



APPENDIX 19-A
**LONG-TERM MANAGEMENT OF PETROLEUM-
CONTAMINATED SOIL AND GROUNDWATER**

LINDA LINGLE
GOVERNOR OF HAWAII



CHIYOME L. FUKINO, M.D.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
919 Ala Moana Boulevard, Room 206
HONOLULU, HAWAII 96814

In reply, please refer to:
File: EHA/HEER Office
2007-314-RB

June 27, 2007

TO: Interested Parties

FROM: Keith E. Kawaoka, D.Env., Program Manager 
Hazard Evaluation and Emergency Response Office

Steven Chang, Chief 
Solid & Hazardous Waste Branch

SUBJECT: Long-Term Management of Petroleum-Contaminated Soil and Groundwater

Attached for your information is a technical report that presents guidance on the long-term management of petroleum-contaminated soil and groundwater. This report serves as an addendum to the Hazard Evaluation and Emergency Response (HEER) Office document *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (May 2005 and updates).

If you any questions, please contact Dr. Roger Brewer of the HEER Office at 1-808-586-4238 or contact him by email at roger.brewer@doh.hawaii.gov.

Attachment

Long-Term Management of Petroleum-Contaminated Soil and Groundwater

This technical memorandum outlines procedures for long-term management of residual petroleum contamination in soil and groundwater at sites where full cleanup is not practicable. Topics discussed include:

- Revisions to *Target Contaminants of Concern* for petroleum-contaminated media;
 - Addition of naphthalene for gasoline releases;
 - Reduction of target PAHs for diesel-only releases to naphthalene and methylnaphthalenes;
 - Inclusion of methane in soil gas samples;
- Identification of specific environmental concerns in an *Environmental Hazard Assessment* (formerly referred to as an *Environmental Risk Assessment*);
- Identification of long-term management needs and preparation of an *Environmental Hazard Management Plan*;
- Need for continued Hawaii Department of Health (HDOH) oversight:
 - Remaining contamination does not exceed action levels: *No Further Action* and case closure with no long-term monitoring or management requirements;
 - Remaining contamination exceeds action levels but very limited threat to human health and the environment: *No Further Action* and case closure with no requirement for continued monitoring; management of remaining contamination in accordance with the *Environmental Hazard Management Plan* required; or
 - Remaining contamination exceeds action levels and potentially significant threat to human health and the environment: Case remains open under continued HDOH oversight but responsible party may request concurrence that further active remediation is not practicable.

An important goal of the guidance is to allow closure of “low-risk” and low-priority cases. These are cases where remaining contamination is minimal and does not pose a significant risk to human health and the environment, even though a limited area of soil or groundwater is contaminated above HDOH environmental action levels. The remaining contamination must be properly managed in accordance with the *Environmental Hazard Management Plan* prepared for the site. No further reporting requirements will be imposed, although HDOH reserves the right to reopen the case if remaining contamination is not properly managed in the future. This allows HDOH to focus its resources on high-risk and high-priority sites. Formally closing low-risk sites also assists the owner in property transactions and redevelopment (which in some cases could assist in further cleanup). Clearly documenting post-remediation site conditions and remaining environmental concerns also reduces the chance that the owner could be inappropriately included as a “responsible party” for future, unrelated releases after the property has been sold.

The guidance draws from and adds to information presented in the Hazard Evaluation and Emergency Response (HEER) and Solid & Hazardous Waste Branch (SHWB) office *Technical Guidance Manual* documents (HDOH 1997, 2000). Guidance documents prepared by the USEPA and other state agencies are also referred to. In particular, this document incorporates guidance published by the State of California in 1996 to address what they termed “low-risk” petroleum-release sites (CalEPA 1996a). California’s guidance is based on the premise that petroleum contamination does not pose a significant threat to human health and the environment

once the source of the release is stopped and gross contamination is removed from the immediate release area (irregardless of contaminant concentrations). While very practical, the discovery of extensive plumes of MTBE-contaminated groundwater from gas stations and leaking pipelines soon afterwards and the growing importance of vapor intrusion concerns reduced the usefulness of California's guidance. The guidance presented below helps address these gaps by requiring a full evaluation of potential environmental concerns and closer HDOH oversight of cases where soil and/or groundwater are contaminated with persistent and highly mobile chemicals like MTBE.

The guidance also serves as an update and addendum to the HDOH document *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (HDOH 2005a). The guidance applies to both petroleum releases overseen by the HEER Office and releases overseen by the SHWB. Responsible parties with cases being overseen by the Underground Storage Tank section of the SHWB may continue to refer to action levels presented in 1995 HDOH Risk-Based Corrective Action guidance if they choose until such time that SHWB regulations pertaining to releases from underground storage tanks are updated (HDOH 2005b, regulations currently under review).

This guidance is intended to provide a starting point for discussion of possible case closure and removal from HDOH oversight. The guidance is *not* intended to represent strict requirements for closure and issuance of *No Further Action* letters to responsible parties. The information provided in this guidance will be updated as appropriate and will be included in future revisions of the HEER and SHWB *Technical Guidance Manual* documents (currently underway). Comments and suggestions are welcome and should be addressed to Roger Brewer of HDOH at roger.brewer@doh.hawaii.gov.

Overview

Responsible parties for sites where full cleanup of contaminated soil and groundwater has occurred and representative concentrations of contaminants in soil, soil gas and groundwater are below HDOH Tier 1 Environmental Action Levels (EALs) can petition HDOH for a *No Further Action* letter and case closure. Site conditions often limit the extent to which contaminated soil and groundwater can be aggressively remediated, however. This situation is especially common in heavily developed, urban areas. Excavation and removal of heavily contaminated soil and free product in the immediate area of the release is generally achievable. Concerns about building foundations, subsurface utilities and roadways coupled with high costs, however, often limit the feasibility of complete cleanup.

This guidance describes conditions where continued HDOH oversight of the site will be required (refer to Figures 1, 2 and 3). The guidance also presents conditions where a responsible party can petition for case closure under a *No Further Action* letter when contaminant concentrations exceeds Tier 1 EALs (or approved, alternative action levels) but the remaining threat to human health and the environment is minimal. When the remaining threat is still significant but further attempts to actively reduce contaminant levels via excavation, soil vapor extraction, direct groundwater treatment, etc., is not practicable, the responsible party can petition HDOH to concur that no further active remediation is required at the site. This allows current and future owners (as well as financial institutions) to better assess the monetary, environmental liability tied to the property and reduce financial uncertainty in property transfer or redevelopment plans.

Costs associated with long-term monitoring or engineered controls (caps, etc., if applicable) are, in contrast, relatively easy to project.

Continued HDOH oversight will likely be required at sites where Tier 1 EALs (or approved, alternative action levels) are exceeded *and* one or more of the following conditions exist (refer also to Figures 2 and 3):

- Sites where active remediation is still technically and economically practicable;
- A plume of contaminated groundwater is present that could threaten existing or future water supply wells;
- A plume of contaminated groundwater is present that could be acutely toxic to aquatic organisms if it discharges into a surface water body;
- Persistent chemicals such as lead, PCBs, chlorinated solvents, etc., are present above action levels for unrestricted/residential land use and no land use covenant/deed restriction in place;
- Remaining contamination poses direct-exposure and/or vapor-intrusion concerns for current and anticipated future land use in the absence of engineered controls;
- Greater than ten cubic meters of grossly contaminated soil are present within three meters of the ground surface (or above groundwater, if less than three meters deep).

