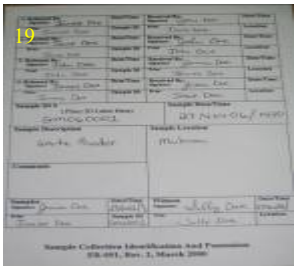
14. ***Sampler*** holds the sample collection container on its side and gently (prevent aerosolization) places laminated card (with the powder on top) into the sample collection container labeled "POWDER SAMPLE."
15. ***Sampler*** seals the bag or places the lid it on the sample collection container (if it is a jar) comprising of the laminated card and dry, bulk powder; ***sampler*** places the closed, pre-labeled container, in the plastic bag, held open by the ***facilitator***.
16. ***Facilitator*** seals bag and places it into a sample transport container for decontamination.

OR

17. If the pile of powder is too large to collect it all, using a single laminated card and swab, repeat steps 8 through 16 with a new card, swab and pre-labeled sample collection container.

18. ***Facilitator*** decontaminates the sample transport containers for each of the samples with a bleach solution; the rinsate should be collected into a container labeled "BIOHAZARD WASTE." ***Facilitator*** places each of these decontaminated bags into separate self-sealing bags and seals the bags.

19. ***Facilitator*** and ***sampler*** move the samples to the cold zone and place the sealed bags into durable hard-sided outer containers sealing the container with evidence/tamper-proof tape. Transfer all sample collection data and notes to a new chain of custody form. Attach the chain of custody and seal to the container with evidence/tamper-proof tape before providing to the transporter. Notify the receiving lab of the sample shipment and inform them that the samples were collected in a method that complies with ASTM E2458-06.



Method B – Swab Sample Collection for On-site Analysis

1. ***Facilitator*** opens the HHA kit and removes the contents.
2. The ***facilitator*** removes the cap of the buffer solution and hands the buffer solution to the sampler.
3. The ***sampler*** removes the swab from the tube and places the swab into the buffer solution to moisten the swab. The ***sampler*** wipes the swab in a Z or S pattern over the sample area (approximately the size of the HHA instruction card) while rolling the swab to ensure maximum contact with the swab surface area.
4. The ***sampler*** places the swab into the buffer solution vial, breaking off the tip, and shaking for 30 sec. Continue following the HHA instructions for analysis.
5. The ***sampler*** pours the buffer solution containing the swab into the sample vial, closes the lid, and places the tube into a bag labeled "WET SWAB" which is held open by the ***facilitator***.
6. The ***facilitator*** seals the bag and places into a sample transport container for decontamination.
7. Continue with steps 17 and 18 from Method A.

6. Sample Prescreening

Use the HazmatID for pre-screening. This analysis may indicate the presence of protein.

7. Sample Analysis

After sample collection, the sample may be analyzed with the DoD hand-held assay, Joint Biological Agent Identification and Diagnostic System (JBAIDS), and the M1M. Additionally, the sample may be shipped to a lab for confirmation.

8. Sample Shipping

Contact applicable reach-back laboratory regarding proper sample shipment procedures. Refer to IATA procedures for shipping requirements.

9. References

- American Society for Testing and Materials (ASTM), *Standard Practices for Bulk Sample*
Collection and Swab Sample, E 2458-06
- NFPA 471 *Recommended Practice for Responding to Hazardous Materials Incidents*
- NFPA 472 *Standard for Professional Competence of Responders to Hazardous Materials Incidents*
- NFPA 1994 *Standard on Protective Ensembles for Chemical/Biological Terrorism Incidents*
- 49 CFR, Parts 171-180 *Hazardous Materials Regulations*
- 29 CFR, Part 1910.*120 Hazardous Waste Operations and Emergency Response, Final Rule*
- CPL 02-02-071 *Technical Enforcement and Assistance Guidance for Hazardous Waste Site and RCRA*
Corrective Action Clean-Up Operations
- HAZWOPER 1910.120 (b)-(o) *Directive*
- Handbook of Forensic Services 2003, *FBI Laboratory Publication*
- U.S. AIR FORCE INSTRUCTION 10-2501, 24 JANUARY 2007, Operations. *AIR FORCE EMERGENCY MANAGEMENT(EM) PROGRAM PLANNING AND OPERATIONS*

AF CBRN Method	Description
AF CBRN Method C-A-1, V2 2007	Metals method for inhalation hazard using RADeCO air sampler, filter media and Niton XRF analysis.

1. Method Overview

This method is for analysis of metal particles in air using a RADeCO variable flow grab air sampler and select type and 4-inch filter media. This field analytical method is useful for the analysis of exposure assessment samples where laboratory analysis can not provide timely results. The method is non-destructive and can identify metals in air in their elemental or aerosol forms. The limit of dection (LOD) is based on air sample volume, and the LOD of the XRF. Since XRF result are provided in ug/cm^2 (mass per unit area), final results must be adjusted to mass reported (ug) by multiplying XRF readings by the surface area of the actual filter used. The required sampling time shown below is based on an established flow rate of 20 cfm. The target analytes and LOD table below is based on the following formula;
Volume of air required = (LOD-ug)/(1000ug/mg) *62cm^2/(OEL – mg/m^3).

2. Target Analyte(s): Target Analytes, XRF LOD, and Minimum Sampling Volume/Time

Metal	Flow Rate (cfm)	Time (min)	Volume (m^3)	LOD (ug/cm^2)	OEL (mg/m^3)	Required Vol (liters)
Ti	20	0.01	0.008	2.00	15.00	8
Cr	20	218.8	124.000	1.00	0.0005	124000
Mn	20	0.02	0.012	1.00	5.00	12
Fe	20	0.03	0.016	2.50	10.00	16
Co	20	1.09	0.620	1.00	0.10	620
Ni	20	0.11	0.062	1.00	1.00	62
Cu	20	0.08	0.047	0.75	1.00	47
Zn	20	0.02	0.009	0.75	5.00	9
As	20	0.19	0.105	0.85	0.50	105
Se	20	0.55	0.310	0.50	0.10	310
Br	20	0.39	0.221	2.50	0.70	221
Os	20	136.7	77.500	2.50	0.0020	77500
Pt	20	109.4	62.000	2.00	0.0020	62000
Pb	20	3.28	1.860	1.50	0.05	1860
Hg	20	0.03	0.016	0.50	2.00	16
Rh	20	0.82	0.465	0.75	0.10	465
Sr	20	0.02	0.009	0.75	5.00	9
U	20	1.09	0.620	2.00	0.20	620

Review all personal and swipe (grab) sampling results, and associated documentation to determine if personnel have been overexposed above the OEL. Key determinations to be made:

- Are results applicable to current operations
- Do ambient particulates present a potential for overloading the filter
- Are required controls in place
- (e.g. administrative, mechanical, or personal)
- Are procedures being followed/utilized
- Is PPE in satisfactory condition
- Inspected/maintained and within the operational area
- Are there alternate routes of exposure
- Applicability, frequency, or need for sampling

5. Sample Collection

Document all sampling data. Any problems encountered during the sample period should be recorded (e.g. logbook.) The following information must also be recorded for all air samples:

- Sample location or name of employee
- Date of sampling
- Start and stop times, total minutes sampled, and sample volume
- Sample identification number
- Part and serial numbers
- Calibration data (sample flow rate)
- Weather conditions such as temperature, barometric pressure, wind, and rain
- Activities near the sampling site
- Direct reading instrument readings (as appropriate)

Take a sufficient number of samples to obtain a representative estimate of exposure. Contaminant concentrations vary seasonally, with weather, with production levels, and in a single location or job class. The number of samples taken depends on the error of measurement and differences in results. Consult the *NIOSH Occupational Exposure Sampling Strategy Manual* (http://www.cdc.gov/niosh/pdfs/77-173.pdf) and the Bioenvironmental Engineering Field manual and Technical guide appendixes for further information.

