State of Hawaii, Department of Health

HEER Office

SECTION 9

SUPPLEMENTAL GUIDANCE FOR SELECT CONTAMINANTS OF CONCERN
INTERIM FINAL – APRIL 2014

Return to the Top of the Page

9.0 SUPPLEMENTAL GUIDANCE FOR SELECT CONTAMINANTS OF CONCERN

This section presents guidance for select contaminants frequently encountered in Hawai'i, including target pesticides at former agricultural facilities/fields as well as non-agricultural sites, and of target petroleum-related contaminants. Additional guidance on these contaminants is provided in the fall 2011 edition (and updates) of the Hawai'i Department of Health (HDOH) document *Screening for Environmental Hazards at Sites with Contaminated Soil and*

Groundwater (Environmental Hazard Evaluation [EHE] guidance [HDOH, 2016]). In the EHE guidance, refer specifically to:

- Volume 1, Chapter 2, Subsection 2.6: Contaminants of Potential Concern at Petroleum Release Sites.

- Volume 1, Chapter 2, Subsection 2.7: Contaminants of Potential Concern for Former Agricultural Lands.

- Volume 1, Chapter 4: Advanced Environmental Hazard Evaluations.

Section 9 also includes information on methane, background metals in soils, and methamphetamine laboratory cleanup.

Return to the Top of the Page

9.1 PESTICIDE CONTAMINATION AT FORMER AGRICULTURAL FACILITIES AND SITES

The Hazard Evaluation and Emergency Response (HEER) Office recommends that sites with known pesticide-related contamination and also those where pesticides were regularly applied be evaluated for residual contamination prior to re-development. "Pesticides" is a general term that includes any type of chemical mixture specifically formulated to kill "pests." Pesticides commonly used in Hawai'i include herbicides, fungicides and insecticides, the latter including termiticides and nematocides.

This section presents specific guidance regarding former sugarcane and pineapple operations because these were Hawai'i's most significant commercial agricultural crops during the 19th and 20th centuries. HDOH has created maps of former sugarcane lands in the Hawaiian islands in the early 20th century that can be accessed on the HEER Office soil arsenic information webpage. Between sugarcane and pineapple operations, these two industries cultivated as much as 250,000 acres of Hawai'i's farmlands (at the peak of production in the 1920s). However, it may be necessary to evaluate additional pesticides that could pose an unacceptable risk to human health and the environment. Large areas of former agricultural land are currently under consideration for residential and commercial development. Strategies for investigating former agricultural operations are discussed in Sections 3 and Section 4.

The criteria for selecting a target pesticide for a soil investigation is the potential for the pesticide to be present in soil at concentrations that pose potential direct-exposure hazards and/or leaching hazards. Factors that should be taken into account in selecting target pesticides for analysis include:

1. Known or suspected use
2. Application rate and duration of application
3. Environmental persistence (e.g., resistance to chemical and biological breakdown)
4. Nature of potential environmental hazards
5. Availability of toxicity and physiochemical data
6. Availability of commercial laboratory test methods

Investigations of former field areas should focus on pesticides and related contaminants that are persistent, toxic, and pose potential direct-exposure hazards for future residents and workers (e.g., dioxins, arsenic, organochlorine pesticides, etc.). Conditions in pesticide mixing and storage areas are much more uncertain, however. In addition to direct-exposure hazards, contamination could also pose leaching hazards and subsequent contamination of underlying groundwater resources (e.g., triazine pesticides and fumigants). This generally requires that the full range of pesticides be screened in these areas, and that all potential environmental hazards be fully evaluated in an Environmental Hazard Evaluation report (refer to Sections 3 and Section 13).

Although specifically directed to former sugarcane and pineapple operations, the approaches described in this section can be modified for investigation of lands that may have been impacted by cultivation of other agricultural crops, including macadamia nuts, coffee, and vegetables, as well as commercial pest control operations.

In 2011 the HEER Office prepared a summary of pesticide data for environmental investigations carried out for fields, mixing areas, seed dipping vats and various other sugarcane operations across Hawai'i (HDOH, 2011d). An overview of the report is provided in Subsection 9.1.4.

Return to the Top of the Page

9.1.1 TARGETED OPERATIONS

Table 9-1 identifies specific areas of sugarcane and pineapple operations to target for investigation. Operations are divided into field areas and various non-field areas. Pesticide mixing and other areas that could contain localized but heavy contamination should be investigated separately from field areas (refer to Section 3). In this way, field areas may be quickly screened and, ideally, cleared of contamination concern while closer investigation of smaller areas is carried out. Bagasse pile and cane wash discharge areas should be tested for the same suite of target pesticides as field areas.

Return to the Top of the Page

9.1.2 TARGET PESTICIDES AND RELATED CONTAMINANTS

Categories of pesticides and related contaminants associated with sugarcane and pineapple cultivation in Hawai'i are shown in Tables 9-2 and 9-3, respectively. These typically are grouped based on laboratory analytical methods, as follows, rather than by type of application:

- Organochlorine pesticides

- Organophosphorus pesticides

- Triazine pesticides

- Chlorinated herbicides

- Carbamates

- Fumigants

- Dioxins/furans

- Heavy metals (primarily arsenic, lead & mercury)

- Petroleum (e.g., Total Petroleum Hydrocarbons (TPH) (middle distillates), often used as a vehicle, or carrier oil, for application of pentachlorophenol, EDB, DBCP and other pesticides)

- Other (pentachlorophenol, etc.)

Appendix 9-A identifies pesticides (and related contaminants) known or suspected to have been used for agricultural purposes, and presents criteria for evaluating specific pesticides for further consideration. The list is based primarily on review of historical documents related to sugarcane and pineapple cultivation (e.g., Hanson 1959, 1962; HDOA 1969, 1977, 1987, 1989, USDA 2000). Few records exist prior to the late 1960s; therefore pesticide use prior to that time is uncertain. Rapid growth in the synthetic organic chemical industry began during the 1930s and 1940s. Prior to World War II, most pesticides were inorganic chemicals and naturally occurring plant extracts (Newman 1978), with the most common being arsenical compounds (Sheets 1980) and sulfur and mercury compounds (Newman 1978). In particular, arsenical compounds are known to have been used in sugarcane cultivation in Hawaiʻi in the 1920s through the 1940s, when up to 200,000 acres of land in Hawaiʻi was being used for sugarcane cultivation.

Return to the Top of the Page

Table 9-1 Example Target Areas for Investigation of Potential Pesticide Contamination

Areas of Concern	[1]Target Pesticide Groups
Sugarcane Operations	
[2]Fields	Heavy metals (arsenic only), organochlorine pesticides
Pesticide mixing areas	Carbamates, chlorinated herbicides, dioxins/furans, heavy metals (arsenic, lead, and total mercury), organochlorine pesticides, organophosphorus pesticides (known spill areas only), semivolatile organic compound (SVOCs), triazine pesticides, Total Petroleum Hydrocarbons (TPH) (middle distillates)
Seed dipping areas	Fungicides (benomyl and propiconizole [carbamates], total mercury)
[3]Settling ponds	Heavy metals (arsenic only), organochlorine pesticides
[3]Bagasse piles	Heavy metals (arsenic only), organochlorine pesticides

Areas of Concern	[1]Target Pesticide Groups
Pesticide container disposal areas	Carbamates, chlorinated herbicides, dioxins/furans, heavy metals (arsenic, lead, and total mercury), organochlorine pesticides, organophosphorus pesticides (known spill areas only), SVOCs, triazine pesticides, TPH (middle distillates)
Pineapple Operations	
[2]Fields	Heavy metals (arsenic only), organochlorine pesticides
Pesticide mixing areas	Carbamates, chlorinated herbicides, dioxins/furans, heavy metals (arsenic and lead), organochlorine pesticides, organophosphorus pesticides (known spill areas only), SVOCs, triazine pesticides, volatile organic compound (VOCs), TPH (middle distillates)
Seed dipping areas	Fungicides (benomyl and propiconizole [carbamates])
Pesticide container disposal areas	Carbamates, chlorinated herbicides, dioxins/furans, heavy metals (arsenic and lead), organochlorine pesticides, organophosphorus pesticides (known spill areas only), SVOCs, triazine pesticides, VOCs, TPH (middle distillates)
[3]**Other Potential Areas of Concern**	
Air Strip mixing and storage areas	Same as for pesticide mixing areas
Drainage ditches	Site specific depending on areas drained (e.g., pesticide mixing areas, seed dipping vats, cane wash, etc.)
Plantation camp	Site-specific
Maintenance facilities	Site-specific
Transformer pads	Polychlorinated biphenyls (PCBs); total petroleum hydrocarbons (TPH) as mineral oil
Rail lines	Same as fields

Areas of Concern	[1]Target Pesticide Groups
Notes 1. Categorized by laboratory method used for analysis. Refer to Appendix 9-B and Appendix 9-C for specific pesticides. 2. Dioxins removed as potential contaminant of concern for former sugarcane field areas based on 2011 HEER Office review (see Section 9.1.4). 3. See Tables 9-2 and 9-3. Testing for full suite of pesticides listed recommended for any areas that may have been impacted by runoff or discharges from a pesticide mixing area (e.g., mill ditches, settling ponds, areas of canewash discharges, bagasse piles, etc.).	

Several pesticides were banned or discontinued after the 1960s (e.g., dichloro-diphenyl-trichloroethane [DDT] in 1972). For the purposes of the target pesticide tables, it is assumed that use of these pesticides in Hawaiʻi ended at that time. However, it is possible that these pesticides may have continued to be used at a given site (e.g., use of existing supplies, etc.). Additional pesticides may have been used in some areas, but the appended list is considered to capture pesticides that would drive the need for remedial actions. Petroleum products, such as diesel fuel (middle distillates), were used to prepare some pesticide mixtures as carrier oils and may need to be included in the site investigation. See also Subsection 9.2 for a discussion of petroleum contaminated sites.