Sites where each of the following conditions are met can petition for a *No Further Action* letter and case closure, provided that the remaining contamination is properly managed in accordance with the *Environmental Hazard Management Plan* prepared for the site (refer to Figures 2 and 3):

General:

- The release has been stopped and ongoing sources, including free product, have been removed or remediated to the extent practicable;
- Remaining contamination documented in an updated site assessment report, including maps that clearly define the extent and magnitude of remaining contamination above HDOH EALs (or other approved screening levels);
- Remaining environmental concerns are documented in an *Environmental Hazard Assessment* report;
- Requirements for long-term management of remaining contamination are presented in an *Environmental Hazard Management Plan*;

For soil:

- Representative concentrations of persistent chemicals do not exceed action levels (e.g., lead, PCBs, PAHs, etc.; multi-increment data preferred for surface and near surface samples, when practicable);
- Engineered controls (pavement, etc.) in place to prevent direct-exposure, vapor-intrusion or leaching concerns;
- Volume of contaminated soil within three meters (ten feet) of surface $\leq 10\text{m}^3$ (approximately 15 cubic yards);

For groundwater:

- Body of groundwater that exceeds action levels is not expanding and/or or migrating (i.e., the plume is “stable” or shrinking);
- For impacted drinking water resources:
 - Plume is not within 300m (approximately 1,000 ft) of an active water supply well and within the producing aquifer or within 150m of a surface water body that is a potential source of drinking water;
 - Persistent chemicals not present above drinking water goals (MTBE, chlorinated solvents, etc.);
 - Non-persistent, petroleum-related contaminants do not exceed drinking water goals by more than one order of magnitude;
- For plumes within 150m of an aquatic habitat (including drainage ways that lead to a surface water body):
 - Contaminant concentrations do not exceed action levels for chronic aquatic toxicity concerns for undeveloped waterfronts; or
 - Contaminant concentrations do not exceed action levels for acute aquatic toxicity concerns for developed waterfronts;
- For plumes not within 150m of an aquatic habitat:
 - Contaminant concentrations do not exceed action levels for acute aquatic toxicity concerns; and
- No vapor intrusion or methane buildup concerns in the absence of engineered controls.

The distance of 300m from a producing well to highlight “high-risk” plumes is subjective and is not necessarily reflective of groundwater flow rates in well capture zones. The two-year capture zone for municipal water wells installed in the basal, basalt aquifer can extend outward from the well head 3,000 meters or more (personal communication, HDOH Safe Drinking Water Branch). The upper few meters of the aquifer (where petroleum-contaminated groundwater is usually restricted), however, may not be included in the primary capture zone for wells that are screened well below the top of the water table. Unfortunately, detailed information on the design and construction of municipal water supply wells is not available to the general public. A more detailed evaluation will be required if HDOH determines that a water supply well is potentially at risk of being contaminated.

Sites where the above conditions are met can petition HDOH for case closure under a *No Further Action* letter. The burden and responsibility for long-term management of remaining contamination, as described in an *Environmental Hazard Management Plan*, is placed on the property owner (or other responsible party). HDOH reserves the right to reopen a case if it is determined that residual contamination is not being adequately managed.

Sites that do not meet these conditions will remain under the long-term oversight of HDOH, unless otherwise determined on a case-by-case basis. Responsible parties can, however, petition HDOH for a letter concurring that *No Further Active Remediation* is required. This lessens uncertainty regarding the financial “environmental liability” associated with the property and can assist in future property transfers and redevelopment.

Determining Need for Continued HDOH Oversight

A stepwise approach to determine the need for continued HDOH oversight of petroleum-contaminated sites is discussed below and summarized in Figures 1 through 3. Target contaminants of concern should be identified based on a comparison to HDOH Tier 1 EALs or approved, alternative action levels. The extent and magnitude of remaining petroleum contamination above action levels must be clearly documented in an updated site assessment report that summarizes post-remediation site conditions.

Potential environmental concerns posed by the contamination must be identified and discussed in an *Environmental Hazard Assessment* report. In most cases, this will involve a comparison of site data to HDOH EALs for specific environmental concerns or acceptable, alternative criteria (HDOH 2005a). A more detailed assessment of environmental concerns can be carried out on a site-by-site basis as needed.

This information should be used to develop an *Environmental Hazard Management Plan* that describes long-term monitoring and management of remaining contaminated soil and groundwater at the site. The report must discuss any engineered or institutional controls necessary to keep the contamination from spreading as well as to prevent adverse exposure of residents or workers and ensure proper reuse or disposal of soil and groundwater that is disturbed during future subsurface activities. Both the *Environmental Hazard Assessment* and *Environmental Hazard Management Plan* can be presented as part of the updated, site assessment report.

Step 1: Identify Target Contaminants of Concern

Table 1 provides an updated summary of contaminants of potential concern that must be included in environmental investigations at petroleum release sites. Petroleum contamination must be evaluated in terms of both Total Petroleum Hydrocarbon (TPH) and target "indicator chemicals" for the specific type of petroleum product released (e.g., benzene, toluene, ethylbenzene and xylenes or "BTEX", methyl tertiary butyl ether [MTBE], polynuclear aromatic hydrocarbons [PAHs], etc.). Soil, groundwater and soil gas samples must always be tested for TPH in addition to the target indicator chemicals noted in Table 1 and discussed below.

Petroleum is a complex mixture of hundreds of different compounds composed of hydrogen and carbon (i.e., "hydrocarbon" compounds). The bulk of these compounds are evaluated under the all-inclusive category of "TPH." Gasoline-range TPH is a petroleum mixture 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 (API 1994). Total Petroleum Hydrocarbon associated with middle distillates (e.g., kerosene, diesel fuel, home heating fuel, jet fuel, etc.) is characterized by a wider variety of straight, branched and cyclic alkanes, PAHs (especially naphthalenes and methyl naphthalenes) and heterocyclic compounds with carbon ranges of approximately C9 to C25. Residual fuels (e.g., Fuel Oil Nos. 4, 5, and 6, lubricating oils, mineral oil, used oils, asphalts, etc.) are characterized complex, polar PAHs, naphthoaromatics, asphaltenes and other, high-molecular-weight, saturated hydrocarbon compounds with carbon ranges that in general fall between C24 and C40.

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 or gravimetric methods. The latter methods are rarely used, however, due to an inability to discriminate the type of the petroleum present and interference with organic material in the soil.

Environmental action levels for TPH are developed by assigning representative fate and transport properties and toxicity factors to each TPH category and applying the same models and approaches as used for the target, indicator compounds (HDOH 2005a). A more in-depth analysis of the specific components of the TPH can be carried out in a site-specific environmental hazard assessment as needed (e.g., TPHWG 1998, MAEDP 2002).

Target indicator chemicals typically make up only a small fraction of the total petroleum present but are important players in the assessment of environmental hazards posed to human and the environment. A brief discussion of target indicator chemicals for petroleum products is included in Chapter 2 of the HDOH document *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (HDOH 2005a). The 2005 HDOH guidance recommends that the following PAHs be included as target indicator chemicals for soil and groundwater contaminated with middle distillates and residual fuels:

- acenaphthene
- acenaphthylene
- anthracene
- benzo(a)anthracene
- benzo(b)fluoranthene
- benzo(g,h,i)perylene
- benzo(a)pyrene
- benzo(k)fluoranthene
- chrysene
- dibenzo(a,h)anthracene
- fluoranthene
- fluorene
- indeno(1,2,3)pyrene,
- methylnaphthalenes (1- and 2-)
- naphthalene
- phenanthrene
- pyrene

Environmental Action Levels for these chemicals are included in the HDOH EAL lookup tables (HDOH 2005a). The list of target PAHs was taken from guidance prepared by the USEPA and various state agencies in the 1990s (e.g., CalEPA 1996b, USEPA 2004).