Sampling and Preparation:

- Using the sample placement template shown in Figure 1 below, scribe required sampling points on the filter to be used

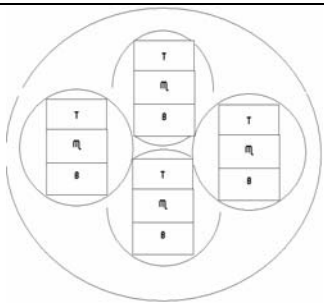


Figure 1: Each of the 4 sample areas scribed within the 101mm filter media represents the correct placement of the XRF meter. (XRF windows identified as M, T,and B are 2 cm x 1 cm)

- Place 4in filter in holder.
- Screw filter holder into pump.
- Calibrate pump.
- Set flow rate to 20 CFM.
- Connect the unit to a compatible power source.
- Run sample based on the time required from section 2 above based on target analyte, or for a minimum of 5 min for most hazards. Longer run times may be required to achieve lower detection limits for Cr, Os, and Pt.

Note: According to manufacture's specifications, during the first five minutes of operation, an increase in flow will be indicated and it will be necessary to turn the "ADJUST" potentiometer counter-clockwise to reduce the flow back to its initial setting. This is due to temperature vs. performance characteristics of the blower. In abnormal ambient airborne particulate environments make flow adjustments as needed. The maximum flow of each model is dependent upon the area and type of filter media used.

- Once sampling is complete, use the forceps to transfer the filter paper to the filter sleeve placing it within the 101mm cutout in the thin cardboard encased in plastic and seal.
- Start the XRF and allow for sufficient warm-up and self calibration.
- Follow manufacture's instructions regarding thin film standards.

6. Sample Prescreening

Select a solid clean surface to lay the filter paper on when taking readings. Take readings on the surface of the area to determine the presence of background materials. Subtract these readings from any like readings found on the filter as required.

7. Sample Analysis

Place the sealed filter onto solid clean surface. Place XRF meter on the filter paper and align survey window with the sample areas drawn on the filter. Follow the following sample procedures for each of the four sample areas indicated below.

- Analyze the middle of the sample area first as shown (see Figure 2, M).
  - Allow the instrument to take a one source-minute reading (This may take longer than one real-time minute, depending upon the source strength). A one source-minute reading will assure the accurate specific shell reading necessary for the analysis of air filter samples.
- Analyze the filter sample at the top of the sample area for one source minute (see Figure 2, T).
- Analyze the filter sample at the bottom of the filter for one source minute (see Figure 2, B).
- Repeat for each of the 4 sections.

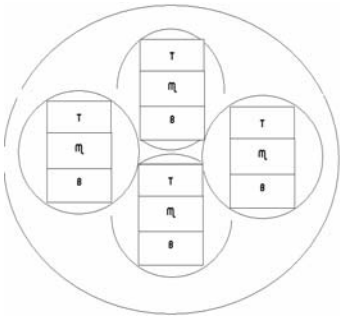


Figure 2: Analysis of a 4 inch (101mm) filter paper using the XRF

The instrument software uses an algorithm that converts the three readings to non-weighted average analytical result in µg/cm^2 of (e.g., lead) metal per sample. This result will be displayed following the third filter reading. Determine the mass concentration per area for metals detected within each of the 4 survey sampling areas on the filter.

Determine the mass concentration per area for metals detected within each of the survey sampling points. Average these results to determine the mass concentration in µg/cm^2.

Mass per cm^2 = [(R1)µg/cm^2 + (R2) µg/cm^2 + (R3)µg/cm^2 +(R4) µg/cm^2]/4 = (mass)µg/cm^2

Determine area of the filter:

Radius = 1.75 in when accounting for 0.25 inches covered by holder
Area= 3.14 x (1.75 in x 2.54 cm/1 in)^2
Area = 62 cm^2

Determine the total mass by multiplying the measured results by the area of the filter:

Example: 10 ug/cm^2 of Lead x 62 cm^2 = 620 ug of Lead mass

Convert flow rate from cubic feet to m3

m3 = cubic feet x 0.283

Volume m^3 = (flow rate (cfm) x 0.283) x time (minutes)

Example: Volume m^3 = (20 x 0.283) x 10 = 56.6 m^3

Determine the mass per volume of air sampled:

$$Concentration(ug/m3) = \frac{mass.reported}{Actual.volume.sampled}$$

Example: Lead = $\frac{620ug}{56.6m^3} = 11ug/m3$

AF CBRN Method	Description
AF CBRN Method C-A-2, V2 2007	Metals method for inhalation hazard using the XMX portable sampler with dry cartridge filter and Niton XRF analysis.

1. Method Overview

This method is for analysis of metal particulates in air using a grab air sampler and select type and size filter media. This field analytical method is useful for the analysis of exposure assessment samples where laboratory analysis can not provide timely results. The method is non-destructive and can identify metals in air in their elemental or aerosol forms. The limit of dection (LOD) is based on air sample volume, and the LOD of the XRF. Since XRF results are provided in ug/cm^2 (mass per unit area), final results must be adjusted to mass (ug) by multiplying XRF readings by the surface area of the actual filter used. When the flow rate on the XMX is set to 535 lpm, sampling time is shown below. The target analytes and LOD table below is based on the following formula; Volume of air required = (LOD-ug)/(1000ug/mg) *10.75cm^2/(OEL – mg/m^3).