Herbicides are the primary pesticide of potential concern for former sugarcane lands in Hawaiʻi (i.e., weed killers). Insect control (i.e., insecticides) on sugarcane fields historically has been primarily through biological control methods (i.e., predator species). The overall use of insecticides by the Hawaiʻi sugar industry historically has been very low (less than one half of one percent of total crop protection chemical usage), and it is unlikely that residues from past applications or handling/storage of insecticides would be of concern at a site used only to cultivate sugarcane. In many cases, the use of insecticides would have been counterproductive, since they could impact the desirable predator species as well as the target species.

Pesticides that are contaminants of potential concern in field and non-field areas are presented in Appendix 9-B and Appendix 9-C. For former field areas, the emphasis is on pesticides and related compounds that are persistent and primarily pose direct-exposure hazards (e.g., vs. leaching hazards).

The assumed persistence of other pesticides is based on published half lives in soil (refer to Appendix 9-A). A pesticide is considered to be highly persistent if the published half life exceeds one year or if the half-life exceeds 100 days and sorption coefficient is greater than 3,000 cubic centimeters per gram (cm³/g) (default cutoff for "mobile" vs. "nonmobile" contaminants; HDOH, 2016). All metals, as well as organochlorine pesticides and dioxins/furans fall into this category.

A pesticide is considered to be moderately persistent if the published half-life is between 30 and 100 days. A pesticide is considered to have low persistence if the expected half-life in soil is less than 30 days. Existing field data support this breakdown of anticipated pesticide persistence. The half-lives noted in Appendix 9-A are considered to be gross estimates only, but suitable for purposes of this guidance.

Information regarding pesticide application rates for field areas was not available for most pesticides at the time this guidance was prepared. Estimating long-term buildup of pesticides in soil was therefore not practical. Assumptions regarding likely application rates, likely persistence, and the time needed to exceed target action levels were used to screen out a small number of pesticides with relatively low toxicity from further consideration (refer to Appendix 9-B and Appendix 9-C).

Toxicity factors, physiochemical constants, and standard commercial laboratory test methods were not available for several pesticides at the time this guidance was published (refer to Appendix 9-A). These pesticides were excluded from further consideration. The majority of these pesticides were developed after the 1960s, when stricter regulations on pesticide formulations were put into effect. These pesticides are assumed to be less persistent and toxic than the broader list of pesticides selected for inclusion in site investigations and noted in the appendices.

Tables 9-2 and 9-3 summarize categories of pesticides that should be tested at former sugarcane and pineapple cultivation operations. The investigation of former field areas should focus on pesticides and associated contaminants that are highly persistent, as indicated, with an emphasis on arsenic and organochlorine pesticides (see Subsection 9.1.4). For non-field areas (mixing areas, storage areas, etc.), the investigation should focus on all pesticides with moderate to high persistence that may have been used or released at the site. Testing for the full suite of pesticides listed is recommended for any areas that may have been impacted by runoff or discharges from a pesticide mixing area (e.g., mill ditches, settling ponds, areas of canewash discharges, bagasse piles, etc.). Contaminants identified in initial, screening level investigations above laboratory reporting limits (e.g., neighborhood-size decision units) should be carried forward in more detailed investigations (e.g., lot-size decision units). Refer to Section 3 and Section 4 for additional information on sampling decision units and sampling strategies.

Return to the Top of the Page

Table 9-2 Summary of Target Pesticide Categories for Investigation of Former Sugarcane Operations

Laboratory Analytical Group[1]	Laboratory Analytical Method	Field Areas	Non-Field Areas[2]	Notes
Carbamates	8321	No	Yes	Test for benomyl and propiconazole at seed dipping operations (fungicides).
Chlorinated Herbicides	8151 or 8321	No	Yes	
Dioxins/furans	8280 or 8290	No	Yes	See footnotes.
Heavy Metals (Arsenic, Lead)	6010B/ 6020	Yes	Yes	Arsenic only in field areas.

Laboratory Analytical Group[1]	Laboratory Analytical Method	Field Areas	Non-Field Areas[2]	Notes
Mercury (elemental)	7471	No	Yes	Test for total mercury at seed dipping operations (fungicides).
Organochlorine Pesticides	8081 or 8270	Yes	Yes	Field areas: heptachlor Non-Field areas: heptachlor and trifluralin.
Organo-phosphorus Pesticides	8141 or 8270	No	No	Limited use. Include as contaminant of concern in known spill areas only.
Triazine Pesticides	8141 or 619M/ 8270	No	Yes	
Volatile Organic Compounds	8260	No	No	
Semi-Volatile Organic Compounds	8270	No	Yes	
Total Petroleum Hydrocarbons	8015M	No	Yes	Petroleum (e.g., diesel fuel) used as a base for applying some pesticides.
Notes:				

1. May differ from actual family of individual pesticides tested under noted laboratory method.

2. Testing for full suite of pesticides listed recommended for any areas that may have been impacted by runoff or discharges from a pesticide mixing area (e.g., mill ditches, settling ponds, areas of canewash discharges, bagasse piles, etc.).

Return to the Top of the Page

Table 9-3 Summary of Target Pesticide Categories for Investigation of Former Pineapple Operations

Laboratory Analytical Group[1]	Laboratory Analytical Method	Field Areas	Non-Field Areas[2]	Notes
Carbamates	8321	No	Yes	Test for benomyl and propiconazole at seed dipping operations (fungicides).
Chlorinated Herbicides	8151 or 8321	No	Yes	

Laboratory Analytical Group[1]	Laboratory Analytical Method	Field Areas	Non-Field Areas[2]	Notes
Dioxins/furans	8280 or 8290	No	Yes	See footnotes. PCP used to lesser extent in pineapple operations than sugarcane operations
Heavy Metals (Arsenic, Lead)	6010B/ 6020	Yes	Yes	Arsenic only in field areas.
Organochlorine Pesticides	8081 or 8270	Yes	Yes	
Organo- phosphorus Pesticides	8141 or 8270	No	No	Limited use. Include as contaminant of concern in known spill areas only.
Triazine Pesticides	8141 or 619M/ 8270	No	Yes	
Semi-Volatile Organic Compounds	8270	No	Yes	
Fumigants (Volatile Organic Compounds)	8260	No	Yes	
Total Petroleum Hydrocarbons	8015M	No	Yes	Petroleum (e.g., diesel fuel) used as a base for applying some pesticides.
Notes:				

1. May differ from actual family of individual pesticides tested under noted laboratory method.
2. Testing for full suite of pesticides listed recommended for any areas that may have been impacted by runoff or discharges from a pesticide mixing area (e.g., drainage ditches, settling ponds, etc.).

Soil action levels are provided in the EHE guidance for the majority of the pesticides listed in Appendix 9-C (HDOH, 2016). Follow the methodology presented in the HDOH EHE guidance to compile action levels for pesticides not currently listed in that guidance. At a minimum, site data should be compared to action levels for both direct exposure and leaching hazards. Soil action levels for a number of additional pesticides are included in the United States Environmental Protection Agency Regional Screening Level guidance (USEPA 2012b).

An evaluation of potential contaminant mobility in terms of vapor-phase or dissolved-phase (i.e., leachate) mobility in soil is important (refer to Appendix 9-B). Detailed discussions of contaminant mobility are provided in Volume 1 and Appendix 1 of the HDOH EHE guidance (HDOH, 2016); refer also to HDOH technical memorandum Use of laboratory batch tests to evaluate potential leaching of contaminants from soil (HDOH, 2007).

Pesticides classified as "volatile" in the HDOH EHE guidance are considered to be highly mobile in the vapor phase [Henry's number >0.00001 atmosphere cubic meters per mole (m³/mol)] and molecular weight <200 (see HDOH, 2016). Pesticides with organic carbon sorption coefficients (Koc) values less than 100 cm³/g are considered highly mobile in leachate. Pesticides with Koc values >100 cm³/g but <3,000 cm³/g are considered to be moderately mobile. Pesticides with Koc values greater than 3,000 cm³/g are considered to be essentially immobile. Metals are given a default mobility ranking of low, although the need to evaluate potential leaching hazards posed by metals should be considered on a site-by-site basis (refer to Sections 3 and 13; see also Subsection 9.1.4).

Return to the Top of the Page

9.1.3 DISCUSSION OF SELECT PESTICIDES

A summary of historical pesticide use for sugarcane and pineapple in Hawai'i is provided in the appendices to this section, including primary references for more detailed information. A brief discussion of select pesticides and pesticide groups is provided below. Additional information on arsenic, dioxins, and technical chlordane is provided in the HDOH EHE guidance document (HDOH, 2016, Volume 1, Chapters 2 and 4).

Return to the Top of the Page

9.1.3.1 FUMIGANTS

Fumigants used in pineapple cultivation to control nematodes began in the 1940s (HDOH 1985b; see Appendices 9-A and 9-B). Soil fumigants commonly used in Hawai'i include:

- 1,2-dibromo-3-chloropropane (DBCP);

- 1,2-dibromoethane (EDB);

- 1,3-dichloropropene (Telone);

- D-D (a mixture of 1,2-dichloropropane; 1,3-dichloropropene; and 2,3-dichloropropene);

- 1,2,3-trichloropropene (TCP; an impurity associated with D-D).

Fumigants were typically injected from four to fourteen inches below ground surface. DBCP and EDB have been detected in groundwater wells on O'ahu and Maui and have not been used since the mid-1980s (HDOH 1985, 1985c). 1,2,3-Trichloropropene (TCP) is an impurity associated with D-D and has also been detected in groundwater wells in the state (see HDOH 1985)

Fumigants are not likely to be persistent in field areas more than one year after use due to a propensity to volatilize into the atmosphere and degrade or be carried downward in leachate. Fumigants could, however, be a contaminant of concern in former pesticide mixing, storage or disposal areas. Soil vapor data collection is strongly recommended when investigating for these areas.