This technical memorandum reduces the PAHs that must be included as target indicator compounds for releases of middle distillate fuels to naphthalene and methylnaphthalene (Table 1, after MAEDP 2002). A review of field data and discussions suggests that the majority of the PAHs are not present in middle distillate fuels at concentrations that would drive environmental concerns and cleanup actions. From an environmental hazard standpoint, cleanup of releases of middle distillate fuels is almost always driven by Total Petroleum Hydrocarbons (TPH) contamination, not PAHs. Naphthalene and methylnaphthalenes are two potential exceptions, since they can be present in middle distillate fuels at relatively high concentrations and are moderately volatile and mobile. Naphthalene is also an upcoming contaminant in vapor intrusion studies, although it is unlikely to be present in middle distillate fuels at levels that would pose vapor intrusion concerns when TPH itself does not exceed HDOH action levels.

Soil and groundwater contaminated with middle distillate fuels must also be tested for BTEX (Table 1). Although BTEX rarely drives cleanup for releases middle distillate fuels, their presence or absence is a useful indicator of past gasoline releases at the site or the migration of

gasoline-contaminated groundwater onto the property from offsite sources. Testing for naphthalene at gasoline release sites is also recommended (refer to Table 1).

Soil and/or groundwater contaminated with used oils, coal tar, asphalt and other heavy petroleum mixtures must be tested for the full suite of PAHs noted above. Releases of unused lube oil, transformer oils, mineral oils, virgin hydraulic oils, Fuel Oil #6 and similar products do not require testing for PAHs and other chemicals if it can be demonstrated that product released was never heated to high temperatures (potentially producing PAHs). Testing must also be carried out for volatile organic compounds (VOCs, including chlorinated solvents), PCBs and heavy metals unless otherwise justified.

Step 2: Prepare Updated Site Assessment Report

Site conditions following active remediation of contaminated soil and groundwater to the extent practicable must be clearly documented in an updated site assessment report. Information that should be provided in the report includes:

- Summary of Past, Current and Anticipated Future Site Activities and Uses:
 - Describe past and current site uses and activities;
 - Describe foreseeable future site uses and activities;
- Summary of Pre- and Post-Remediation Site Conditions:
 - Identify all types of impacted media;
 - Identify all sources of chemical releases;
 - Identify all chemicals of concern;
 - Delineate on to-scale maps the magnitude and extent of contamination above EALs (or other approved action levels) to extent practicable and applicable;
 - Identify nearby groundwater extraction wells, bodies of surface water and other potentially sensitive ecological habitats;
 - Ensure data are representative of site conditions.

Surveyed, to-scale maps of the site that clearly indicate the location of remaining contaminated soil and groundwater must be included in the report. This information will be necessary for both the assessment of potential environmental concerns or *hazards* posed by the contamination as well as the preparation of an *Environmental Hazard Management Report*, discussed in the following steps.

Step 3: Prepare Environmental Hazard Assessment

An *Environmental Hazard Assessment* is an evaluation of potential environmental concerns at sites where releases of petroleum or other hazardous chemicals have occurred (HDOH 2005a). Common environmental concerns that must be assessed at sites where petroleum-contaminated soil and/or groundwater are identified include:

Soil:

- Direct exposure to contaminants in soil (ingestion, dermal absorption, inhalation of vapors and dust in outdoor air);

- Emission of vapors to building interiors;
- Impacts to terrestrial ecological habitats;
- Leaching and impacts to groundwater resources; and
- General gross contamination and resource degradation (including generation of vapors and explosive hazards, potentially mobile free product, odors, general resource degradation, etc.);

Groundwater:

- Impacts to drinking water resources;
- Emission of vapors to building interiors;
- Impacts to aquatic habitats (discharges of contaminated groundwater to surface water); and
- Other gross contamination and resource degradation concerns (including intrusion of vapors into utility conduits, potentially mobile free product, sheens, etc.).

A more detailed discussion of common environmental concerns posed by contaminated soil and groundwater is provided in the HDOH document *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (HDOH 2005a).

The presence or absence of potential environmental concerns is first evaluated in a brief, *Environmental Hazard Assessment*. This can be done by comparison of site data to the summary, Tier 1 EALs presented in Volume 1 of the HDOH document *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (HDOH 2005a). The presence of chemicals at concentrations above an action level *does not* necessarily indicate that hazardous conditions exist at the site. It *does*, however, indicate that additional evaluation of identified, potential concerns is warranted.

When a Tier 1 EAL (or approved, alternative action level) is exceeded, specific environmental concerns can be identified by comparison of representative contaminant concentrations to detailed action levels presented in Appendix 1 of the HDOH EAL document. The Excel-based, EAL “Surfer” or electronic lookup tables can be used to expedite this process (available for download from the HDOH EAL webpage, see URL address in HDOH 2005a reference). The Surfer allows direct input of representative contaminant concentrations. Specific environmental concerns are identified if input contaminant concentrations in soil or groundwater exceed the primary Tier 1 EAL. The Surfer then generates a “Summary Report” that can be printed and included as supporting documentation for a basic *Environmental Hazard Assessment* report. Note that decision unit and multi-increment investigation strategies are preferred over the use of discrete sample data, when feasible (refer to HDOH 2007b).

An *Environmental Hazard Assessment* report must be prepared to document potential environmental concerns associated with remaining contamination at the site. This document should include the following information:

- Site Background;
- Summary of investigations (including to-scale maps with a north arrow);
- Applicability of HDOH EALs or alternative action levels;
- Selection of soil and groundwater categories;

- Selection of EALs & comparison to site data;
- Identification of specific environmental concerns if final Tier 1 EALs exceeded; and
- Recommendations for followup actions, including preparation of an *Environmental Hazard Management Plan* or, if needed, a more detailed assessment of identified environmental concerns.

A more detailed discussion of the preparation of *Environmental Hazard Assessment Reports* is provided in Volume 1 of the HDOH EAL document (HDOH 2005a). For relatively simple sites, the assessment can be included as a separate chapter in the post-remediation report, with EAL Surfer printouts, etc., included in the appendices. Maps that depict specific environmental concerns posed by contamination in various areas of the site can also be very useful, and in some cases required, for inclusion in the site *Environmental Hazard Management Report*, as discussed below (e.g., areas that pose direct-exposure, leaching or vapor intrusion concerns; areas of free product, grossly contaminated soil or methane buildup, etc.).

Conditions that pose immediate or short-term environmental concerns should be addressed as quickly as possible. This includes exposure of residents or workers to potentially harmful levels of contaminants in soil (“direct exposure”), impacts to water supply wells, intrusion of vapors or methane into overlying structures (including explosive hazards) and discharges of free product to surface water.

Note that the approach described above is referred to as *Environmental “Risk” Assessment* in the 2005 HDOH EAL document. The term “risk” is replaced with the term “hazard” in this guidance document. This was done to emphasize the fact that some environmental concerns are not necessarily toxicological in nature, as the term “risk” is often interpreted to indicate. Examples include explosive hazards, leaching of contaminants from soil and even general gross contamination concerns. Human health and ecological risk are of course an important component of an *Environmental Hazard Assessment*, but they cannot be used as stand-alone tools to assess the need for potential cleanup actions at sites where petroleum-contaminated soil and groundwater are identified. This change in terminology will be noted in upcoming revisions of HDOH environmental guidance documents.