2. Target Analyte(s): Target Analytes and LOD/LOQ

Metal	Flow Rate (lpm)	Time (min)	Volume (m^3)	LOD (ug/cm^2)	OEL (mg/m^3)	Required Vol (liters)
Ti	535	0.003	0.001	2.00	15.00	1
Cr	535	40.187	21.5	1.00	0.0005	21500
Mn	535	0.004	0.002	1.00	5.00	2
Fe	535	0.005	0.003	2.50	10.00	3
Co	535	0.201	0.11	1.00	0.10	108
Ni	535	0.020	0.01	1.00	1.00	11
Cu	535	0.015	0.008	0.75	1.00	8
Zn	535	0.003	0.002	0.75	5.00	2
As	535	0.034	0.02	0.85	0.50	18
Se	535	0.100	0.05	0.50	0.10	54
Br	535	0.072	0.04	2.50	0.70	38
Os	535	25.117	13.4	2.50	0.0020	13438
Pt	535	20.093	10.75	2.00	0.0020	10750
Pb	535	0.603	0.32	1.50	0.05	323
Hg	535	0.005	0.003	0.50	2.00	3
Rh	535	0.151	0.08	0.75	0.10	81
Sr	535	0.003	0.002	0.75	5.00	2
U	535	0.201	0.11	2.00	0.20	108

3. Equipment Required

XMX/2L–MIL AEROSOL SAMPLER

- Dry COTS filter: 37-mm diameter, 0.8-um pore size, mixed cellulose filter, in an open-faced cassette filter holder
- Dry Impingement Module
- Phillips #2 screwdriver (no longer than 7 inches)
- 110V/220VAC power supply

XLt 700 Series Analyzer with Miniture X-Ray Tube

- Filter sleeve
- Thin cardboard with 37mm diameter cut out, and encased between two pieces of clear plastic material (e.g. plastic zip lock bag)
- Sample placement template for scribing the exact sample points onto the filter
- Forceps
- Personal Protective Equipment if required

4. Site Prescreening

Review all personal and swipe (grab) sampling results, and associated documentation to determine if personnel have been overexposed above the OEL.

- Key determinations to be made:
    - Are results applicable to current operations
    - If ambient particulates present a potential for overloading the filter
    - Are required controls in place
        - (e.g. administrative, mechanical, or personal)
    - Are procedures being followed/utilized
    - Is PPE in satisfactory condition
        - Inspected/maintained and within the operational area
- Are there alternate routes of exposure
- Applicability, frequency, or need for sampling

5. Sample Collection

Document all sampling data. Any problems encountered during the sample period should be recorded (e.g. logbook.)

- The following information must also be recorded for all air samples:
- Sample location or name of employee
- Date of sampling
- Start and stop times, total minutes sampled, and sample volume
- Sample identification number
- Part and serial numbers
- Weather conditions such as temperature, barometric pressure, wind, and rain
- Work activity of employee
- Direct reading instrument readings (as appropriate)

Take a sufficient number of samples to obtain a representative estimate of exposure. Contaminant concentrations vary seasonally, with weather, with production levels, and

in a single location or job class. The number of samples taken depends on the error of measurement and variability in results. Consult the *NIOSH Occupational Exposure Sampling Strategy Manual* (http://www.cdc.gov/niosh/pdfs/77-173.pdf) and the Bioenvironmental Engineering Field manual and Technical guide appendixes for further information.

Sampling and Preparation:

- Using the sample placement template shown in Figure 1 below, scribe required sampling points on the filter to be used

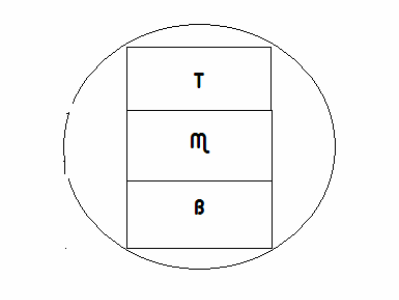


Figure 1: Scribed sample points for analysis of a 37-mm filter media using the XRF

- Install Dry Impingement Module (DIM).
  - Reference XMX/2L-MIL Operator's Manual 1.7, section 4.2
- Install Dry Filter Cartridge with scribed filter media.
  - Reference XMX/2L-MIL Operator's Manual 1.7, section 4.3
- Connect the unit to a compatible power source.
- Run sample based on the time required from section 2 above based on target analyte, or for a minimum of 5 min according to the manufacture's instructions. Longer run times may be required to achieve lower detection limits for Cr, Os, and Pt.
- Once sampling is complete, use the forceps to transfer the filter paper to the filter sleeve placing it within the 37-mm cutout in the thin cardboard and close plastic sleeve.
- Start the XRF and allow for sufficient warm-up and self calibration.
- Follow manufacture's instructions regarding thin film standards.

6. Sample Prescreening

Select a solid clean surface to lay the filter paper on when taking readings. Take readings on the surface of the area to determine the presence of background materials. Subtract these readings from any like readings found on the filter as required.

7. Sample Analysis

Place the sealed filter onto solid clean surface. Place XRF meter on the filter paper and align survey window with the sample areas drawn on the filter. Follow these sample procedures:

- Analyze the middle of the sample area first as shown (see Figure 2, M).
    - Allow the instrument to take a one source-minute reading (This may take longer than one real-time minute, depending upon the source strength). A one source-minute reading will assure the accurate specific shell reading necessary for the analysis of air filter samples.
- Analyze the filter sample at the top of the sample area for one source minute (see Figure 2, T).
- Analyze the filter sample at the bottom of the filter for one source minute (see Figure 2, B).

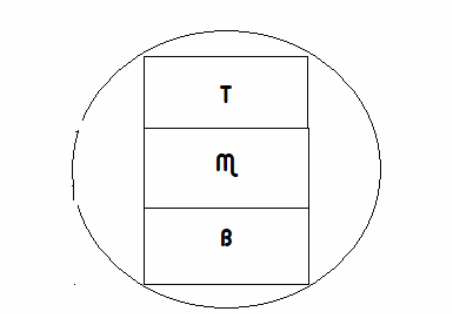


Figure 2: Analysis of a 37-mm filter paper using the XRF

Note: The instrument software uses an algorithm that converts the three readings to non-weighted average analytical result in µg/cm^{2}µg of (e.g. lead) metal per sample. This result will be displayed following the third filter reading. This is the mass concentration per area for metals detected on the filter shown in µg/cm^2.

Example: Lead 10 µg/cm^2

Convert 37-mm filter to cm: 37mm/10 = 3.75cm

Determine area of the filter:

Radius = 1.875 cm

Area= 3.14 x (1.875 cm)^2

Area = 10.75 cm^2

Determine the total mass by multiplying the measured results by the area of the filter:

Example: 10 ug/cm^2 of Lead x 10.75cm^2= 107.5ug of Lead mass reported

Convert volume from liters to cubic meter

$$\text{Volume } m^3 = \frac{\text{flow rate (lpm) X time (minutes)}}{1000}$$

Example: Flow rate of 535 lpm for 1 minute

$$\text{Volume}(m^3) = \frac{535 \times 1}{1000} = 0.535\ m^3$$

Determine the mass per volume of air sampled

$$Concentration(ug/m3) = \frac{mass.reported}{Actual.volume.sampled}$$

$$\text{Example: Lead} = \frac{107.5ug}{0.535m^3} = 201ug/m^3$$

8. Sample Shipping

Consult the *NIOSH Occupational Exposure Sampling Strategy Manual* (http://www.cdc.gov/niosh/pdfs/77-173.pdf) and applicable reach-back laboratory regarding proper sample shipment procedures for further information.