Return to the Top of the Page

9.1.3.2 ARSENIC

Appendix 9-E, Update to Soil Action Levels for Inorganic Arsenic and Recommended Soil Management Practices, contains detailed information on updated soil action levels for total inorganic arsenic, bioaccessible arsenic, and recommended soil management practices. Contact the HEER Office for further assistance if needed.

Historical Use

Arsenic-based pesticides are largely associated with sugarcane cultivation in Hawai'i during the 1910s through the 1940s. Various arsenic-based compounds were used as herbicides, insecticides and rodenticides in agricultural operations. The primary use was for weed control with respect to the overall volume stored, mixed and applied. The HEER Office has a dedicated webpage, Soil Arsenic Guidance and Information, which houses fact sheets, arsenic assessments throughout Hawai'i, maps and technical guidance for arsenic. Monosodium methane arsenate (MSMA) and sodium arsenite were used as herbicides during various stages of sugarcane cultivation (HDOA 1969). Arsenic was typically applied to surface soils by "poison gangs" using backpack sprayers. In addition, Canec, a building material made from sugarcane waste (i.e., bagasse) and used extensively in Hawai'i, was treated with calcium arsenate and arsenic acid as an anti-termite agent (NOAA 1990). The HEER Office fact sheet, Arsenic in Canec Ceilings and Wallboard in Hawai'i, provides an overview of the potential public health concerns associates with Canec (HDOH 2010b). Other arsenic-based pesticides include lead arsenite and lead arsenate, but it is unknown if these were used in Hawai'i.

Significantly elevated levels of total arsenic have been identified in a small number of former sugarcane fields in Hawai'i. Based on a review of pesticide data for former sugarcane operations, arsenic drives human health risk posed by residual pesticides in these fields (HDOH, 2011d, see Subsection 9.1.4). A brief discussion on public health concerns associated with arsenic is provided in HDOH's Arsenic in Hawaiian Soils: Questions and Answers on Health Concerns (HDOH, 2013).

Arsenic Bioaccessibility Tests

Because of extensive, historic use of arsenic-based pesticides in Hawai'i, soil samples collected at former agricultural sites should always be analyzed for total arsenic. The HEER Office recommends that a laboratory bioaccessibility test be carried out when the total arsenic concentration in the <2mm fraction of soil exceeds 24 mg/kg, the default, upper limit assumed for background arsenic in soil (see Appendix 9-E and HDOH, 2016). Soil action levels and categories specific to bioaccessible arsenic are included in Appendix 9-E. The bioaccessibility test and the associated action levels apply to the <250μm, fines fraction of soil.

Bioaccessible tests are used to estimate the fraction of total arsenic that could be stripped or "desorbed" from the soil following ingestion and thus made available for uptake. Arsenic that remains sorbed to the soil sample is considered to be unavailable for uptake and essentially non-toxic. Bioaccessibility should be tested and evaluated based on the gastric-phase, *in vitro* Solubility Bioaccessibility Research Consortium method ("SBRC" or "Drexler method"; Ruby 1996, 2001; Kelly 2002; Juhasz et al 2007). Studies have demonstrated that the SBRC assay

method provides the best predictive capability to swine *in vitro* bioavailability testing in comparison to other in vitro methods, such as the Physiologically Based Extract Test (PBET) method or the In-Vitro Gastrointestinal Method (IVG).(Juhasz et al 2009; Juhasz et al 2011). These studies concluded that a 1:1 relationship between swine arsenic bioavailability and bioaccessibility using the SBRC gastric-phase method could be estimated, without the need for a correction factor. A direct correlation between SBRC data and in vivo data was also observed in soil from Hawaiʻi that was included in a cynomolgus monkey study overseen by the University of Florida (Roberts et al 2007). In this study an average of 5.4% bioavailability was determined in the in vivo tests compared with an average SBRC-gastric phase bioaccessibility of arsenic in the same soil of 6.5%.

A higher confidence in the SBRC-gastric method over other approaches was also observed in suite of twenty arsenic contaminated soil samples from Hawaiʻi that were submitted to a Canadian laboratory (RMC, 2007). Three different bioaccessibility in vitro tests were evaluated, including SBRC, PBET and In Vitro Gastro-Intestinal (IVG) methods. The results demonstrated that the SBRC assay provided the highest estimate of bioaccessible arsenic of the gastric phase testing results, and consequently provides the most "protective" estimate of bioaccessibility of the three in vitro methods.

The SBRC bioaccessibility test is carried out on the <250μm fraction of dried soil separated from the original bulk sample by the laboratory. Under this method, one gram of the <250μm soil fraction is placed in 100ml of extraction solution intended to mimic human gastro-intestinal fluids and agitated for one hour. The concentration of bioaccessible arsenic in the soil sample is calculated by dividing the mass of arsenic that moves into the batch test solution by the mass of the sample. The percent bioaccessibility is calculated as the concentration of bioaccessible arsenic divided by the concentration of total arsenic reported for the same sample.

Both the total and bioaccessible concentrations of arsenic (mg/kg) in the <250μm fraction of the soil should be reported, even though the former may not be required as part of the bioaccessibility test. The percent bioaccessible arsenic, calculated as the concentration of bioaccessible arsenic divided by the concentration of total arsenic in the <250μm fraction, should also be reported. This will help confirm the test results and provide insight on possible enrichment of arsenic in the fine-grained fraction of contaminated soil.

The USEPA recommends a default bioavailability of 60% for arsenic in soil, based on a review of data for samples collected primarily on the mainland (USEPA 2012c). This default can be applied to the concentration of total arsenic reported for the <250μm soil fraction in lieu of a laboratory-based test if desired, provided that the total concentration of arsenic in this fraction does not exceed 160 mg/kg. This reflects the concentration of total arsenic in soil that would equate to the commercial/industrial action level for bioaccessible arsenic of 95 mg/kg and a bioaccessibility of sixty-percent. Laboratory-based bioaccessibility tests are recommended when the concentration of total arsenic in the <250μm soil fraction exceeds a concentration of 160 mg/kg.

Data compiled for Hawaiʻi suggest that bioaccessibility as well as bioavailability is unlikely to exceed this threshold for soils with low to moderate concentrations of total arsenic, regardless of iron content and other factors (e.g., Cutler 2011, HDOH, 2011c, Cutler et al 2013). Note that this default value is highly conservative for iron-rich, volcanic soils, where bioaccessibility is more typically less

than 30% and as low as 5%. The default factor should not be applied to total arsenic in the <2mm fraction of soil due to the potential for enrichment of metal concentrations in the fines.

Return to the Top of the Page

9.1.3.3 TECHNICAL CHLORDANE AND OTHER ORGANOCHLORINE PESTICIDES

Technical chlordane is a mixture of chlordane isomers (50-75%) and over 100 related compounds, including heptachlor and heptachlor epoxide (ATSDR 1994). Technical chlordane was used in Hawai'i in large quantities by pest control operators, lawn and garden services, and homeowners for the control of termites, armyworms, and other pests. The use of technical chlordane was discontinued in the 1980s. Soil contaminated with technical chlordane is highly likely to be present around and under the foundations of buildings constructed before this time. Technical chlordane was also used as an insecticide during pineapple cultivation (HDOA 1969).

The HEER Office recommends that soil samples be analyzed for technical chlordane rather than individual chlordane isomers and related compounds generally found in technical chlordane. The concentrations of chlordane isomers, heptachlor, and heptachlor epoxide do not need to be reported unless applied as a separate chemical. Laboratories should be directed to test for technical chlordane using USEPA Method 8081A or an equivalent method (USEPA 1996). This must be specifically requested prior to submitting the samples for analysis and noted on the chain of custody form. Laboratories also should be instructed to report any additional organochlorine pesticides that are not typically found in technical chlordane (e.g., DDT, dieldrin, endrin, etc.). Additional information on technical chlordane is presented in HDOH, 2011g, 2011h.

In addition to the approach noted for technical chlordane, concentrations of the following chemicals should be summed as indicated for comparison to HDOH EALs in a screening level EHE:

- Hexachlorocyclohexane ("BHC" as Lindane) = Alpha-BHC + Beta-BHC + Gamma-BHC (Lindane) + Delta-BHC;

- Endosulfan = Endosulfan I + Endosulfan II + Endosulfan sulfate;

- Endrin = Endrin + Endrin aldehyde + Endrin ketone.

These chemicals can be evaluated individually in a site-specific risk assessment as necessary.

Return to the Top of the Page

9.1.3.4 DIOXINS AND FURANS

Appendix 9-F, Update to Soil Action Levels for TEQ Dioxins and Recommended Soil Management Practices, contains detailed information on updated soil action levels for TEQ dioxins and recommended soil management practices. Contact the HEER Office for further assistance if needed.

Dioxins and furans ("dioxins") should be included as chemicals of potential concern at former pesticide mixing areas associated with both sugarcane and pineapple operations. Although significant data are not currently available for the latter, dioxin contamination in soil well above HDOH action

levels have been documented at numerous former pesticide mixing and storage areas associated with past, sugarcane operations (see following section).

Dioxins were created as a manufacturing byproduct in older formulations of several commonly used pesticides, especially pentachlorophenol (PCP), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and 2,4,5-trichlorophenoxypropionic acid (2,4,5-TP or Silvex; NTP 2005). Soils in former pesticide mixing areas should be analyzed for dioxins if any the above-noted pesticides are known or suspected to have been stored, mixed or otherwise released in the area under investigation. These chemicals are not known to have been widely used in pineapple fields and dioxins are no longer considered a potential chemical of concern for these areas (see Table 9-3). Organochlorine pesticides such as heptachlor, used for ant control, are instead considered to drive the need for investigation of former pineapple field areas.