Step 4: Prepare Environmental Hazard Management Plan

The purpose of an *Environmental Hazard Management Plan* (EHMP) is threefold: 1) document the extent and magnitude of contaminated soil and groundwater left in place at a site, 2) summarize identified environmental concerns posed by the contamination and 3) provide a framework for long-term management of the contamination. An EHMP must be prepared for all petroleum-release sites where residual soil and groundwater contamination is left in place above levels that could pose potential environmental concerns. A copy of the plan must be submitted to HDOH for inclusion in the public file.

An *Environmental Hazard Management Plan* is similar in intent to what are commonly referred to as *Risk Management Plans* or *Soil and Groundwater Management Plans*, as described in the current editions of the HEER Office and SHWB *Technical Guidance Manuals* (HDOH 1997, 2000; USEPA 2003). A *Risk Management Plan* or *Exposure Prevention Management Plan* typically focuses on the reduction or elimination of risks to human health posed by direct exposure to contamination in soil or groundwater or by the emission of vapors into buildings.

While important, other potential concerns such as leaching, explosive hazards and the simple need to properly manage grossly contaminated soil or groundwater are often ignored. A *Soil and Groundwater Management Plan* describes measures for handling, reusing and/or disposing of contaminated soil and groundwater that is encountered during future subsurface activities, including the repair of underground utilities or redevelopment of the property. Again, this information is important but these plans often fail to identify the specific environmental concerns posed by the contamination.

An *Environmental Hazard Management Plan* combines all necessary information into a single, stand-alone document that identifies the nature of the contamination present, the potential environmental concerns posed by the contamination, and appropriate measures to ensure that these concerns are adequately addressed. An *Environmental Hazard Management Plan* should include the following information, at a minimum:

- Brief summary of the site background and history of contaminant releases;
- Identification of specific contaminants of concern, including TPH, “Target Indicator Compounds” and any other contaminants associated with the release (refer to Step 1);
- Clear depiction of the extent and magnitude of remaining contamination in soil, groundwater and/or soil gas, presented on easily readable, to-scale maps with a north arrow (refer to Step 2);
- Identification and discussion of all potential environmental concerns (refer to Step 3);
- Requirements for long-term monitoring of contaminants in soil, groundwater, and/or soil gas;
- Discussion of engineered and/or institutional controls needed to address identified environmental concerns, including caps, barriers, etc., needed to eliminate exposure pathways;
- Guidance on the proper handling, reuse and disposal of contaminated soil and/or groundwater that is encountered during future site activities;
- Measures for repair or replacement of engineered controls that are disturbed or breached during future site activities; and
- Any other information required to adequately mitigate and manage remaining environmental concerns at the site.

A brief Fact Sheet that summarizes key elements of the *Environmental Hazard Management Plan* in simple, non-technical terms will be required for large, complex sites where significant public review is anticipated.

Long-term environmental concerns must be clearly assessed and documented to ensure that in-place management of the remaining petroleum contamination is viable and carried out properly. Examples of potential, long-term management actions include: 1) capping of grossly contaminated soil under paved areas or buildings, 2) installation of vapor barriers beneath buildings, 3) lining of utility corridors to prevent the migration of contaminated groundwater or vapors into storm drains, utility trenches or other subsurface conduits, 4) restrictions on subsurface activity in some areas without pre-approved work plans, 5) procedures for proper disposal or reuse of contaminated soil and groundwater disturbed during subsurface activities, 6) long-term monitoring of on-site groundwater and soil gas and, 7) installation of offsite “sentinel

wells” to monitor potential long-term impacts to more distant water supply wells or surface water bodies.

Additional guidance on engineered and institutional controls and the preparation of *Environmental Hazard Management Plans* will be provided in the upcoming revision of the HEER Office *Technical Guidance Manual* (anticipated late 2007, refer also to USEPA 2003). The complexity of the *Environmental Hazard Management Plan* for a given site will depend on the extent and nature of the specific contaminants released (mobility, toxicity, explosive hazard, etc.), the specific environmental concerns posed by the contamination and the current and future site use. For relatively simple sites, the *Environmental Hazard Management Plan* can be included as an appendix in the final site closure report.

Step 5: Determine Need for Continued HDOH Oversight

Figures 2 and Figure 3 provide flow charts to assist in determining an appropriate course of action for long-term oversight of petroleum-contaminated soil and groundwater, respectively. The flow charts, and related discussion below, should be considered general guidance only and not strict requirements that must be met before the status of a site can be updated to “closed” under a *No Further Action Letter*. As in any subject where the distinct lines between “yes” and “no” are difficult to draw, the use of sound, professional judgment is very important.

Cases where remaining contamination is minimal in extent and/or magnitude and not likely to pose significant environmental concerns under worst-case conditions can generally be closed under a *No Further Action* letter from HDOH. No further monitoring or reporting requirements will be imposed on these sites. Long-term management of remaining contamination must be carried out in accordance with the *Environmental Hazard Management Plan* prepared for the site. HDOH retains the right to reopen the case and impose enforcement actions if contaminated soil or groundwater is not properly managed.

Continued HDOH oversight will be necessary at sites where remaining contamination could pose significant environmental concerns if not appropriately managed. Sites where potentially significant, environmental concerns remain but active remediation (excavation, soil vapor extraction, etc.) is no longer practical can, and should, request a letter from HDOH clarifying that no *further active remediation* is required. The need for ongoing groundwater or in some cases soil gas monitoring should also be evaluated. The letter is intended to clarify that all major cleanup actions have been completed at the site and that the site has moved into a status of long-term monitoring and management. These letters help property owners, financial institutions and potential purchasers establish the “environmental liability” associated with the remaining environmental contamination and can greatly assist in future property transactions and redevelopment. The *Environmental Hazard Management Plan* should include a description of conditions that will need to be met before the case can be formally closed and a no further action letter issued.

Long-Term Oversight of Petroleum-Contaminated Soil

Continued HDOH oversight of cases with residual petroleum contamination in soil will be required if one of more of the following conditions exists and sufficient justification to close the case is not otherwise provided (see Figure 2):

- Additional remediation technically and economically practicable;
- Anticipated residential redevelopment in near future and representative contaminant concentrations exceed action levels for unrestricted land use;
- Persistent contaminants present above direct-exposure or vapor intrusion action levels for unrestricted land use and no deed restriction recorded (PAHs, MTBE, heavy metals, PCBs, chlorinated solvents, etc.);
- Direct exposure, vapor intrusion and/or leaching concerns under current or anticipated land use but engineered controls not in place prevent exposure or contaminant migration; and/or
- Nonpersistent contaminants only (e.g., TPH, BTEX, etc.) but volume of soil contaminated above action levels exceeds 10 cubic meters (approximately 15 cubic yards).

HDOH Tier 1 EALs are pre-approved for use at all sites and should be referred to in the absence of acceptable, site-specific, Tier 2 or Tier 3 action levels (refer to HDOH EAL document, HDOH 2005a).