9. References

- Centers for Disease Control. (1977) *NIOSH Occupational Exposure Sampling Strategy Manual* (http://www.cdc.gov/niosh/pdfs/77-173.p df).
- *2007 TLVs and BEI.* American Conference of Governmental Industrial Hygienist.
- AFOSH Standard 48-8 (1997). *CONTROLLING EXPOSURES TO HAZARDOUS MATERIALS;* http://www.e-publishing.af.mil/pubfiles/af/48/afoshstd48-8/afoshstd48-8.pdf
- *NIOSH Occupational Exposure Sampling Strategy Manual* (http://www.cdc.gov/niosh/pdfs/77-173.pdf).
- NITON Xli 700 Series Environmental Analyzer User's Guide
- DYCOR Technologies XMX/2L-MIL Operator's Manual Version 1.7

AF CBRN Method	Description
CBRN-C-2-A-3, V2 2007	Metals method for inhalation hazard using air sampling pump and cassette with Niton XRF analysis.

1. Method Overview

This method is for metals analysis in air samples using 37mm cellulose cassettes. This field analytical method is useful for the analysis of exposure assessment samples where laboratory analysis can not provide timely results. The method is non-destructive and can identify metals in air in their elemental or aerosol forms using X-Ray Fluorescence (Niton XRFxLt792). The limit of dection (LOD) is based on air sample volume, and the LOD of the XRF. Since XRF result are provided in ug/cm^2 (mass per area), final results must be adjusted to mass reported (ug) by multiplying XRF readings by the surface area of the actual filter used. The target analytes and LOD table below is based on the following formula; Volume of air required = (LOD-ug)/(1000ug/mg) *10.17cm^2/(OEL – mg/m^3).

2. Target Analyte(s):

Metal	Flow Rate (lpm)	Time (min)	Volume (m^3)	LOD (ug/cm^2)	LOD (1000ug/mg)* Af	OEL (mg/m^3)	Required Vol (L)
Ti	2	0.7	0.001	2.00	0.02	15.00	1.4
Cr	2	10750	21.500	1.00	0.01	0.0005	21500
Mn	2	1.1	0.002	1.00	0.01	5.00	2.2
Fe	2	1.3	0.003	2.50	0.03	10.00	2.7
Co	2	53.8	0.108	1.00	0.01	0.10	107.5
Ni	2	5.4	0.011	1.00	0.01	1.00	10.8
Cu	2	4.0	0.008	0.75	0.01	1.00	8.1
Zn	2	0.8	0.002	0.75	0.01	5.00	1.6
As	2	9.1	0.018	0.85	0.01	0.50	18.3
Se	2	26.9	0.054	0.50	0.01	0.10	53.8
Br	2	19.2	0.038	2.50	0.03	0.70	38.4
Os	2	6718	13.438	2.50	0.03	0.0020	13437
Pt	2	5375	10.750	2.00	0.02	0.0020	10750
Pb	2	161.3	0.323	1.50	0.02	0.05	322.5
Hg	2	1.3	0.003	0.50	0.01	2.00	2.7
Rh	2	40.3	0.081	0.75	0.01	0.10	80.6
Sr	2	0.8	0.002	0.75	0.01	5.00	1.6
U	2	53.8	0.108	2.00	0.02	0.20	107.5

3. Equipment Required

- Mixed cellulose ester filter, 0.8-um pore size, 37-mm diameter, with cellulose back-up pad, in a open-faced cassette filter holder
- Personal sampling pump, 1-4 liters per minute with flexible sample tubing
- XLt 700 Series Analyzer with Miniture X-Ray Tube

    - Filter sleeve: thin cardboard with 37-mm diameter cut out, encased between two pieces of plasticacetate (Mylar™) (NITON, Bedford, MA, or equivalent). Note: The material must be transparent to X-ray.
        - two pieces of clear plastic material (e.g. plastic zip lock bag)
    - Sample placement template for scribing the exact sample points onto the filter
        - Forceps
- Personal Protective Equipment if required

4. Site Prescreening

Review all personal and swipe (grab) sampling results, and associated documentation to determine if personnel have been overexposed above the OEL.

- Key determinations to be made:
    - Are results applicable to current operations
    - If ambient particulates present a potential for overloading the filter
    - Are required controls in place (e.g. administrative, mechanical, personal)
    - Are procedures being followed/utilized
    - Is PPE in satisfactory condition
        - Inspected/maintained and within the operational area
- Are there alternate routes of exposure
- Applicability, frequency, or need for sampling

5. Sample Collection

Collect sample for time listed in above table based on flow rate and volume.

6. Sample Prescreening

- Using the sample placement template shown in Figure 1 below, scribe required sampling points on the filter to be used.

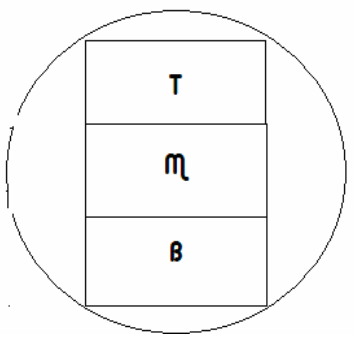


Figure 1: Scribed sample points for analysis of a 37-mm) filter media using the XRF

- Calibrate each sampling pump with a representative sampler in line.
- Sample at an accurately known flow rate (1 to 4 L/min) for a total sample size of approximately 1000 L. Do not exceed a filter loading of 2 mg total dust.
- With forceps, transfer the MCE filter without the backup pad to a filter sleeve and seal the plastic.

Note: Take special care when removing the filter from the backup pad to avoid loss of lead- containing dust.

- Start the XRF and allow for sufficient warm-up and self calibration.
- Follow manufacture's instructions regarding thin film standards.

7. Sample Analysis

Place the sealed filter onto solid clean surface. Place XRF meter on the filter paper and align survey window with the sample areas drawn on the filter. Follow the following sample procedures for each of the four sample areas indicated below.

- Analyze the middle of the sample area first as shown (see Figure 2, M).
    - Allow the instrument to take a one source-minute reading (This may take longer than one real-time minute, depending upon the source strength). A one source-minute reading will assure the accurate specific shell reading necessary for the analysis of air filter samples.
- Analyze the filter sample at the top of the sample area for one source minute (see Figure 2, T).
- Analyze the filter sample at the bottom of the filter for one source minute (see Figure 2, B).
- Repeat for each of the 4 sections.