Dioxins and furans are evaluated in terms of Toxicity Equivalent calculations or "TEQ "dioxins. Quantification of dioxins in soil for use in human health risk assessments requires conversion of congener-specific gas chromatography/mass spectrometry (GC/MS) data to TEQ dioxin concentrations by use of Toxicity Equivalence Factors (TEFs) (WHO, 2005). A summary of World Health Organization (WHO) TEFs is provided in Table 9-4. The TEQ concentrations for individual congeners are then added together to calculate a total TEQ dioxin concentration for the sample. Unless otherwise approved by HDOH, one-half of the Method Detection Limit (not the Reporting Limit) should be used for calculation of TEQ concentrations when the specific congener is reported as "Non Detect."

The HEER Office currently accepts the use of bioassay methods such as CALUX for testing of TEQ dioxins in soil provided that splits of 10% of the samples are tested using GC/MS methods such as Method 8280 or 8290, generally samples with the highest-reported concentration of TEQ dioxins (see Appendix 9-F). Bioassay data in studies carried out by the HEER Office consistently overestimated TEQ dioxin concentrations in soil in comparison with split samples that were tested using laboratory GC/MS methods (HDOH, 2007e). This suggests that the bioassay tests provide a conservative estimate of TEQ dioxin concentrations. Paired GC/MS and bioassay data for split samples can be used to develop a correction factor and adjust the bioassay data for actual comparison to HEER Office EALs.

Other investigations, however, suggest that bioassay tests may *underestimate* TEQ dioxin concentrations for very-low concentrations of dioxins in soil (e.g., <100 ng/kg; e.g., see TTEMI 2012). While this will not affect development of a correction factor based on paired, GC/MS data, it is important to be aware of for initial screening of sites, and emphasizes the need for Method 8280 or 8290 data.

Return to the Top of the Page

Table 9-4 Summary of Toxicity Equivalence Factors for Dioxin

Compound	WHO 2005 TEF
chlorinated dibenzo-p-dioxins	

2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
chlorinated dibenzofurans	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
op2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003
WHO World Health Organization	
TEF Toxicity Equivalence Factor	

Return to the Top of the Page

9.1.4 REVIEW OF PESTICIDE CONTAMINATION AT FORMER SUGARCANE OPERATIONS

In 2011 the HEER Office prepared a summary of pesticides identified in fields, mixing areas, seed dipping vats and various other sugarcane operations across Hawaiʻi (HDOH, 2011d). An overview is provided below. Refer to references in the 2011 report, for examples associated with different operations.

Return to the Top of the Page

9.1.4.1 PESTICIDE MIXING AREAS

Data reviewed for the pesticide and dioxin summary report (HDOH 2011d) confirm that pesticide mixing areas have the highest potential for significant contamination and maintain a high priority for identification and investigation. Identification of these areas through historical records, interviews with past employees and field reconnaissance is especially important as urban growth expands into former agricultural areas.

In order of potential risk to human health and the environment and presence at former mixing sites, the pesticide categories and pesticide-related chemicals can be generally prioritized as follows (see HDOH, 2011d):

- Arsenic and dioxins (chronic direct exposure),

- Ametryn and atrazine (leaching),

- Petroleum (vapor intrusion, gross contamination, leaching),

- Lead (chronic direct exposure),

- DDT (chronic direct exposure),

- Chlorinated herbicides (leaching),

- Carbamates (leaching),

- Organophosphates (acute direct exposure).

Arsenic, dioxins, ametryn, atrazine, and petroleum in particular drive the need for remediation at former mixing areas. Significant lead contamination is also identified at many mixing area sites, although this may in part be due to the use of lead-based paint, since lead-based pesticides are not known to have been widely used.

Although the remaining chemicals can also be present in the same soil at elevated levels, addressing potential environmental hazards posed by the former will almost always coincidentally address potential concerns posed by the latter. Organophosphates primarily pose a short-term, direct exposure risk during and immediately after application. These chemicals are not normally identified in abandoned, former mixing areas above levels of potential concern. Full testing of Decision Units within a former pesticide mixing area most suspected of heavy contamination is recommended. These observations, however, can be used to limit testing for these chemicals to areas suspected of the highest contamination in order to reduce investigation costs, if needed.

Heavy arsenic contamination due to the past use of water-based, arsenical herbicides has been identified to depths of greater than ten feet at former pesticide mixing areas. In some cases contamination can be so significant that soils will fail Toxicity Characteristic Leaching Procedure (TCLP) tests and require management as hazardous waste. It is important to determine this as part of the site investigation in order to help design future remedial actions. Fortunately, the strong binding capacity of iron-rich, volcanic soils in Hawai'i limits this potential problem to sites with arsenic concentrations in excess of several thousand ppm or at sites where the soil is relatively iron-

poor. Arsenic can expected to be much more mobile (and bioaccessible) at sites in coastal areas that are situated on low-iron, calcareous soils rather than volcanic soils.

Petroleum contamination is also present at many former pesticide mixing areas. This can be associated with the use of diesel for preparation of pesticide emulsions. Examples include the use of Concentrated Activated Diesel Emulsion or "CADE" that is "activated" with pentachlorophenol (PCP) for application as an herbicide. Long-term release of petroleum-based emulsions at mixing sites can lead to heavy contamination of underlying soils with dioxins to a depth of ten or more feet. The identification of diesel-contaminated soil at a mixing site should raise concerns about potential dioxin contamination.

Trace levels of PCP are typically identified at pesticide mixing areas operated prior to 1970, when the use of PCP for agricultural operations was banned (HDOA 1969, 1977). Most non-wood preservative uses of PCP were banned in 1987 and use of PCP for wood treatment was significantly restricted by the Federal government (USEPA 2008e; see also ATSDR 2001). The reported concentration of PCP in soil is often below or only marginally above the Tier 1 soil action level of 0.82 mg/kg (HDOH, 2016). Pentachlorophenol degrades relatively rapidly in the environmental and is only moderately persistent (see Appendix 9-A). The reported level of PCP in the soil is not a reliable indicator of the presence or absence of significant dioxin contamination. Heavy dioxin contamination, well over 10,000 to 100,000+ ng/kg, associated with the past use of PCP has been identified at sites where little to no PCP remains.

This highlights that the presence or absence of PCP in soil cannot be used as a stand-alone tool to screen for potentially significant dioxin contamination. Soils that could have been significantly impacted by past releases of PCP or similar, dioxin containing chemicals (e.g., 2,4,5 TP) should always be independently tested for dioxins in addition to the suspected parent chemical.

Soils in some, but not all, pesticide mixing areas are also heavily contaminated with ametryn and atrazine. While reported levels often do not exceed action levels for potential direct-exposure concern, these chemicals can still pose leaching threats to underlying groundwater. Comparison to screening levels that do not consider leaching is therefore not appropriate (e.g., USEPA Regional Screening Levels, USEPA 2012b). Reference to the more comprehensive HDOH EALs or equivalent is required. It is important to identify and remediate soils contaminated with these chemicals in order to prevent and/or cease long-term contamination of drinking water aquifers.

Return to the Top of the Page

9.1.4.2 FORMER FIELD AREAS

With the local exception of arsenic, residual pesticides in former sugarcane fields are rarely detected above levels of potential concern (see Appendix 9-E). Arsenic has been identified in some fields at concentrations that are marginally above HDOH action levels for residential exposure. The distribution of former field areas with elevated arsenic is not uniform, but appears to be associated with specific sugarcane companies that operated from the 1910s through the 1940s and relied on arsenic-based herbicides for weed control in high-rainfall areas (see Subsection 9.1.3.2). Continued testing for arsenic in former sugarcane fields is recommended (see Table 9-2).

Data compiled over the past ten (and especially five) years indicate that dioxins in former sugar-cane fields do not pose significant health risk should these areas be redeveloped for residential use in the future. Dioxins have subsequently been removed as a recommended contaminant of concern for former field areas (see Table 9-2). Trace levels of dioxins, reported in terms of Toxicity Equivalent or TEQ dioxins, are often below or slightly above expected, ambient background in many fields (<20 ng/kg; refer to Appendix 9-F). In other fields the concentration of TEQ dioxins typ-ically ranges between 50ng/kg and 100 ng/kg, below the HDOH residential action level of 240 ng/kg (e.g., see HDOH, 2007e). In relatively rare cases, the concentration of TEQ dioxins in soil at the scale of an individual, hypothetical, residential lot (e.g., 5,000 ft2; see Section 3), may slightly exceed the current action level but are still at or below past, residential action levels (e.g., 390 to 1,000 ng/kg; see Appendix 9-F; see also USEPA 1998g). This does not pose a significant risk to future residents when more site-specific exposure factors such as soil ingestion rates for urban ar-eas are taken into consideration (see HDOH 2016).

Return to the Top of the Page

9.1.4.3 SEED DIPPING VATS

Heavy mercury contamination has been identified at the outfalls of seed dipping vats that operated before the mid 1970s (see HDOH, 2011d). Contaminated sediment has also been identified in mill ditches that drain these areas, however contamination to date is primarily associated with arsenic and dioxins (see HDOH, 2011d). Earlier reports of mercury contamination in mill ditches that drained former seed dipping vats were not verified in followup sampling. This may have been due to misreporting of units in laboratory reports or investigation summaries. Laboratories in general report metal concentrations in soil or sediment in units of mg/kg. In the case of mercury, however, laboratories sometime report concentrations in units of µg/kg (1 mg/kg = 1000 µg/kg). Background levels of mercury in soil are typically less than 1.0 mg/kg (HDOH 2012b). It is important to review and confirm units for mercury at sites where apparent contamination is identified.

Return to the Top of the Page

9.1.4.4 OTHER AREAS AND TARGET PESTICIDES

The review of data for former sugarcane operations did not identify a need to revise guidance for testing in other areas where pesticides may have been used or stored. Significant contamination with organochlorine pesticides (e.g., DDT, Technical Chlordane, aldrin-dieldrin) has not been iden-tified at the majority of pesticide mixing areas or field areas (see HDOH, 2011d). Given their high toxicity and persistence in the environment, however, and past use for mosquito, termite and other pest control around former agricultural areas (e.g., around field margins), continued testing for these chemicals in both former mixing areas and in former field areas is still recommended.