For the purposes of this guidance, the term “soil” refers to any unconsolidated soil, sediment or fill material. HDOH Environmental action levels for soil are primarily intended for comparison with sample data collected above the water table. This is because residents, as well as commercial and industrial workers, are unlikely to come into regular contact with soil below the water table. The EALs also include consideration of vapor intrusion concerns and leaching concerns, both of which should not be applied to soils situated in groundwater. Direct collection of groundwater data is instead more pertinent to evaluate these concerns. The collection of soil sample data below the water table can sometimes assist in developing long-term management strategies for sites where residual contamination is to be left in place, however. Procedures for management of contaminated soil situated at or below the water table that is disturbed during future subsurface activities should also be included in the site *Environmental Hazard Management Plan*. Formal covenants that restrict land use and implement engineered controls to prevent exposure or leaching are required for sites where representative concentrations of persistent chemicals exceed action levels for unrestricted, residential land use.

Multi-increment sample data are preferred to establish representative contaminant concentrations within designated decision units over discrete sample data, although in practice this approach is most applicable for surface samples to be tested for non-volatile contaminants. The State of Alaska recently published guidance on the collection of multi-increment samples that area to be tested for volatile chemicals (ADEC 2007). The approach calls for the placement of soil increments in methanol in the field. Restrictions on airline transportation of methanol may limit the use of this approach in Hawai‘i, however. Additional guidance on this subject to be presented in the upcoming update of the HEER Office *Technical Guidance Manual* (anticipated Fall 2007).

Soil gas data are preferred over soil data for evaluation of potential vapor intrusion concerns. Leaching concerns should be evaluated based on comparison to HDOH action levels, the results of laboratory batch test (HDOH 2007a) and/or groundwater monitoring data for sites where the contaminated soil is not capped or in direct contact with groundwater. Closure of a case under a *No Further Action* letter with deeper, grossly contaminated soil that exceeds ten cubic meters in

volume is acceptable provided that the soil does not pose significant leaching and groundwater contamination concerns. This should be discussed on a case-by-case basis with HDOH.

Gross contamination action levels for soil address odor and aesthetic concerns and resource degradation in general (refer to Volume 1 of the HDOH EAL document). The action levels also help identify soil with mobile free product or explosive levels of vapors. Remaining gross contamination concerns at sites where active soil cleanup is no longer practicable should be evaluated by an inspection of soils that exceed action levels for TPH. Gross contamination action levels for soils contaminated with gasoline and middle distillate fuels (diesel, jet fuel, etc.) are based to a large degree on field experience. Action levels for shallow soils ($\leq 3\text{m}$) are considered to be relatively accurate for odor concerns in a residential land use scenario (100 mg/kg and 500 mg/kg for gasoline and middle distillate fuels, respectively, refer to Appendix 1 of the HDOH EAL document for commercial/industrial action levels). Action levels for deeper soils are useful to identify the presence of potentially mobile, free product or the production of potentially explosive petroleum or methane vapors (2,000 mg/kg and 5,000 mg/kg, respectively).

Gross contamination action levels for the broad category of TPH “residual fuels” (motor oil, mineral oil, grease, etc.) are significantly more flexible. Used oil could in some cases pose nuisance concerns at concentrations as low as the default residential action level of 500 mg/kg for residual fuels but higher levels are acceptable on a case-by-case basis if it can be adequately demonstrated that the contamination does not pose adverse nuisance conditions. An in-house study using spiked soil samples indicated action levels of 5,000 mg/kg (shallow soils) and 25,000 mg/kg (deep soils) are appropriate for mineral oil (commonly used in electrical transformers), provided that the oil has not been heated to high temperatures, subjected to fire or contaminated with other chemicals. Similar gross contamination action levels may be appropriate for heavy greases.

Long-Term Oversight of Petroleum-Contaminated Groundwater

Continued HDOH oversight of cases with residual petroleum contamination in groundwater will be required if one of more of the following conditions exists and sufficient justification to close the case is not otherwise provided (see Figure 3):

- The area of the plume that exceeds action levels is still expanding and/or or migrating away from the original release area;
- The plume is within the capture zone of an active water supply well or within 150m of a potable surface water body and contaminant levels exceed drinking water action levels;
- The plume is not within the capture zone of an active supply well but within a potential drinking water aquifer and concentrations of TPH, BTEX and related petroleum compounds exceed action levels by an order of magnitude or more;
- The plume is not within the capture zone of an active supply well but within a potential drinking water aquifer and concentrations of MTBE, chlorinated solvents or other persistent compounds exceed action levels;
- The plume is within the capture zone of a nondrinking water, industrial or irrigation supply well and contaminant levels exceed action levels for impacts to surface water bodies or other environmental concerns;
- The plume is within 150m of an undeveloped water front or sensitive aquatic habitat and contaminants exceed action levels for chronic toxicity to aquatic organisms;

- The plume is within 150m of a highly developed waterfront area (e.g., wharf area) and contaminants exceed action levels for acute toxicity to aquatic organisms or potentially mobile free product is present;
- Storm sewers, abandoned pipelines or other subsurface utilities are located adjacent to or within plume and could serve as potential conduits for migration of free product or other contaminants to surface water bodies above the levels of concern noted above; and
- Free product on groundwater could pose a risk to on-site workers involved in excavation or dewatering activities, and/or long-term methane generation or vapor intrusion concerns.

A more detailed discussion of groundwater utility (e.g., drinking water supply, irrigation supply, etc.) is provided in Volume 1 of the HDOH document *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (HDOH 2005a). The status of an aquifer as a potential source of drinking water is determined in part on the location of the groundwater with respect to the Underground Injection Control (UIC) Line and the state *Aquifer Identification and Classification* technical reports prepared by the University of Hawai'i. Groundwater in a viable aquifer that is situated inland ("mauka") of the UIC line or in the basal aquifer under coastal caprock sediments is generally considered by HDOH to be a potential water supply resource.

Once the source of a release has been removed (including vadose-zone soil that could act as a secondary leaching source), a minimum of two years of quarterly monitoring is generally required to establish that a plume is not expanding or migrating above levels of potential concern. This assumes that groundwater is not contaminated with MTBE and other persistent chemicals above levels of concern, in which case a plume may never become truly "stable" and long-term monitoring will be required. Long-term monitoring data can also be used to develop degradation trends for contaminants of concern (e.g., API 2007). If a convincing case can be made that contaminant levels will reach target goals within five years and currently used water supply wells are not threatened then closure of the case under a *No Further Action* letter will be considered.

If the source(s) of groundwater contamination has been gone for five or more years earlier, less data, in some cases even a single monitoring event, will be adequate to establish that a plume has reached it's greatest extent and is unlikely to spread further. Natural degradation and sorption of remaining contamination to soil particles quickly halt the spread and migration of petroleum-contaminated groundwater once the source has been removed. Plumes rarely extend more than 150 meters from the original release area in the absence of MTBE or other persistent and highly mobile chemicals. However, storm sewers, abandoned pipelines, other subsurface utilities or shallow irrigation wells could act as conduits for contaminated groundwater to reach more distant surface water bodies. Potential dewatering at construction sites must also be considered in areas of shallow groundwater, as should the potential for contaminated groundwater to enter an irrigation or industrial water supply well and ultimately be discharged into an irrigation canal, storm water drain or other direct conduit to a surface water body. These situations will require that the groundwater be screened against chronic rather than acute aquatic toxicity goals and must be evaluated on a site-by-site basis. HDOH NPDES requirements may also apply for surface discharges of contaminated groundwater.