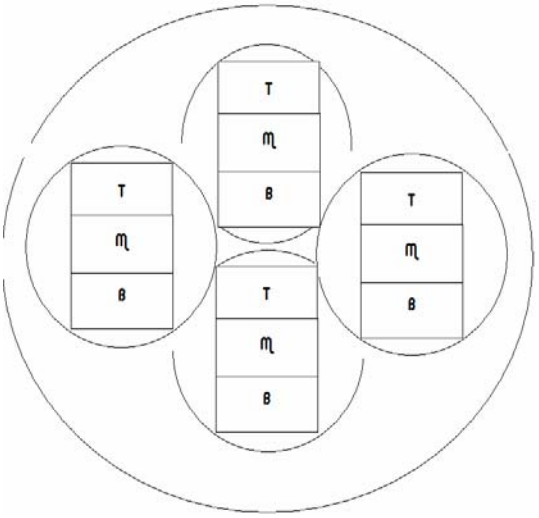


Figure 2: Analysis of a 4 inch (101mm) filter paper using the XRF

The instrument software uses an algorithm that converts the three readings to non-weighted average analytical result in µg/cm^2 of (e.g., lead) metal per sample. This result will be displayed following the third filter reading. Determine the mass concentration per area for metals detected within each of the 4 survey sampling areas on the filter.

Determine the mass concentration per area for metals detected within each of the survey sampling points. Average these results to determine the mass concentration in µg/cm^2.

Example: Lead 10 µg/cm^2

Convert 37-mm filter to cm: 37mm/10 = 3.75cm
Determine area of the filter:

Radius = 1.875 cm
Area= 3.14 x (1.875 cm)^2
Area = 10.75 cm^2

Determine the total mass by multiplying the measured results by the area of the filter:

Example: 10 ug/cm^2 of Lead x 10.75cm^2=
107.5ug of Lead mass reported

Convert volume from liters to cubic meter

$$\text{Volume } m^3 = \frac{\text{flow rate (lpm) X time (minutes)}}{1000}$$

Example: Flow rate of 2 lpm for 1 minute

$$\text{Volume}(m^3) = \frac{2 \text{ X } 1}{1000} = 0.002\ m^3$$

Determine the mass per volume of air sampled

$$Concentration(ug/m3) = \frac{mass.reported}{Actual.volume.sampled}$$

$$\text{Example: Lead} = \frac{107.5ug}{0.002m^3} = 53.75mg/m^3$$

8. Sample Shipping

NA

9. References

- United States Air Force. (1997). *Controlling Exposures to Hazardous Materials;* AFOSH Standard 48-8. http://www.e-publishing.af.mil/pubfiles/af/48/afoshstd48-8/afoshstd48-8.pdf
- United States Environmental Protection Agency. *National Ambient Air Quality Standards (NAAQS).* http://www.epa.gov/air/criteria.html
- United States department of Labor (Occupational Safety and Health Administration, 1997). *29 CFR 1910.1000, TABLE Z-3 Mineral Dusts.* *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9994*
- Hach, DREL 2400 Complete Water Quality Laboratory – HACH method 8006

AF CBRN Method	Description
CBRN-CB-A-4, V1 2007	Sample collection of airborne particulate matter (PM_{10}) aerosols in aerodynamic diameter of particles of 10 micrometers or less.

1. Method Overview

The following method was developed using 886H supplies. The XMX/2L–MIL Aerosol Sampler is used for airborne sample collection of PM_{10} aerosols using a liquid impinger. Sample analysis is performed using the HACH, DREL 2400 Complete Water Quality Laboratory and Hach method 8006, Suspended Solids (photometric.) The limit of detection (LOD) is determined by air sample volume, water sample analysis volume, and Hach instrument LOD. The photometric result is then calculated to compare with the United States EPA, National Ambient Air Quality Standards (NAAQS) of 150 ug/m^3 of aerosolized particulate matter. The method parameters are designed to include this standard within its range for comparability.

2. Target Analyte(s):

Airborne particulate matter (PM_{10}) aerosols.

3. Equipment Required

1. XMX/2L–MIL Aerosol Sampler
2. Hach, DREL 2400 Complete Water Quality Laboratory with HACH method 8006.
3. 1 liter of deionized water
4. 25 milliliter sample cell (vial)
5. 25 milliliter graduated cylinder

4. Site Prescreening

None.

5. Sample Collection

1. Perform XMX/2L–MIL Aerosol Sampler preparation and functional check-out per manufacture's direction.
2. Collect a 5 minute air sample with XMX/2L–MIL Aersol Sampler at 800 lpm in the liquid impinger using deionized water solution (Refer to manufacture's directions).

6. Sample Prescreening

None.

7. Sample Analysis

1. Pour entire contents of 5 milliliter sample collected into a clean and empty 25 milliliter sample vial and add 20 milliliters of deionized water (dilution) from graduated cylinder for required sample volume for analysis per Hach method 8006.
2. Follow Hach method 8006 directions and perform photometric measurement.
3. Take Hach measurement result in mg/L and perform the following calculation to determine airborne concentration of PM_{10}.

$$\frac{\text{(Hach result in mg/L)} \times 0.025\ \text{L (water sample volume)} \times 1{,}000\ \text{ug/mg} \times 1{,}000\ \text{L/m}^3}{535\ \text{lpm (flow-rate)} \times 5\ \text{mins (airborne sample time)}} = ?\ \text{ug/m}^3$$

4. Compare calculated result (ug/m^3) with NAAQS standard of 150 ug/m^3.

Note: Range of measurement is from 9.35 ug/m^3 – 7,009 ug/m^3 for a 5 minute air sample and sample dilution of 20 milliliters of deionized water only. Photometric result of 16 mg/L equates to 150 ug/m^3.

8. Sample Shipping

NA

9. References

- United States Air Force. (1997). *Controlling Exposures to Hazardous Materials;* AFOSH Standard 48-8. http://www.e-publishing.af.mil/pubfiles/af/48/afoshstd48-8/afoshstd48-8.pdf
- United States Environmental Protection Agency. *National Ambient Air Quality Standards (NAAQS).* http://www.epa.gov/air/criteria.html
- United States department of Labor (Occupational Safety and Health Administration, 1997). *29 CFR 1910.1000, TABLE Z-3 Mineral Dusts. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9994*
- Hach, DREL 2400 Complete Water Quality Laboratory – HACH method 8006

AF CBRN Method	Description
C-A-5, V1 2007	Sample collection and analysis (screening) of airborne (inhalation) aerosol metal level(s) in air using XMX/2L–MIL Aerosol Sampler and Hach DREL/ 2400, Complete Water Quality Laboratory.

1. Method Overview

The following method was developed using HLD/PAM supplies. The XMX/2L–MIL Aerosol Sampler is used for airborne sample collection of metal aerosols using a liquid impinger. This field analytical method is useful for the analysis of exposure assessment samples where laboratory analysis can not provide timely results. Sample analysis is performed using the HACH, DREL 2400 Complete Water Quality Laboratory and various specific Hach metal method(s) as outlined in Target Analytes found in section 7 below. The limit of detection (LOD) is determined by air sample volume, water sample volume, and Hach instrument LOD. The result is then calculated and units converted so as to compare against the 8 hour Air MEG Standard and the American Conference of Governmental Industrial Hygienists, Threshold Limit Values (TLVs®).

2. Target Analyte(s):

Airborne metal particulate matter aerosols. See section 7 for more information.