Testing for thallium and barium in an area where rat poison was formerly stored and potentially mixed is currently underway (used in cakes, versus sprayed as a liquid), and data are anticipated in the future. Elevated levels of thallium have not been reported in mixing areas or fields. Due to its potential toxicity, anticipated background levels in soil are likely to be close to risk-based action levels for direct exposure (see HDOH, 2016, 2011d). Toxicity factors employed in the action levels

assume that the thallium is highly soluble and bioavailable, however. Like arsenic, the actual bioavailability of both natural and pesticide-related thallium in soil is expected to be low.

Return to the Top of the Page

9.2 PESTICIDE CONTAMINATION AT NON-AGRICULTURAL FACILITIES AND SITES

The HEER Office recommends safe management practices to limit potential exposure to and test soil for organochlorine (OC) termiticides found in and near wooden buildings built between the 1940s to the 1980s. The recommendations in this section are described in further detail in two HEER Office website fact sheets regarding the past use of OC termiticide, and soil testing for OC termiticides at residential sites (HDOH, 2011g, 2011h).

Termiticides is a general term that includes any type of chemical mixture specifically formulated to kill termites. Organochlorine termiticides are a group of persistent pesticides used for termite control in and around wooden structures from the mid-1940s to the late 1980s. Technical Chlordane and/or aldrin were applied in most instances (refer to Subsection 9.1.3.3). Dieldrin, a breakdown product of aldrin, is also commonly identified at these sites. The chemicals were used primarily by pest control operators in Hawai'i's urban areas, but also by homeowners, the military and counties to protect buildings against termite damage.

The USEPA banned all production and import of these and other OC pesticides in the 1970s (DDT) and 1980s (e.g., Technical Chlordane) due to concerns over potential long-term, ecological impacts as well as risks to human health.

Organochlorine termiticides were commonly applied directly to soil underneath foundations (e.g., around wooden piers or under slabs) and/or around the immediate perimeter of a building foundation. Application practices included pouring a liquid mixture into shallow (e.g., six inches) trenches excavated around the foundation, or by injection through holes drilled next to the foundation or in the flooring at the edge of foundation walls.

Reported concentrations of these compounds in treated soil can exceed HDOH soil action level for soil that is regularly contacted by residents or workers over many years. Typically the highest concentrations of termiticides in soil are found beneath the house or around the perimeter extending away from the building foundation up to 1 to 3 feet. The top six inches to one foot usually have the highest concentrations of OC termiticide. These chemicals were developed to be persistent and can be expected to remain in the soil for decades. Concentrations of OC termiticides under building slabs could be higher because the slab can act as a barrier or cap protecting the degradation of the termiticides in the soil over time. In some cases OC termiticides have been identified in open yard areas, apparently due to additional spraying, the existence of a former building in that area, or reuse of treated soil from former building foundations.

The HEER Office fact sheets discuss potential health concerns associated with OC termiticides in soil and recommend that contact with treated soils be minimized (HDOH, 2011g, 2011h). Termiticides applied more than two decades ago are not detectable by smell or sight. Soil testing is recommended to confirm the presence and level of these chemicals. Soil sampling techniques are described further in the HDOH fact sheet on soil testing for OC termiticides at residential sites in

Hawaiʻi (HDOH 2011g, 2011h). This fact sheet provides an overview of the soil sampling techniques for construction or demolition contractors, homeowners, and others. Further information on soil sampling techniques can be found in TGM Sections 4 and 5.

If OC termiticides are confirmed by testing or suspected based on the age of the building then measures to minimize contact are recommended. This can include removal of treated soil or placement of gravel or landscaping around the perimeter of a house or building. Soil treated with termiticides should not be reused for other purposes without testing (refer to Clean Fill guidance, HDOH 2017d).

Return to the Top of the Page

9.3 PETROLEUM CONTAMINATED SITES

A discussion of target chemicals of potential concern and the evaluation of petroleum releases is included in Volume 1 and Appendix 1 of the EHE guidance document (HDOH, 2016). This guidance is summarized and expanded below.

Petroleum is a complex mixture of hundreds of different compounds composed of hydrogen and carbon or "hydrocarbon" compounds (API 1994). The chemistry and toxicity of petroleum releases depends in part on the type of fuel released and the media tested. The bulk of the compounds are evaluated collectively under the all-inclusive category of Total Petroleum Hydrocarbons (TPH). The concentration of TPH in soil and groundwater is typically reported in terms of "carbon ranges," or the number of carbon molecules in individual hydrocarbon compounds based on the type of fuel released: 1) C5-C12 ("gasoline range" or "TPHg"), 2) C10-C24 ("diesel range" or "TPHd") and 3) C24-C40+ ("residual fuels" or "TPHo"). A number of different terms are applied to these ranges. As discussed below, reference to these ranges is less useful for air and soil vapor data.

"Gasoline-range" TPH is defined as a mixture of petroleum compounds characterized by a predominance of branched alkanes and aromatic hydrocarbons with carbon ranges of C6 to C12 and lesser amounts of straight-chain alkanes, alkenes, and cycloalkanes of the same carbon range (see also NEIWPCC 2003). Vapors from these fuels tend to be dominated by lighter-range, more volatile, C5-C8 aliphatics (HDOH, 2016, 2012). Although not studied in detail, dissolved-phase gasoline in groundwater is also likely to be biased towards more soluble, lighter-range compounds.

Petroleum compounds characterized by a wider variety of straight, branched, and cyclic alkanes, polynuclear aromatic hydrocarbons (PAHs, especially naphthalenes and methylnaphthalenes), and heterocyclic compounds with carbon ranges of approximately C9 to C25 are referred to as "Diesel Range" TPH. These compounds dominate the makeup of diesel and other middle distillates fuels (e.g., kerosene, diesel fuel, home heating fuel, JP-8, etc.). These fuels also contain a small but important amount of lighter, aliphatic compounds. Vapors from the fuels can somewhat counterintuitively be dominated by these "gasoline range," C5-C12, aliphatic compounds (HDOH 2012). As discussed in Subsection 9.3.1.2 below and in Section 7, it is important that these compounds be included in the analysis of TPH in air and soil vapor samples associated with releases of middle distillate fuels. Dissolved-phase, middle-distillate fuel in groundwater could also be biased towards more soluble, "gasoline-range" compounds. A dominance of "TPHg" in groundwater samples does not in itself indicate that the source of the contamination is associated with gasoline. A more de-

tailed review of the chromatograph pattern and site history will be necessary to make this determination.

Residual fuels (e.g., Fuel Oil Nos. 4, 5, and 6, lubricating oils, mineral oil, used oils, and asphalts) are characterized by complex polar PAHs, naphthenoaromatics, asphaltenes, and other high-molecular-weight saturated hydrocarbon compounds with carbon ranges that in general fall between C24 and C40. Compounds associated with these fuels and related products are not considered to be volatile, although methane generated by degradation of the fuels could pose potential hazards at some sites.

Note that the breakdown of heavy petroleum can lead to an increase in volatile petroleum compounds (Chaplin 2002). This necessitates the collection of soil vapor samples at sites contaminated by heavier fuels, as well as gasolines and middle distillates.

Due to the number of sites with residual petroleum contamination, HDOH prepared a guidance document that outlines procedures for long-term management of residual petroleum contamination where full cleanup is not practicable. This guidance, Long-Term Management of Petroleum-Contaminated Soils and Groundwater (HDOH, 2007c) is included in TGM Section 19 as Appendix 19-A. The document includes three, supporting decision trees for determining the need for continued, HDOH oversight. Self-implemented, long-term management by the property owner and closure of the case in the HDOH database is possible in scenarios where the area and volume of contaminated soil and/or groundwater is minimal.

Return to the Top of the Page

Table 9-5 Target Analytes for Releases of Petroleum Products

Petroleum Product	Media	[1]Recommended Target Analytes
Gasolines	Soil	TPH, BTEX, naphthalene, MTBE and appropriate additives and breakdown products (e.g., TBA, lead, ethanol, etc.)
	Soil Vapor	TPH, BTEX, naphthalene and MTBE plus other volatile additives and methane
	Groundwater	Same as soil
Middle Distillates (diesel, kerosene, Stoddard solvent, heating fuels, jet fuel, etc.)	Soil	TPH, BTEX, naphthalene, and methylnaphthalenes (1- and 2-)
	Soil Vapor	TPH, BTEX, naphthalene, and methane
	Groundwater	Same as soil
Residual Fuels (lube oils, hydraulic oils, mineral oils,	Soil	TPH, [2]VOCs, naphthalene, methylnaphthalenes (1- and 2-), the remaining 16 priority pollutant PAHs,

transformer oils, Fuel Oil #6/Bunker C, waste oil, etc.)		PCBs, and heavy metals unless otherwise justified
	Soil Vapor	TPH, VOCs, naphthalene, and methane
	Groundwater	same as soil

1. Include any additional volatile additives in soil vapor samples if suspected to be present.
2. VOCs includes BTEX and chlorinated solvent compounds.

Return to the Top of the Page

9.3.1 RECOMMENDED TARGET ANALYTES

Recommended target analytes for petroleum contaminated soil and groundwater are provided in Table 9-5.

Petroleum contamination in soil, water or air/soil vapors should be evaluated in terms of both TPH and a short list of target "indicator chemicals" that are specific to the type of petroleum product released. As discussed in the previous section, non-specific compounds collectively reported as TPH typically comprise the bulk of petroleum fuels. Target indicator chemicals typically make up only a small fraction of the total petroleum present but are also important players in the assessment of environmental hazards posed to human health and the environment. The toxicity and fate and transport of these chemicals in the environment has been studied in detail.