Dilution of contaminated groundwater upon discharge to a surface water body is not taken into consideration for initial screening of potential impacts to aquatic habitats. This is because organisms living in the sediment that organisms living in the water column rely on as a food source could be exposed directly to the groundwater prior to discharge. Benthic habitats located along natural stream or channel banks or shoreline areas are particularly at risk. Groundwater in these areas should be screened against the more stringent, chronic, aquatic toxicity action levels included in Tier 1 EALs for areas within 150m of a surface water body (refer to Appendix 1 of the HDOH EAL document). Screening of groundwater data against acute aquatic toxicity action levels is considered adequate in highly developed waterfront areas (wharfs, seawalls, etc.) where significant benthic communities are generally absent in the area where contaminated groundwater may discharge and the primary risk is to aquatic organisms living in the water column. Impacts that result in a sheen on a surface water body must be avoided in all cases.

Other factors that can be considered in evaluating the need for continued HDOH oversight include the aerial extent of impacted groundwater and impacts to deep, non-potable groundwater. In commercial/industrial areas, petroleum-contaminated groundwater generally does not pose a significant threat to human health and the environment regardless of the actual concentrations of TPH or petroleum-related target indicator chemicals if the following conditions are met: 1) plume is not expanding or migrating away from the release area above final, target action levels, 2) area of remaining free product is less than approximately 100 square meters (assumed size of an existing or future building, minimal vapor intrusion and methane buildup concerns,) and 3) depth to groundwater is greater than five meters (unlikely to be encountered during future construction activity). This assumes the absence of conduits for offsite migration (storm sewers, etc.). Closure of such cases under a *No Further Action* letter with management of remaining contamination under an *Environmental Hazard Management Plan* should be considered. The primary concerns for deep (e.g., >5m), non-potable groundwater impacted with petroleum are offsite migration, the generation of methane and vapor intrusion into existing or future buildings. Closure of the case under *No Further Action* letter should be considered regardless of contaminant concentrations in groundwater if long-term groundwater monitoring data indicate that the plume is not migrating away from the release area above levels of concern and soil gas data rule out the potential for significant methane buildup or vapor intrusion concerns.

Wells that will no longer be used to monitor groundwater must be properly abandoned. Documentation on well abandonment must be submitted to HDOH for inclusion in the public file.

References:

- ADEC, 2007, *Guidance on Multi-Increment Soil Sampling* (March 2007): Alaska Department of Environmental Conservation, Division of Spill Prevention and Response, Contaminated Sites Program, http://www.dec.state.ak.us/SPAR/csp/guidance/multi_increment.pdf
- API, 1994, *Transport and Fate of Non-BTEX Petroleum Chemicals in Soils and Groundwater*: American Petroleum Institute, Health and Environmental Sciences Department, Publication No. 4593.
- API, 2007, *Technical Protocol for Evaluating the Natural Attenuation of MtBE*: American Petroleum Institute, Regulatory and Scientific Affairs Department, Publication No. 4761, http://www.api.org/ehs/groundwater/oxygenates/upload/4761_Final.pdf.

- CalEPA, 1996a, *Interim Guidance on Required Cleanup at Low Risk Fuel Sites*: California Department of Environmental Protection, California Regional Water Quality Control Board, San Francisco Bay Region, January 5, 1996.
- CalEPA, 1996b, *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities*: California Department of Environmental Protection, Department of Toxics Substances Control, August 1996, www.dtsc.ca.gov/ScienceTechnology/index.html.
- HDOH, 1997, *Technical Guidance Manual For Implementation of the State Contingency Plan* (October 1997): Hawai'i Department of Health, Hazard Evaluation and Emergency Response Office, <http://www.hawaii.gov/health/environmental/hazard/index.html>.
- HDOH, 2000, *Technical Guidance Manual For Underground Storage Tank Closure and Release Response* (March 2000): State of Hawai'i, Department of Health, Environmental Management Division, Solid and Hazardous Waste Branch, <http://www.hawaii.gov/health/environmental/waste/ust/index.html>
- HDOH, 2005a, *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (May 2005 and updates): Hawai'i Department of Health, Hazard Evaluation and Emergency Response Office, www.hawaii.gov/health/environmental/hazard/eal2005.html.
- HDOH, 2005b, *Use of May 2005 Environmental Action Levels ("EALs") at Leaking Underground Storage Tank Sites* (June 7, 2005): Hawai'i Department of Health, Solid & Hazardous Waste Branch, <http://www.hawaii.gov/health/environmental/waste/ust/index.html>.
- HDOH, 2007a, *Use of laboratory batch tests to evaluate potential leaching of contaminants from soil* (April 12, 2007): Hawai'i Department of Health, Solid & Hazardous Waste Branch, www.hawaii.gov/health/environmental/hazard/eal2005.html.
- HDOH, 2007b, *Pesticides in former agricultural lands and related areas - Updates on investigation and assessment* (May 11, 2007): Hawai'i Department of Health, Solid & Hazardous Waste Branch, www.hawaii.gov/health/environmental/hazard/eal2005.html.
- MADEP, 2002, *Characterizing Risks Posed by Petroleum Contaminated Sites* (October 2002): Massachusetts Department of Environmental Protection, Policy #WSC-02-411, http://mass.gov/dep/cleanup/laws/vph_eph.htm.
- TPHCWG, 1998, *Analysis of Petroleum Hydrocarbons in Environmental Media*: Total Petroleum Hydrocarbon Working Group (ed. Wade Weisman), Amherst Scientific Publishers, Amherst, Massachusetts, ISBN 1-884-940-14-5, <http://aehs.com/publications/catalog/contents/tph.htm>.
- USEPA, 2003, *Institutional Controls: A Guide to Implementing, Monitoring, and Enforcing Institutional Controls at Superfund, Brownfields, Federal Facility, UST and RCRA Corrective Action Cleanups* (Draft December 2002): US Environmental Protection Agency, Office of Solid Waste and Emergency Response, <http://www.epa.gov/superfund/action/ic/guide/icdraft.pdf>

Table 1. Recommended Target Analyte List For Petroleum Products

Petroleum Product	Media	Recommended Target Analytes
Gasolines	Soil	TPH, benzene, toluene, ethylbenzene, xylenes (BTEX), naphthalene, MTBE and appropriate additives and breakdown products (e.g., DBA, TBA, lead, etc.)
	Soil Gas	Same as soil plus methane
	Groundwater	Same as soil
Middle Distillates (diesel, kerosene, stoddard solvent, heating fuels, jet fuel, etc.)	Soil	TPH, BTEX, naphthalene, methylnaphthalenes (total 1- and 2-)
	Soil Gas	Same as soil plus methane
	Groundwater	Same as soil
Residual Fuels (lube oils, hydraulic oils, mineral oils, transformer oils, Fuel Oil #6/Bunker C, waste oil, etc.)	Soil	TPH, *VOCs, naphthalene, methylnaphthalenes plus remaining 15 priority pollutant PAHs, plus PCBs and heavy metals unless otherwise justified
	Soil Gas	TPH, VOCs, naphthalene, methylnaphthalenes, methane
	Groundwater	same as soil

*VOC: Volatile Organic Compounds, including BTEX and chlorinated solvent compounds