3. Equipment Required

1. XMX/2L–MIL Aerosol Sampler
2. Hach, DREL/ 2400 Complete Water Quality Laboratory.
3. Deionized dilution water (amount required method dependent.)
4. Labware products for sample analysis (see individual Hach metal method(s) for more information.)
5. Personal Protective Equipment (e.g. aprons and etc.)

4. Site Prescreening

None.

5. Sample Collection

Background:

1. Perform XMX/2L–MIL Aerosol Sampler preparation and functional check-out per manufacture's direction.
2. Collect a 5 minute air sample (*true for most samples, see table 1 for proper sample time)* with XMX/2L–MIL Aerosol Sampler at 800 lpm on the liquid impinger using deionized water solution (refer to manufacture's directions).

6. Sample Prescreening

None.

7. Sample Analysis

Warning: *Several Hach methods require use of acids, other potential hazardous*

*chemicals and special equipment for metal analysis. Pay strict attention to method direction(s) and **always** use proper personal protective equipment.*

Target Analytes:

Substance	Hach Method	ACGIH TLV® (mg/m^3)	Result Minimum (mg/m^3)	Result Maximum (mg/m^3)
Arsenic	8013	0.01	0.000625	2
Barium	8014	0.5	0.00625	100
Beryllium	NA	0.002 (STEL 0.01)	NA	NA
Boron	10061	0.02 to 1.50	0.000125	75
Cadmium(1)	HCT 154	0.01	0.00005	37.5
Cadmium(2)	HCT 154	0.002 (R)	0.00005	37.5
Chromium (Cr^{6+})	8023	0.01	0.0000375	133.333
Chromium (Cr^{6+})	HCT 156*	0.01	0.0000375	133.333
Chromium (Total)	8024	0.5	0.0000625	70
Chromium (Total)	HCT 156*	0.5	0.0000375	133.333
Lead	8317	0.05	0.000125	7.5
Lead	HCT 152, PAR	0.05	0.0005	25
Manganese	8034	0.2	0.0005	250
Manganese	8149	0.2	0.0000175	250
Mercury	10065*	0.00025	0.0125	0.0125
Nickel	8037	See (3) below	0.0015	7.5
Nickel	8150	See (3) below	0.0000175	357.142
Nickel	HCT 167	See (3) below	0.000125	240
Silver	8120	See (4) below	0.0000625	70
Zinc	8009	ND	0.00005	250
Zinc	HCT 170, PAR	ND	0.000125	240

Review specific Hach method above, take analytical result (mg/L), and perform following calculation to determine airborne concentration (see note below):

$$\frac{\text{(Hach result in mg/L) x 5 ml (or other water sample volume)}}{\text{535 lpm (flow-rate) x 5 mins (airborne sample time)}} = ?\ mg/m^3$$

Compare calculated result (mg/m^3) with Air MEG and ACGIH TLV® standards above.

Notes:

* Some Hach methods require reduced sample volumes other than 5 ml collected by XMX for 5 mins. Results above reflect that minimum sample volume. Collect 5 ml sample volume as stated above, shake sample vigorously before pipetting/pouring reduced volume necessary per specific Hach method and perform calculation using actual volume sampled.

Use deionized water in addition to actual collected (5 ml sample) to make-up any required sample volume necessary for sample analysis. Example: Hach method requires a 10 ml sample for analysis and you collected 5 ml sample; add 5 ml of deionized water to make-up required volume for analysis. Ensure you mix combined sample volume by vigorous shaking sample container by hand before analysis begins.

Notes:

(1) No Hach method listed for DREL/2400 Complete Water Quality Laboratory.
(2) Elemental metal
(3) Cadmium compounds
(4) 1.5 mg/m^3 (Inh Fraction) for 7440-02-0, 0.2 mg/m^3 (Inh Fraction) for insoluble inorganic compounds, 0.1 mg/m^3 (Inh Fraction) for soluble inorganic compounds.
(5) 0.1 mg/m^3 (elemental metal) and (soluble compounds as Ag) 0.01 mg/m^3.

8. Sample Shipping

NA.

9. References

- American Conference of Governmental Industrial Hygienists, (2005). *Threshold Limit Values and Biological Exposure Indices.* ACGIH World Wide Signature Publications, Cincinnati, Ohio. http://www.acgih.org/home.htm
- United States Air Force, (1997). *Controlling Exposures to Hazardous Materials;* AFOSH Standard 48-8. http://www.e-publishing.af.mil/pubfiles/af/48/afoshstd48-8/afoshstd48-8.pdf
- United States Department of Labor, Occupational Safety & Health Administration. *29 CFR 1910.1000, TABLE Z-1 Limits for Air Contaminant.* *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992*
- Hach, DREL 2400 Complete Water Quality Laboratory

AF CBRN Method	Description
CBRN-R-W-1, V1 2007	Sample collection and analysis (screening) of alpha and beta particles in source drinking water.

1. Method Overview

The following screening method was developed using 886H and PAM team supplies. The ADM-300A multi-function survey meter combined with a filter method used for the analysis of drinking water can be used to identified alpha and beta particles in water. The water sample is filtered through a Millipore filter paper. Once filtered and dried, sample filters are measured using the ADM-300, alpha and beta probes to determine radioactivity. The activity result is then converted by formula into a measured result that can be compared to the maximum contamination level (MCL).

2. Target Analyte(s):

Alpha and beta radiation particles.

Limitations:

- The method is applicable to the measurement of alpha emitters having energies above 3.9 megaelectronvolts (MeV) and beta emitters having maximum energies above 0.1 MeV.
- The TSS concentration must be less than 2 mg/L to avoid solid overloading which could interfere with measuring alpha emissions.

3. Equipment Required

1. 47mm Millipore MF Filter, HAW(2 ea)
2. 47mm Millipore Petri dish with pad (2 ea)
3. Vacuum Pump (1 ea)
4. Incubator or oven if available (1 ea)
5. Labware to run filtration method (e.g. what is required to run MF method for coliform bacteria analysis)
6. Round tipped forceps (1 ea)
7. Deionized dilution water (2 liters)
8. ADM-300A Multi-Function Survey Meter with AP-100 (alpha) and BP-100 (beta) probes

4. Site Prescreening

Review any historical water sampling results for radiation measurements. Method may be limited by high suspended solids or turbidity.

5. Sample Collection

Background:

Sample preparation of source water is similar to the membrane filter method used in the analysis of colifom bacteria in potable drinking water. This method requires no preservation or storage requirements of collected water sample.

Detailed sample documentation is an integral part of the overall sampling program. The following information must be recorded for all samples:

- Date of sampling, sample time, and weather conditions
- Collected by and method used
- Sample volume and collection method (e.g. grab)
- Sample identification number
- Sample location and sample source (e.g. well, lake or etc.)
- Direct reading instrument readings (as appropriate)

Note 1: Ensure sample collected is free of any sediment (e.g. do not muddy the source). Take a sufficient number of samples to obtain a representative estimate of the source.