Return to the Top of the Page

9.3.1.1 TARGET INDICATOR COMPOUNDS

Target, indicator compounds for petroleum fuels include benzene, toluene, ethylbenzene, xylenes (total), methyl-tert butyl ether (MTBE), naphthalene and number of individual, polyaromatic hydrocarbon compounds (see Table 9-5). Separate evaluation of these chemicals is based on the availability of adequate toxicity data and the potential for the chemicals to drive risk and the need for remedial actions at contaminated properties in conjunction with TPH. Separate environmental action levels for these compounds are presented in the HEER Office EHE guidance (HDOH 2016).

All other petroleum compounds are collectively reported and evaluated under "TPH," as described above. Volatile components of petroleum that are not specifically identified as target indicator compounds in Table 9-5 but reported as separate compounds by the laboratory using EPA Method 8260 or similar methods do not need to be separately evaluated. Examples include trimethylbenzenes and other aliphatics and aromatics not specifically identified as target indicator compounds (refer to Subsection 2.11 in the EHE guidance document; HDOH, 2016). These compounds are included under the analysis and evaluation of the TPH component of petroleum.

Seventeen, semi-volatile PAHs are recommended as target, indicator compounds for releases of heavier petroleum fuels or waste oils:

• Acenaphthene	• dibenzo(a,h)anthracene

- Acenaphthylene
- Anthracene
- benzo(a)anthracene
- benzo(b)fluoranthene
- benzo(g,h,i)perylene
- benzo(a)pyrene
- benzo(k)fluoranthene
- chrysene

- fluoranthene
- fluorine
- indeno(1,2,3)pyrene,
- methylnaphthalenes (1 & 2)
- naphthalene
- phenanthrene
- pyrene

In practice, the need for remedial actions at sites impacted with PAHs is typically driven by benzo(a)pyrene. Naphthalene can be reported with either semi-volatile or volatile compounds (see Section 7). Separate Environmental Action Levels (EALs) for 1- and 2- methylnaphthalenes are presented in the EHE guidance document (HDOH, 2016).

The suite of PAHs that should be tested at a given site depends on the type of the petroleum product released (after MADEP 2002). As indicated in the Table 9-5, naphthalene is the only PAH that requires reporting for gasoline release sites. Both methylnaphthalenes and naphthalene should be reported at sites with releases of middle distillates (diesel, jet fuel, etc.). The full suite of PAHs should be considered at sites with releases of heavier petroleum fuels and waste oil, unless site-specific information on the product released justifies eliminating specific PAHs.

Methylnaphthalenes do not need to be reported for soil vapor samples as a default. Based on data reviewed by HDOH, these compounds are unlikely to drive potential vapor intrusion hazards at petroleum release sites over TPH or benzene due to their relatively low volatility and concentration in most middle distillates and residual fuels. Testing for these compounds in soil vapor also requires different sample collection and analytical methods (e.g., sorbent tubes and TO-1 analysis; see Subsection 7.8.2). Reporting of these compounds in soil vapor samples may, however, be required at sites impacted by Manufactured Gas Plant waste.

Return to the Top of the Page

9.3.1.2 TOTAL PETROLEUM HYDROCARBONS

Soil, groundwater, and soil vapor samples must always be tested for TPH (or equivalent) in addition to targeted, individual chemicals. Laboratory analysis for TPH as gasolines and middle distillates is generally carried out using gas chromatography, modified for "gasoline-range" organics ("Volatile Fuel Hydrocarbons") and "diesel-range" organics ("Extractable Fuel Hydrocarbons"), respectively (e.g., EPA Method 8015). Analysis for TPH as residual fuels up to the C40 carbon range can be carried out by gas chromatography, infrared absorption, or gravimetric methods. The latter methods are rarely used, however, due to their inability to discriminate the type of the petroleum present and interference with organic material in the soil.

The concentration of TPH (or equivalent) in soil vapor should always be reported as the sum of C5-C12 compounds for whole air samples and C5-C18 for sorbent tube samples, regardless of the

type of petroleum fuel involved. Refer to Appendix 1 of the HDOH EHE guidance for a detailed dis-
cussion on total volatile petroleum hydrocarbons (see also Brewer et al 2013). As discussed above
and in Subsection 7.8.2, results from a petroleum vapor study carried out by HDOH study indicate
that C5-C8 aliphatic compounds can make up a significant if not dominant fraction of the total TPH
present in vapors associated with diesel and other middle distillate fuels (HDOH, 2012, 2012c).
This is important, since current laboratory protocols typically require that they report "TPHdiesel" in
any media as the sum of C10 to approximately C24 hydrocarbon compounds. Excluding the contri-
bution of C5-C8 aliphatics to the total concentration of TPH reported in air or soil vapor samples
associated with middle distillate fuels would be inappropriate, however.

To help address this issue, laboratories should be instructed to report TPH (or equivalent) in air or
vapor samples as: 1) The sum of C5-C12 compounds for whole-air samples (e.g., summa canister
samples and TO-15 lab methods, with the understanding that aromatics can only be confidently
summed to C10) or 2) The sum of C5-C18 for samples collected using a sorbent media (e.g., sor-
bent tubes and TO-17 lab methods, with the understanding that aromatics can only be confidently
summed to C16). This should be done regardless of whether the samples are associated with
gasolines or middle distillates.

Laboratory methods for reporting of TPH in indoor air and soil gas are discussed in Subsection
7.13. A combination of both TO-15 (Summa canister samples) and TO-17 (sorbent tube samples)
is currently recommended for initial investigation of petroleum-contaminated sites (see HDOH,
2012c). The collection of concurrent, sorbent tube samples can be discontinued if initial data indi-
cate that C12+ compounds make up less than 10% of the total TPH present in vapors.

Designation of chromatogram patterns as "gasoline range" (e.g., C5-C12) or "diesel range" (e.g.,
C10-C24) with respect to traditional, laboratory methods for TPH in soil or water is not applicable
to air and vapor samples and can be misleading. The reported concentration of TPH can then be
compared to HDOH soil gas action levels. The sum of concentrations of individual, target analytes
such as BTEX and naphthalene that will be evaluated separate can be subtracted from the re-
ported concentration of TPH in order to avoid double counting, although this is not likely to make a
significant difference in the final concentration.

As discussed in TGM Subsection 7.8, the initial collection of both Summa canister samples and
sorbent tube samples is recommended for soil vapor investigations at diesel and middle distillate
sites. This is due to limitations on the ability to extract >C12 compounds from Summa canisters
(see Subsection 7.13.1.1). A minimum Summa canister size of one-liter is recommended, in order
to help collect a representative sample (tested for both TPH and target, indicator compounds such
as BTEX and naphthalene). A maximum, 50ml vapor draw might be required for sorbent tube sam-
ples due to limitations of the sorbent material (tested only for TPH). Sorbent tube data are used to
evaluate the relative proportion of >C12 compounds associated with TPH.

If the relative fraction of >C12 is less than 10% of the TPH then the concentration of TPH reported
for the Summa canister can be used for comparison to action levels and Summa canisters can be
relied upon for the collection of future samples. If >10% of the vapor-phase TPH is associated with
>C12 compounds then a combined use of Summa data and sorbent tube data should be used to
evaluate the site. For example, request that the laboratory report TPH for the sorbent tube sample
as the sum of >C12 compounds. Add this to the concentration of TPH reported for the Summa

sample (i.e., TPH as sum of C5-C12). The resulting, total TPH concentration can then be compared to soil gas action levels. This approach excludes the concentration of aromatic compounds greater than C10 but less than C12. Based on published information and data collected by the HEER Office, however, these compounds make up an insignificant (i.e., <10%) proportion of TPH vapors at typical, petroleum-release site.

Reported concentrations of unidentified hydrocarbons as gasoline, diesel or oil indicate that the chromatogram generated for the sample does not match standards used to quantify TPH. Reported concentrations of TPH should be considered approximate, but adequate for comparison to HDOH action levels. A more detailed evaluation through petroleum carbon range analysis can be carried out on a site-specific basis as warranted.

Silica gel cleanup of samples, in particular for surface water and groundwater, should not be carried out without consultation with HDOH. Two options are recommended: (1) Directly compare TPH data to HDOH EALs in the absence of silica gel cleanup, and/or (2) Report data both with and without silica gel cleanup. For the second option, compare the nonpolar, TPH fraction to HDOH EALs and evaluate potential hazards posed by TPH-derived, polar breakdown products to drinking water and aquatic habitats in a site-specific EHE (see HDOH, 2016).

Dissolved-phase TPH in water is composed of unaltered, nonpolar compounds originally in the parent fuel and polar compounds associated with the oxidation and biodegradation of the former (e.g., Zemo 1995, 2008, Lang et al 2009, Mohler et al. 2013). Polar compounds can be removed by passing the sample through silica gel prior to analysis, referred to as "silica gel cleanup (SGC)." A column SGC lab method should be used rather than a shake or funnel method (e.g., Method 3630C, USEPA 1996k). If polar compounds are removed, both non-SGC and SGC data should be reported.

In many cases silica gel cleanup will significantly reduce the concentration of TPH reported for the sample. The polar compounds, which can dominate the overall mass of TPH in groundwater at aged-release sites, are primarily organic acids/esters and alcohols with variable amounts of ketones, phenols and aldehydes. These compounds must be taken into account as part of a site investigation. From an environmental hazard standpoint, the sum of the polar compounds and nonpolar compounds (i.e., the concentration of TPH reported in the absence of a silica gel cleanup) represents the concentration of TPH that should be directly compared to HDOH Environmental Action Levels (refer to HDOH EHE guidance; HDOH, 2016).