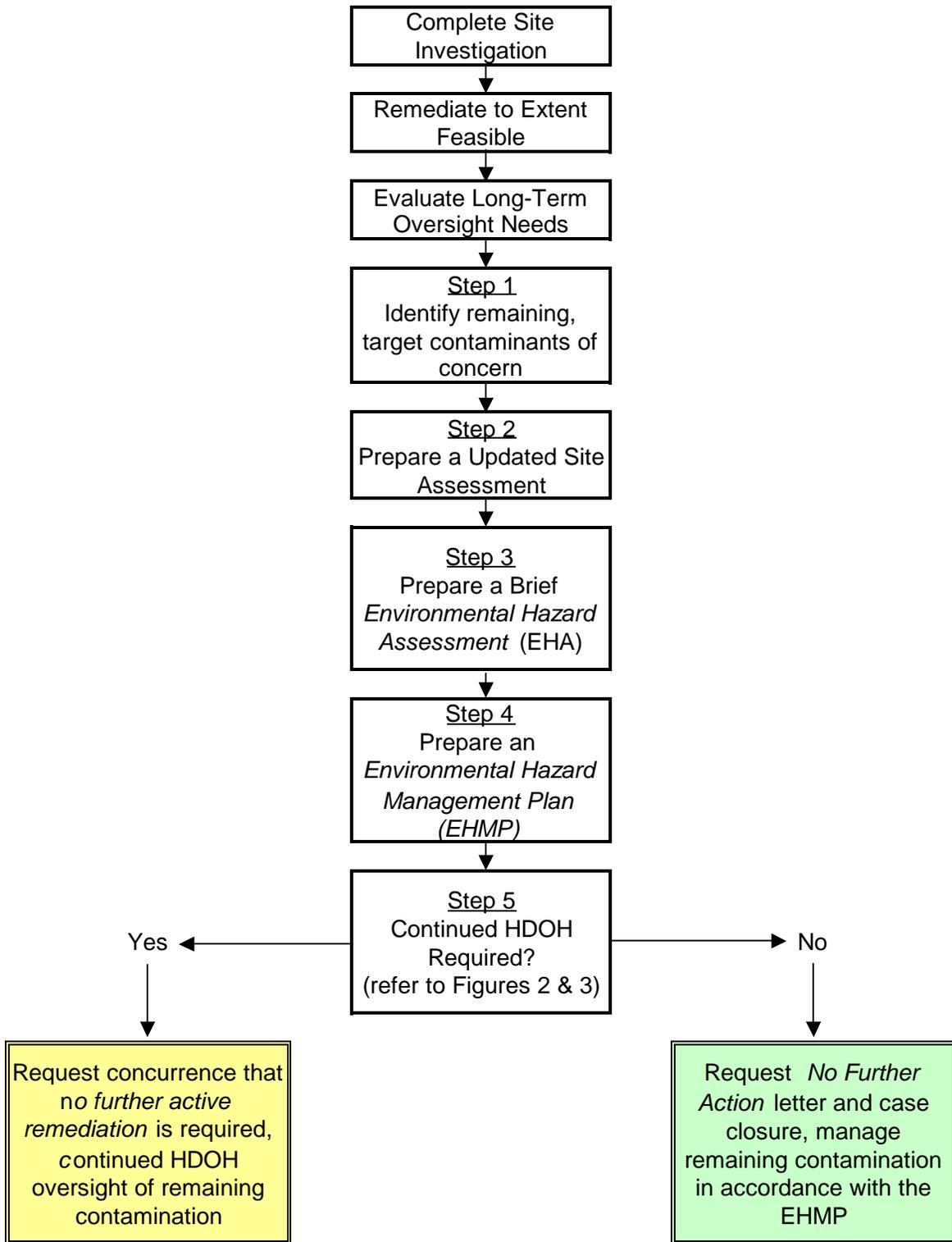


Figure 1. Overview of procedure to determine need for continued, HDOH oversight at sites with remaining petroleum contamination in soil or groundwater above HDOH EALs (or other approved action levels).

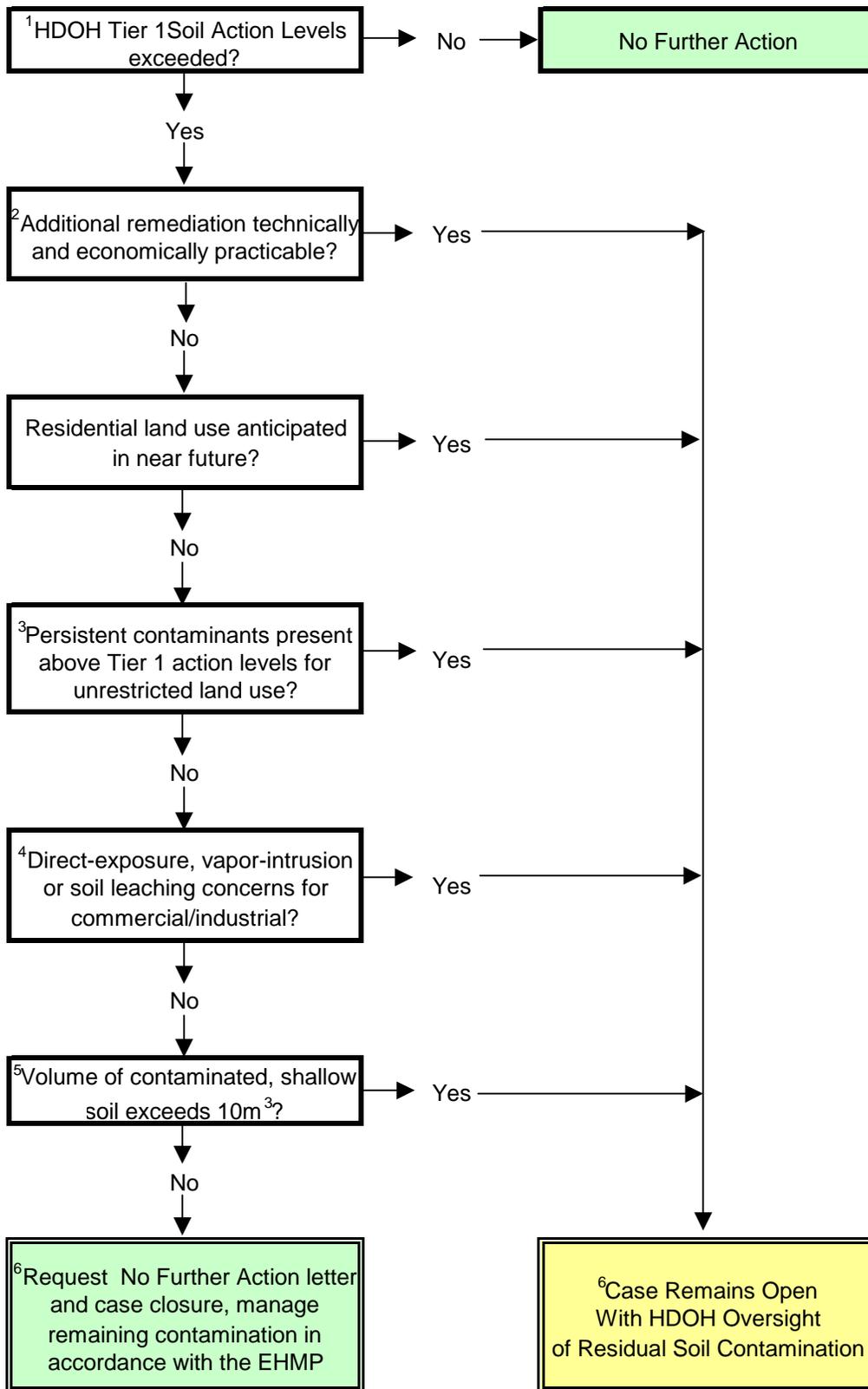


Figure 2. Decision path for long-term oversight of petroleum-contaminated soil following active remediation to extent practicable.