Use clean and unused sample container during sample collection.
Collect a 1 liter representative sample from the source for analysis (do not use preservative).

6. Sample Prescreening

Sample cannot effectively be pre-screened with the ADM-300 since alpha and beta particles will not likely penetrate the water.

7. Sample Analysis

Warning: *Do not eat, drink, or smoke while performing this analysis or when handling radiation check sources. Always wash hands when finished.*

1. Prepare blank by filtering 1 liter of deionized water through 47 mm filter apparatus using vacuum pump. If deionized water is unavailable, use medical grade IV solution.
2. Drain off excess water and place filter on dry pad using rounded forceps (pad should be inside Petri dish already).
3. Wash filter apparatus before proceeding with next step.
4. Filter the sample through a second 47 mm filter and filter apparatus using a vacuum pump (do not tear filter paper). If vacuum pump is unavailable, filtration process will take longer.
5. Drain off excess water and place filter on dry pad using rounded forceps (pad should be inside Petri dish already).
6. Place Petri dishes inside Millipore Field Incubator for evaporation/drying at 55^0 C for 3 hrs. Do not use excessive heat which can melt the Petri dish).
7. Remove Petri dishes from incubator/oven and place on a clean, debris-free surface.
8. Start-up, perform operational check of the ADM- 300A (ensure instrument is calibrated) and alpha probes (each probe should be within the appropriate range indicated on the inside cover of the check source kit).
9. Place the alpha probe 1.0 cm above the Petri dish(s) and note the measurement in counts per minute (cpm). Allow the output to stabilize. Take a measurement for 60 sec (alpha). Subtract blank sample measurement (background) from source water results.
10. Calculate individual results (using below formulas) and compare to standards below.

Alpha: pCi/L = $\frac{A \times 1000}{0.5 \times 2.22 \times C \times V}$

A= net alpha rate minus background (cpm).

C= counting efficiency factor; 0.3 is a conservative estimate which is used for air sampling.

V= volume of sample collected (Liters).

0.5= factor used to correct from 2 pi efficiency to 4 pi efficiency

2.22= conversion factor from dpm/pCi

Perform the same method with the beta probe attached and use the following equation to estimate annual dose.

Beta: mrem/yr = $\frac{B \text{ (cpm/L)} \times 2 \text{ L/day} \times 365 \text{ days/yr}}{2400 \text{ cpm/mrad/hr}}$

B= beta radiation (cpm)
2 L/day and 365 days/yr= amount of water ingested each year
2400 cpm/mrad/hr= estimate for converting beta counts to dose
Equation assumes that radiation dose from 1 L of water is purged from body and there is no residual after 1 hour.

Public health standard (MCL) for gross alpha particles is (15 pCi/L) and for beta emitters is 4 mrems/yr. Zero is the goal per EPA.

If the gross alpha result is greater than 5 pCi/L, the filter should be recounted after 24 hours to discount the contribution from Radon progeny. Both results are relevant and should be recorded.

8. Sample Shipping

Contact applicable reach-back laboratory regarding proper sample shipment procedures.

9. References

United States Environmental Protection Agency (2000). 40 *CFR 141.1National Primary Drinking Water Regulations.* http://www.epa.gov/safewater/contaminants/index.html
EPA Method 900 – *Gross Alpha and Beta*

Appendix AB: Acronym List

ACGIH	American Conference of Governmental Industrial Hygienists
AEF	Air Expeditionary Force
AEGL	Acute Exposure Guideline Levels
AFH	Air Force Handbook
AFI	Air Force Instruction
AFIOH	Air Force Institute for Operational Health
AFMAN	Air Force Manual
AFMIC	Armed Forces Medical Intelligence Center
AFPAM	Air Force Pamphlet
AFRAT	Air Force Radiation Assessment Team
AFRMWO	Air Force Radioactive and Mixed Waste Office
AFTO	Air Force Technical Order
AFTTP	Air Force Tactics, Techniques and Practices
AICUZ	Air Installation Compatible Use Zone
AIHA	American Industrial Hygiene Association
AL	Action Level
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit of Intake
AMU	Atomic Mass Unit
ANSI	American National Standards Institute
AOC	Areas Of Concern
AOR	Area of Responsibility
API	Armor Piercing/Incendiary
AST	Above Ground Storage Tank
ASTM	American Society for Testing and Materials
ATFP	Anti-Terrorism Force Protection
ATG	Army Technical Guide
ATNAA	Antidote Treatment-Nerve Agent Autoinjector
BEIs	Biological Exposure Indices
BOD	Biochemical Oxygen Demand
BPDs	Backflow Prevention Devices
Bq	Becquerel (radiation unit)
BR	Breathing Rate
BW	Biological Warfare
CAM	Chemical Agent Monitor
CAS	Chemical Abstracts Service
CATM	Combat Arms Training and Maintenance
CBRN	Chemical, Biological, Radiological, and Nuclear
CBRNE	Chemical, Biological, Radiological, Nuclear, high-yield Explosive
CBW	Chemical and Biological Warfare
CCA	Contamination Control Area
CCPs	Critical Control Points
CDC	Center for Disease Control
CDS	Civil Defense Simultest
CE	Civil Engineer
CEF	Civil Engineer Fire Emergency Services

CEP	Civil Engineer Planning
CEV	Civil Engineer Environmental Flight
CEX	Civil Engineer Readiness and Emergency Management
CF	Compliance Factor
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CFU/ml	Colony Forming Unit/milliliter
CHART	Chemical Health Assessment and Risk Tool
CHEMRAT	Chemical Hazard Estimation Method and Risk Assessment Tool
CHPPM	Center for Health Promotion and Preventive Medicine
CHS	Compensated Heat Stress
CMR	Carcinogens, Mutagens, and Reproductive toxins
CMS	Dräger Chip Measurement System
COA	Course Of Action
CoC	Constituent Of Concern
COD	Chemical Oxygen Demand
ColPro	Collective Protection
COMAFFOR	The Commander, Air Force Forces
CONOP	Concept of Operations
COT NRC	Committee on Toxicology of the National Research Council
CSM	Conceptual Site Model
CWA	Chemical Warfare Agents
DAC	Derived Air Concentration
DBPs	Disinfection Byproducts
DE	Diatominaceous Earth
DF	Duty Factor
DFU	Dry Filter Unit
DIM	Dry Impingement Module
DL	Detection Limit
DNA	Deoxyribonucleic Acid
DNL	Day-Night Level
DoD	Department of Defense
DOE	Department of Energy
DOEHRS-IH	Defense Occupational and Environmental Health Readiness System-Industrial Hygiene
DOT	Department of Transportation
dpm	Disintegrations per Minute
dps	Disintegrations Per Second
DQOs	Data Quality Objectives
DU	Depleted Uranium
DWTP	Domestic Wastewater Treatment Plant
EBS	Environmental Baseline Survey
ECt	Effective Concentration Time
EHSA	Environmental Health Site Assessment
ELISA	Enzyme-Linked ImmunSorbet Assay
EM	Emergency Management
EMEDS	Expeditionary Medical Support
EOD	Explosive Ordnance Disposal