Methods for development of separate EALs for TPH-related, polar compounds or evaluation of these compounds in a site-specific EHE or human-health risk assessment have not been fully developed. The toxicity of the polar fraction of the TPH to both humans and aquatic organisms has only recently begun to be studied (e.g., Zemo et al. 2013). As a default, and for the purposes of this guidance, the health risk and other potential environmental concerns associated with these compounds (e.g., toxicity to aquatic organisms, taste and odors in drinking water, etc.) is assumed at an initial screening level to be identical to the parent, nonpolar TPH compounds.

If silica gel cleanup of samples for a site is still desired (e.g., evaluation of degradation, fingerprinting of fuel releases, site-specific risk assessment, etc.), then the objectives and methodology to be implemented should be presented to HDOH for review and approval. A quantitative evaluation of

potential threats to human health and the environment should be carried out in accordance with the HDOH EHE guidance document for a site-specific EHE. This includes addressing potential aquatic ecotoxicity concerns as well as gross contamination concerns (e.g., drinking water taste and odors). Alternative action levels for each environmental hazard should be presented and supported for comparison to data. In most cases, it is anticipated that long-term management of groundwater contaminated primarily with polar, TPH breakdown compounds above HDOH action levels will still be required due to potential nuisance and aquatic toxicity hazards, even in the absence of apparent risk to human health (e.g., via impacts to drinking water resources).

Comparison of data for groundwater samples tested with and without silica gel cleanup could be useful for assessing the state of natural biodegradation within a plume of petroleum-contaminated groundwater and optimizing remedial and monitoring actions. For example, no further active remediation may be appropriate for areas of the plume where the majority of dissolved-phase hydrocarbons have degraded into polar compounds (i.e., significant reduction of reported TPH concentration in samples processed with silica gel cleanup). Active remediation could focus on areas of the plume where a comparison of data indicates that significant, natural degradation is not occurring. Data can also be used as one line of evidence to support a recommendation for no further monitoring and site closure following the HEER office guidance for long-term monitoring of petroleum-contaminated sites (HDOH, 2007c; see TGM Section 19, Appendix 19-A).

Return to the Top of the Page

9.3.2 PETROLEUM CONTAMINATION ENCOUNTERED DURING SUBSURFACE SOIL EXCAVATION

Unanticipated petroleum (free product) or petroleum-contaminated soil is sometimes encountered during construction work where subsurface soil is being excavated. The HEER Office has a Guidance Fact Sheet, consistent with the Hawai'i Environmental Response Law (HRS 128D HDOH, 1990), to assist project managers, contract workers, safety and health personnel or anyone involved in construction and excavation of soils when petroleum is encountered on a site. This document, "Guidance Fact Sheet for Use When Petroleum Contamination is Encountered During Subsurface Soil Excavation", is provided in Appendix 9-D.

In rare cases the reported concentration of TPH in soil with strong petroleum odors could fall below HEER Office EALs for gross contamination (refer to HDOH, 2016). This could be due to sampling error in the field, laboratory sample processing error, or the inability of the laboratory method to accurately quantify the amount of TPH in the soil. Even so, soil with an obvious petroleum odor should be considered grossly contaminated and managed appropriately. Removal and/or treatment of vadose-zone soil that exceeds the HEER Office EAL for subsurface gross contamination (e.g. 5,000 mg/kg) is typically recommended at a minimum when complete cleanup cannot be achieved. The HEER Office should be contacted regarding the on-site management or re-use of additional, petroleum contaminated soil. Refer also to the HEER Office Clean Fill Guidance for additional information (HDOH 2017d).

Return to the Top of the Page

9.3.3 PAHS IN ASPHALT, TAR AND WASTE OIL

Understanding the potential source of polyaromatic hydrocarbon compounds (PAHs) in soil is important for decision making. Benzo(a)pyrene, the most potent of the PAHs, is almost always the risk driver in soils contaminated with PAHs. With the possible exception of naphthalene and methylnaphthalenes, these compounds are not present in significant amounts in gasolines and middle distillate fuels or soils impacted by these fuels (API 1994, TPHCWG 1998). They are present, however, in asphalt, waste oil and coal tar.

Samples of soil impacted with waste oil can have concentrations of benzo(a)pyrene and related PAHs in the tens of parts-per-million, well above Tier 1 EALs for potential direct-exposure concerns. Correlative concentrations of TPH up to approximately C40 are usually in the thousands of parts-per-million range (e.g., see API 1994). The concentration of PAHs in Bunker C and similar, residual fuels can also contain similar levels of BaP and other PAHs. Investigation and remediation of these soils is necessary for the protection of human health and the environment.

Soils impacted with asphalt can express similar concentrations of PAHs (e.g., see API 1994). An asphalt source of the PAHs is usually readily identifiable by relatively low concentrations of TPH, usually in the low hundreds of parts-per-million range. The bioavailability of PAHs in asphalt is relatively low and the presence at these levels does not pose a significant health risk. Asphalt is also regulated as an "inert waste" under Hawai'i Revised Statutes 342H-1 and does not fall under HEER Office oversight, even if BaP concentrations exceed EALs. If the source of PAHs identified in soil can reasonably be attributed to asphalt, then no further action is required. The inclusion of small particles of asphalt in soil from heavily developed areas or previously paved areas may be unavoidable. The reuse or import of asphalt as fill material is not recommended at remediation sites overseen by the HEER Office (HDOH, 2017d).

Relatively low concentrations of <C40 TPH are also often reported for soils impacted with coal tar, including manufactured as plant waste, older clay pigeons used at skeet ranges and petroleum-based patching material for roads or roofing (API, 1994; EPRI, 1993). The concentration of PAHs associated with these materials is often in the hundreds of parts-per-million range, however, highlighting coal tar or similar material as the likely source of the PAHs. Concentrations of PAHs in soil at these levels could pose potential direct-exposure concerns, even if the bioavailability of the PAHs is relatively low. Investigation and remediation of sites impacted with coal tar and similar material is essential.

In addition to asphalt, parts-per-billion to low, parts-per-million range concentrations of PAHs in soil in urban environments in combination with relatively low concentrations of TPH can also be associated with exhaust from vehicles, ash from fires and other source of combustion (Mauro et al., 2006). Recognition of anthropogenic background as part of a site investigation is necessary in order to correctly define the extent of contamination associated with releases of waste oil, manufactured gas plant waste or other sources that might require remediation.

Return to the Top of the Page

9.4 METHANE

Methane is a colorless, odorless and highly flammable gas generated by the anaerobic biodegradation of organic material, including petroleum. Methane can pose explosion and fire hazards un-

der some conditions. In order for methane to create hazardous conditions, three conditions must be met: 1) A sufficient concentration of methane; 2) A sufficient concentration of oxygen and 3) An ignition source. Potential safety risks should be assessed by considering concentrations of methane and oxygen in soil gas, significance of advective (i.e., under pressure) transport, and potential for methane attenuation between the soil gas and structure or enclosed space.

Figure 9.1 Methane Mitigation Decision Matrix

Distance to structure	Methane Concentration in Soil Gas			
	<1000 ppm (<0.1%, <2% LEL)	1000 – 5000 ppm (0.1% – 0.5% 2% LEL – 10% LEL)	5000 – 12,500 ppm (0.5% – 1.25% 10% LEL – 25% LEL)	> 12,500 ppm (> 1.25% > 25% LEL)
0 ft (beneath structure)	No Controls Recommended	Methane Monitoring Conduit Seals and Utility Trench Dams	Methane Monitoring Conduit Seals and Utility Trench Dams Vapor Mitigation	Methane Monitoring Conduit Seals and Utility Trench Dams Vapor Mitigation
0 – 100ft	No Controls Recommended	Methane Monitoring	Methane Monitoring Conduit Seals and Utility Trench Dams	Methane Monitoring Conduit Seals and Utility Trench Dams Vapor Mitigation
100 – 300ft	No Controls Recommended	No Controls Recommended	Methane Monitoring	Methane Monitoring Conduit Seals and Utility Trench Dams
>300ft	No Controls Recommended	No Controls Recommended	No Controls Recommended	Methane Monitoring

1. Decision matrix modeled after Geonsyntec 2011.
2. Actions listed in this decision matrix assume soil gas pressure is < 2 in-H2O. If soil gas pressure is greater than 2 in-H2O, then the need for enhanced mitigation measures should be evaluated.
3. This mitigation matrix does not preclude site-specific evaluation of engineering controls. Engineering control requirements can be reduced if additional indoor/sub-slab monitoring is conducted following construction of building or if site conditions are in the more conservative end of the listed criteria (i.e., lower end of methane concentration and upper end of distance criteria). If reduced controls are utilized, a mitigation decision matrix for soil gas and indoor air data should be developed.
4. Methane Monitoring can include testing of exterior soil gas, sub-slab, and/or indoor air. A specific monitoring program should be proposed prior to building construction.

Advective flow of methane under pressure from a source area is primarily a concern at landfills. This creates a high risk for significant, offsite migration and potential intrusion into the lower floors of buildings or subsurface utility corridors. Methane can be present at high concentrations in vadose-zone soil at petroleum-contaminated sites but is rarely under significant pressure and typically migrates by diffusion rather than advection. While significant offsite migration is less likely, diffusion into subsurface utility corridors could pose localized flash explosion or fire concerns if the

methane mixes with oxygenated air and is encountered during subsurface construction or utility work. Accumulation of methane in poorly ventilated rooms of buildings with cracked floors, gaps around utility penetrations in the floor or other vapor entry routes could also pose potential hazards.

Figure 9-1 presents a summary of recommended monitoring and mitigation actions for site where high levels of methane are detected in soil vapors (Geosyntec 2011).

Final monitoring and mitigation actions for potential methane hazards will necessarily be site spe-cific, and depend in part on the estimated area and volume of the source area, planned remedial actions to address the source, the presence and use of existing buildings and the planned use or redevelopment of the site. Coordination with HDOH and submittal of a site-specific workplan for re-view is recommended. Additional methane guidance can be found in the following document: Advisory on Methane Assessment and Common Remedies at Schools Sites (CalEPA 2005b).