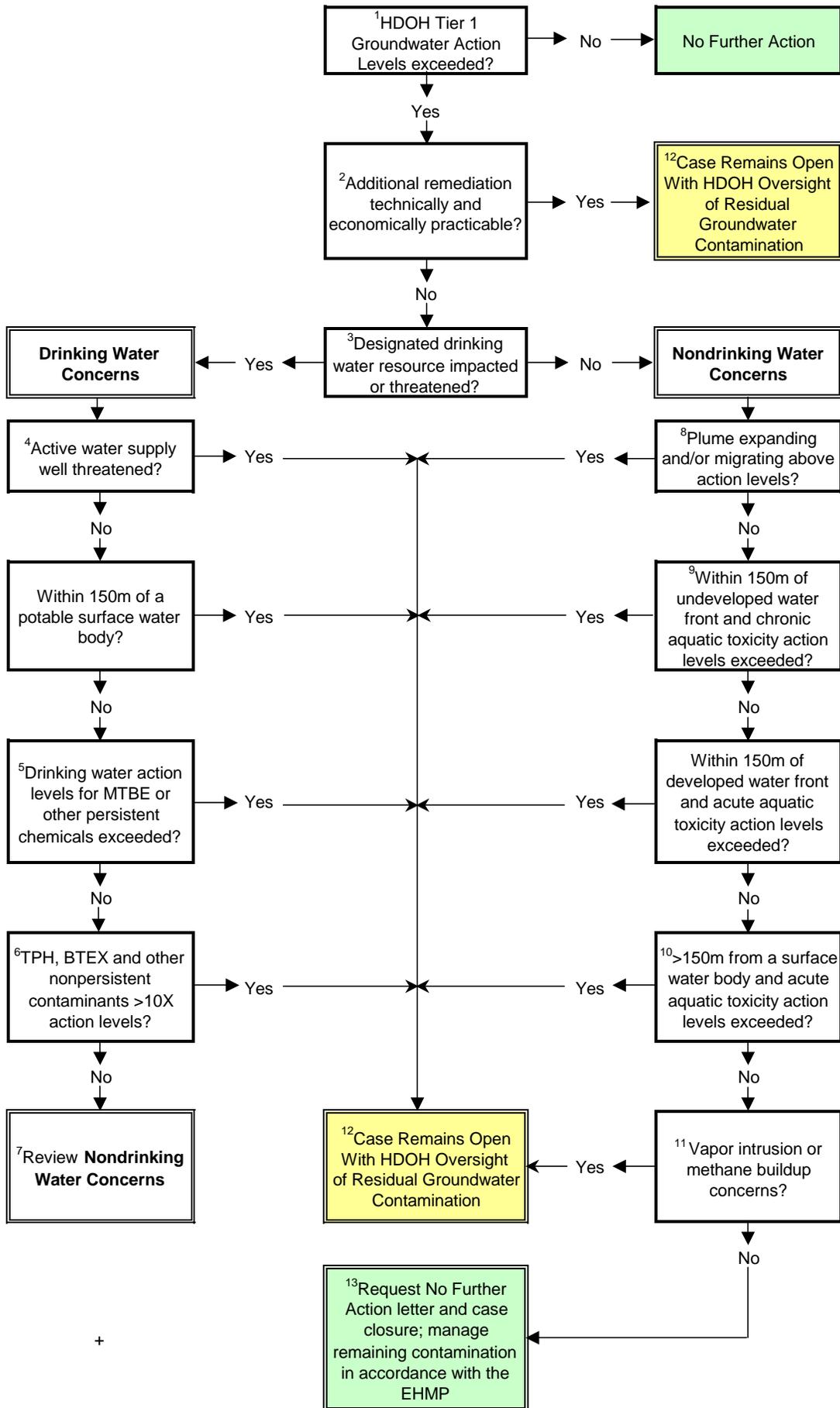


Figure 3. Decision path for long-term oversight of petroleum-contaminated groundwater following active remediation to extent practicable.

Figure footnotes

Figure 2 – Residual soil contamination:

1. Based on comparison of representative contaminant concentrations to HDOH Tier 1 EALs or approved, alternative action levels. “Soil” refers to any unconsolidated media situated above groundwater and does not include soil in the capillary fringe zone or in a smear zone associated with a fluxuating water table. Use groundwater data to evaluate potential concerns posed by soils situated below water table or within capillary fringe zone or groundwater smear zone.
2. Technical and economic practicability of additional cleanup should be discussed with HODH on a case-by-case basis.
3. MTBE, heavy metals, PCBs, chlorinated solvents, etc.
4. Commercial/industrial HDOH EALs for direct-exposure, vapor-intrusion exceeded and/or action levels for leaching concerns exceeded (or approved, alternative action levels) and engineered controls (pavement, etc.) not adequate to prevent exposure or leaching.
5. Shallow soils defined as soils within three meters (approximately ten feet) of the ground surface (HDOH 2005a). Closure of cases with greater volumes of contaminated soil left in place possible is based on a case-by-case review with HDOH.
6. No Further Action. Submittal of updated site assessment, *Environmental Hazard Assessment* and *Environmental Hazard Management Plan* required. Manage remaining contamination in accordance with the *EHMP*.
7. Case remains open under HDOH oversight. Submittal of updated site assessment, *Environmental Hazard Assessment* and *Environmental Hazard Management Plan* required. Option to petition HDOH for *No Further Remedial Action Required* letter.

Figure 3 – Residual groundwater contamination:

1. Based on comparison of representative contaminant concentrations to HDOH Tier 1 EALs or approved, alternative action levels.
2. Technical and economic practicability of additional cleanup should be discussed with HODH on a case-by-case basis.
3. Inland of UIC line or based on published groundwater resource reports.
4. Plume is within 1,000 feet in the upgradient direction of an active, producing water supply well and within producing aquifer (closer review of the potential threat to water supply wells may be required on a case-by-case basis).
5. Contaminants such as MTBE and chlorinated solvents that are known to degrade very slowly in the environment under natural conditions. Contaminant level as exhibited by current monitoring data or projected five-year degradation curve.
6. Contaminants such as TPH and BTEX that are known to rapidly degrade in the environment under natural conditions.
7. Refer to decision pathway for potential environmental concerns not directly related to drinking water.
8. Plume expanding and/or migrating above action levels, includes potential offsite migration via storm sewers, utility corridors, etc.
9. Within 150m of a sensitive aquatic habitat, generally including streams and shoreline areas that have not been significantly altered by culverts, shoreline development, etc., or otherwise protected habitat areas.
10. Consider No Further Action regardless of contaminant concentrations if plume is not migrating, area of remaining free product <math><100\text{m}^2</math>, no vapor intrusion or methane buildup concerns and depth to groundwater is greater than five meters (see text).
11. Vapor intrusion or methane buildup concerns in the absence of engineered controls.
12. Case remains open under HDOH oversight. Submittal of updated site assessment, *Environmental Hazard Assessment* and *Environmental Hazard Management Plan* required. Option to petition HDOH for *No Further Remedial Action Required* letter.
13. Case closed. Submittal of summary report, *Environmental Hazard Assessment* and *Environmental Hazard Management Plan* required. No further monitoring required. Manage remaining contamination in accordance with the *EHMP*.