EPA	Environmental Protection Agency
EPDs	Electronic Personal Dosimeters
ERPG	Emergency Response Planning Guideline
ESOH-MIS	Environmental Safety Occupational Health Management and Information System
EUCOM	Headquarters United States European Command
FAC	Free-Available Chlorine
Far IR	Far-Infrared
Far UV	Far-Ultraviolet
FC	Fecal Coliform
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FGS	Final Governing Standards
FID	Flame Ionization Detector
FIDLER	Field Instrument for Detecting Low Energy Radiation
FITS	Fighter Index of Thermal Stress
FOTW	Federally Owned Treatment Works
FPCONs	Force Protection Conditions
FPO	Fleet Post Office
GEMS	Global Expeditionary Medical System
GHz	Gigahertz.; one GHz represents 1 billion cycles per second
GPS	Global Positioning System
GRR	Ground Radiological Reconnaissance
GSD	Geometric Standard Deviation
GWUDI	Ground Water Under the Direct Influence [of surface water]
HAZWOPER	Hazardous Waste Operations and Emergency Response Standard
HEPA	High Efficiency Particulate Air (filter)
HEU	Highly Enriched Uranium
HHA	Hand-Held Immunoassays
HLD	Homeland Defense
HPAC	Hazard Prediction and. Assessment Capability
HPC	Heterotrophic Plate Count
HPLC	High Performance Liquid Chromatography
HRA	Health Risk Assessment
HRM	Health Risk Management
HSS	Headspace System
HVAS	High Volume Air Sampler
HVL	Half-Value Layers
HW	Hazardous Waste
IC	Incident Commander
ICt	Incapacitating Concentration Time
IDLH	Immediately Dangerous to Life and Health
IMS	Ion Mobility Spectrometry
IND	Improvise Nuclear Device
IPE	Individual Protective Equipment
IRP	Installation Restoration Program
IWTP	Industrial Wastewater Treatment Plan
JBAIDS	Joint Biological Agent Identification and Diagnostic System

JSLIST	Joint Services Lightweight Integrated Suit Technology
LC	Lethal Concentration
LCt	Lethal Concentration Time
LD_{50}	Lethal Dose of 50% (one half) of a group of test animals
LDt	Lethal Dose
LEL	Lower Explosive Limit of contaminant
LEP	Laser Eye Protection
Leq	Equivalent-Continuous Sound Level expressed in dB
LOC	Levels Of Concentration
LOD	Limit Of Detection
LOQ	Limit of Quantification
lpm	Liters per minute
MBq	Megabecquerel
MCE filter	Mixed Cellulose Ester Filter
mCi	Millicurie
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	Method Detection Limits
MEGs	Military Exposure Guidelines
MeV	Mega-electronvolts
MGRL	Medical Global Reach Laydown Team
MNBC	Medical Nuclear, Biological, and Chemical
MOPP	Mission Oriented Protected Postures
MPE	Maximum Permissible Exposure (laser radiation)
MRDL	Maximum Residual Disinfectant Level
MRDLG	Maximum Residual Disinfectant Level Goal
mW	Milliwatt
MW	Megawatt
MW	Molecular Weight (mass of substance)
NAAQS	National Ambient Air Quality Standards
NARP	Nuclear Weapon Accident Response Procedures
NATO	North Atlantic Treaty Organization
NCRP	National Council on Radiation Protection and Measurements
NDI	Nondestructive Inspection
Near IR	Near infrared (infra-red region of the electromagnetic spectrum)
Near UV	Near ultraviolet (ultraviolet region of the electromagnetic spectrum)
NEPMU	Navy Environmental and Preventive Medicine Unit
NFPA	National Fire Protection Association
NHZ	Nominal Hazard Zone
NIMA	National Imagery and Mapping Agency
NIOSH	National Institute for Occupational Safety and Health
nm	Nanometer (wavelength)
NORTHCOM U.S.	Northern Command
NR	Noise Reduction
NRC	Nuclear Regulatory Commission
NTAs	Non-Traditional Agents
NTU	Nephelolometric Turbidity Units
OAQPS	Office of Air Quality Planning and Standards

OD	Optical Density
OEHSA	Occupational and Environmental Health Site Assessment
OEL	Occupational Exposure Limit
ORM	Operational Risk Management
PACOM	U.S. Pacific Command
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Prevention and Aerospace Medicine Team
PAR	Precession Approach Radar
PAVE PAWS	U.S. Air Force Space Command, Radar
PCBs	Polychlorinated biphenyls
PEL	Permissible Exposure Limit
PercVapor	Percutaneous Vapor
PFU/ml	Plaque-Forming Unit per milliliter
pg/mL	Picograms per milliliter
pH	Potential of Hydrogen
PID	Photoionization Detector
PM_{10}	Particulate Matter less than 10 microns in diameter
POTW	Publicly Owned Treatment Works
POU	Point of Use (water treatment systems)
PPE	Personal Protective Equipment
PRF	Pulse Repetition Frequency
psi	Pounds per Square Inch
PW	Pulse Width
RaAlm	Radiation Alarm Level
rad	Radiation Absorbed Dose
RADAR	Radio Detection And Ranging
RAM	Radioactive Material
RB	Reach Back Laboratory
RCRA	Resource Conservation and Recovery Act
RDD	Radiological Dispersal Device
REL	Recommended Exposure Limit (NIOSH)
RF	Radiofrequency
RfD	Reference Dose Data
RFR	Radio-Frequency Radiation
RIC	Radioisotope Committee
ROWPU	Reverse Osmosis Water Purification Unit
RPP	Respiratory Protection Program
RRF	Rotational Reduction Factor
SAE	Sampling and Analytical Error
SARS	Severe Acute Respiratory Syndrome
SCBA	Self-Contained Breathing Apparatus
SCPS	Survivable Collective Protection Systems
SEG	Similar Exposure Group(s)
SEL	Sound Exposure Level
STEL	Short Term Exposure Limit
STP	Standard Temperature and Pressure
TCNs	Third Country Nationals
TICs	Toxic Industrial Chemicals

TIMs	Toxic Industrial Materials
TLDs	Thermoluminescent Dosimeter
TLVs	Threshold Limit Values
TTHM	Total Trihalomethanes
TWA	Time Weighted Average
TWDS	Tactical Water Distribution System
UCL	Upper Confidence Level
UST	Underground Storage Tank
UXO	Unexploded Ordnance
VETCOM	U.S. Army Veterinary Command
VLSTRAK	Vapor, Liquid, and Solid Tracking
VOCs	Volatile Organic Chemicals
VSP	Visual Sample Plan
WBGT	Wet Bulb Globe Thermometer
WDS	Water Distribution System
WHO	World Health Organization
WMD	Weapon of Mass Destruction
WVA	Water Vulnerability Assessment