Be aware that high levels of light-end (C5-C12), petroleum vapors can cause false, elevated read-ings of methane in vapor samples using a standard, landfill gas analyzer. The use of a carbon trap is recommended when evaluating for methane when using field instruments at sites where high levels of petroleum may be present in soil gas. A carbon trap will remove the majority of petroleum aliphatic and aromatic compounds from the soil gas and allow for a more accurate reading of methane.

Return to the Top of the Page

9.5 BACKGROUND METALS IN SOIL

Return to the Top of the Page

HDOH, 2012b). The results of this study were incorporated into the EHE guidance document and associated EALs. As discussed in the EHE guidance document, naturally occurring background concentrations of some metals in soil exceed risk-based action levels for these metals (see HDOH, 2016). This is especially true for arsenic, but can also occur for heavy metals such as thallium, vanadium and other metals associated with soils developed over basaltic bedrock. These metals in soils are tightly bound to iron hydroxide and other complexes and do not pose a health risk, however. The upper bound concentration of the metal was selected for background screening purposes in the EALs. A summary of selected background concentrations is provided in Table 9-6. Risk-based action levels were replaced with the natural background concentration of the chemical if the background value was higher.

As discussed in the HEER EHE guidance, the risk-based action level for arsenic for soils in an unrestricted ("residential") land use scenario is 0.42 mg/kg based on a 10-6 excess cancer risk (see HDOH, 2016). This purely risk-based action level is based

Return to the Top of the Page

Table 9-6 [1]Background Metals in Hawai'i Soils

Metal	Range (mg/kg)	[2]Upperbound Concentration (mg/kg)
Antimony	0.004-2.4	2.4
Arsenic	0.3-50	24
Barium	4.5-926	690
Beryllium	0.05-3.8	3
Cadmium	0.02-17	2.3

on an assumed bioavailability of arsenic in soil of 100%. This is unrealistic for most soils and especially iron-rich, volcanic soils in Hawai'i, since arsenic will tightly bind to iron in soil and not be available for uptake if the soil is incidentally ingested (e.g., Cutler et al 2013). Background concentrations of arsenic in soils in Hawai'i typically range from 5 mg/kg to 24 mg/kg (see above references). A default, upper bound background concentration of 24 mg/kg arsenic is incorporated into the EAL lookup tables. Soils with total arsenic that exceed this concentration should be tested for bioaccessible arsenic (see Subsection 9.1.3.2). Upper threshold background values of arsenic in soil can approach 40 to 50 mg/kg, especially in discrete samples.

Note that background concentrations of naturally occurring metals in soil should not be included in calculation of cumulative risk as part of a site-specific risk assessment. Additional guidance on site-specific risk assessments is included in the HEER Office EHE guidance document (HDOH, 2016).

Direct comparison of background metals concentrations to sediment samples should be done with caution. Although data are limited, concentrations and relative ratios of metals in sediment derived primarily from volcanic soils and rocks should be similar to those noted in the table. Separation and concentration of heavy metals during sediment transport is possible, however. This could lead to either elevated or decreased concentrations of heavy metals in sediment in comparison to the parent material. A high concentration of organic matter in sediment (e.g., >10%) will also "dilute" the reported concentrations of heavy metals in comparison to the parent material. This can be accounted for by adjusting reported metal concentrations with respect to the concentration of Total Organic Carbon (TOC) in the sample (i.e., Adjusted Concentration = Reported Concentration/(1-Fraction TOC). As discussed in the report, the background data also focus on volcanic soils are not directly applicable to either soils or sediments derived primarily from coral and limestone. Concentrations of heavy metals in these cases are likely to be considerable lower than those noted in the above table.

Further information on background metals in Hawaiian island soils can be found on the HEER Office website. This website also has a link to the HEER Office document *Hawaiian Islands Soil Metal Background Evaluation* (HDOH, 2012b).

Chromium (Total)	8.52-3,180	1145
Cobalt	0.69-113	80
Copper	2.4-450	252
Lead	0.76-73	73
Mercury	<0.017-1.4	0.72
Molybdenum	0.06-4.0	4.0
Nickel	2.1-767	410
Selenium	0.24-12	7.1
Silver	0.02-1.5	1.5
Thallium	<0.25-15	0.25
Vanadium	0.25-1,090	770
Zinc	3.6-1,200	349

Reference: HDOH, 2012b

Notes:
1. Excludes samples with known or suspected anthropogenic contamination.
2. Upper Bound concentration selected based on evaluation of univariate sample data plots.
3. Background Threshold Value set to maximum-reported concentration, excluding samples with suspected anthropogenic contamination.
4. Background action level based on Upper Bound concentration unless otherwise noted.

Return to the Top of the Page

9.6 METHAMPHETAMINE LABORATORY CLEANUP

9.6.1 BACKGROUND

Methamphetamine, also known as "meth," "speed," "crank," "crystal" and "ice," is a very powerful man-made drug that affects the central nervous system. Manufacture of methamphetamine is illegal. The product is often made in makeshift laboratories set up in rented property, including houses, apartments and hotel rooms. The majority of current operations in Hawai'i are believed to be small scale.

Many of the chemicals used to produce methamphetamine are highly volatile and toxic. These chemicals can cause death or injury to the lab operators and other occupants, law enforcement officials and first responders to lab explosions.

The number of properties contaminated by illegal methamphetamine laboratories has been increasing through the years. After the operations move or are shut down, property owners are often left with unknown and not necessarily obvious levels of contamination. Carpeting, wall board, ceiling tile, wood and fabric and other materials in a building can absorb the chemicals used in meth labs. Furniture or draperies also can be contaminated. Contamination can spread to other areas of the building if residues enter the heating, ventilation and air-conditioning system. Soil or groundwater may become contaminated if chemicals are disposed of in a septic system or dumped outside.

Detailed information and guidance on methamphetamine laboratory cleanup can be found at the HEER Office meth labs webpage. The webpage contains fact sheets, policies, and useful links outside of the website. A brief overview is provided below.

Return to the Top of the Page

9.6.2 HDOH GUIDANCE

In 2006, Act 170 was signed into law in response to concern over the potential health effects associated with residual methamphetamine and related contaminants at these operations. The Act required HDOH to establish administrative rules for the cleanup of these sites. These rules became effective in November 2007. Guidance was prepared and published in July 2010 (HDOH, 2010c).

The guidance discusses methamphetamine manufacturing in Hawai'i, safety considerations during inspection and testing of former operations, hazardous materials disposal, decontamination procedures, reporting, and criteria that must be met before a No Further Action determination can be made by HDOH.

Return to the Top of the Page

9.6.3 INVESTIGATION PROCESS

The HDOH HEER Office provides general oversight for the decontamination of methamphetamine manufacturing sites upon referral by the chief investigating law enforcement officer and coordina-

tion with the property owner. Testing is carried out prior to commencement of remediation activities.

The HEER Office reviews and approves the field sampling plan, quality assurance project plan, hazard assessment and recognition plan and health and safety plan submitted by the cleanup contractor(s). The contractor in most cases is hired by the property owner, unless a separate responsible party can be located to conduct sampling and decontamination. HDOH itself does not carry out sampling or decontamination activities.

Chemicals of potential concern to test for at former methamphetamine operations are necessarily site-specific. A number of methods are used to synthesize methamphetamine. The active ingredient is derived from one of three chemicals, ephedrine, pseudoephedrine, or phenylpropanolamine. Other chemicals used in the synthesizing process include iodine, red phosphorous, hydrochloric acid, ether, kerosene (e.g., Coleman fuel), paint thinner, acetone, drain cleaner, battery acid, lithium batteries, hydriodic acid, and anhydrous ammonia.

Table 9-7 includes a summary of chemicals that typically need to be included for testing for former methamphetamine labs and their associated hazards.

Return to the Top of the Page

Table 9-7 Chemical Hazards Associated with Illegal Methamphetamine Labs

Typical Chemicals Found in Lab Sites	Common Legitimate Uses	Poison	Flam-mable	Toxic Vapors	Explosive	Corrosive	Skin Absorp-tion	Con Hea Haz
Acetone	Fingernail polish remover, solvents	X	X	X			X	Rep diso
Methanol	Brake cleaner fluid, fuel	X	X	X			X	Blin eye
Ammonia	Disinfectants	X		X		X	X	Blist lung
Benzene	Dye, varnishes, lacquers	X	X		X	X	X	Car leuk
Ether	Starter fluid, anesthetic	X	X		X			Res failu
Freon	Refrigerant,	X		X		X		Fros

	propellants							lung
Hydriodic Acid	Driveway cleaner	X		X		X	X	Burr thyr dam
Hydrochloric Acid (HCL Gas)	Iron ore processing, mining	X		X		X	X	Res liver
Iodine Crystals	Antiseptic, catalyst	X	X		X	X		Birth kidn
Lithium Metal	Lithium batteries	X				X	X	Burr puln eder
Muriatic Acid	Swimming pool cleaners	X		X		X		Burr vapo
Phosphine Gas	Pesticides	X		X			X	Res failu
Pseudoephedrine	Cold medicines	X						Abu dam
Red Phosphorus	Matches, fireworks	X	X	X	X			Uns flam
Sodium Hydroxide	Drain cleaners, lye	X		X		X	X	Burr ulce
Sulfuric Acid	Battery acid	X		X		X	X	Burr thyr dam
Toluene	Paint, thinners, solvents	X	X	X	X		X	Feta dam pne
Liquid Lab Waste	None	X	X	X	X	X	X	Unk long effe

Reference: HDOH, 2010c

Prior to issuance of a No Further Action determination, the HEER Office confirms that each reme-diation process has been completed according to the approved work plan, and that the property

has been decontaminated to below state-approved levels of concern. Refer to the full guidance for additional details (HDOH 2010c).