POLICY
GUIDELINES FOR INVESTIGATING AND REMEDIATING
NITRATE/AMMONIA CONTAMINATION FROM AGRICULTURAL
CHEMICAL RELEASES

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1 previously titled Remediating Soil from Agricultural Chemical Incidents by Excavation and Land Application Interim Measures
INTRODUCTION

Soil, groundwater and surface water at facilities where agricultural chemicals are manufactured, stored, or sold may become contaminated due to accidental catastrophic releases or incremental releases over years of operation. This is especially true of nitrogen fertilizer that may be sold as dry pellets, aqueous solutions or anhydrous ammonia. Once in soil, the nitrogen from fertilizer may remain for long periods of time as nitrate or ammonia, subsequently releasing nitrate to the underlying groundwater or nearby surface water bodies. Excessive nitrogen in soil or water is detrimental to human health and the environment and is considered a contaminant of concern (COC) at many agricultural sites throughout Kansas. Typically, soil and groundwater are the principal media of interest; however, the potential for impact to surface water should be assessed as well. In addition, there may be other known or suspected agricultural COCs that must be addressed through the assessment/remediation process.

The Kansas Department of Health and Environment-Bureau of Environmental Remediation (KDHE-BER) has gained considerable experience with sites contaminated with nitrate and ammonia, learning that certain approaches and technologies are more effective, expedient, and less costly than others for a particular contaminant and situation. This policy and guidance outlines the general requirements and guidelines for remediation of soil and groundwater contaminated with nitrate, ammonia, and nitrite, with consideration of prospective beneficial reuse options for soil, groundwater and/or surface water and cost-benefit analysis to refine any soil excavation strategy. Use of the generic terms nitrate and ammonia in this document refer to the nitrogen form of nitrate-N and ammonia-N. This policy and guidance is intended to be used in conjunction with the KDHE-BER Policy No. BER-RS-047 entitled Nitrate Presumptive Remedy; the Risk-Based Standards for Kansas RSK Manual; and/or, the Voluntary Cleanup and Property Redevelopment Program (VCPRP) Manual.

GENERAL APPROACH

A presumptive remedy is generally a preferred approach or cleanup process for a common category of contamination, used to streamline site investigations and speed up selection of cleanup actions for a site. As described in BER Policy No. BER-RS-47, a nitrate presumptive remedy (NPR) implementation may consist of providing alternate water supplies, as needed; delineating nitrate and ammonia contamination in soil; excavating soil source area(s) to a practicable extent with beneficial reuse (e.g., land application) or off-site disposal; design,
installation, and operation of a groundwater and/or surface water extraction/recovery system (if applicable) with beneficial reuse (e.g., land application, make-up water), etc.

The threat of continuing contamination of groundwater resources by nitrate leaching from contaminated soil at agricultural facilities leads KDHE-BER to encourage use of a NPR approach for soil removal from such facilities as early as possible in the cleanup process. In KDHE’s experience, the most satisfactory and cost-effective remedy for soil contaminated by fertilizer is excavation with land application of the contaminated soil to nearby agricultural fields at an appropriate agronomic rate for beneficial reuse or disposed off-site at an approved landfill. Remediation and/or extraction of water is often costly and may require a long implementation period, making the timely removal of nitrate- and ammonia-contaminated soil critical for minimizing or reducing the continued impact to groundwater or surface water. If groundwater or surface water is already contaminated above the allowable limit, an extraction/recovery system design and implementation may be required.

REMEDIAL ACTION OBJECTIVES

KDHE-BER has adopted 10 milligrams per liter (mg/L) of nitrate as nitrogen (N) and 1 mg/L of nitrite as N as the maximum permissible level in groundwater, which corresponds with the maximum contaminant level established by the U.S. Environmental Protection Agency (EPA) for public drinking water supplies. The maximum level established for nitrate plus ammonia as N in soil is 40 milligrams per kilogram (mg/kg) below 8 inches in depth in unvegetated areas and below 24 inches in depth in vegetated areas. Nitrogen fertilizer is present in soil and water as nitrate and ammonia. Analytical procedures convert ammonium to ammonia. By convention, the levels of both nitrate and ammonia are reported as nitrogen (N). Threshold levels for nitrate, ammonia, and nitrite in both soil and groundwater are published in the Risk-Based Standards for Kansas RSK Manual, available at http://www.kdheks.gov/remedial/rsk_manual_page.htm. While the levels established in groundwater are risk-based, it should be noted that the values established in soil are based on the potential for the contamination to leach from soil to groundwater. In some cases, KDHE-BER may require that the implementing party evaluate whether surface water has been impacted and, if so, may require monitoring and/or remediation. The KDHE-Bureau of Water (KDHE-BOW) should be consulted regarding appropriate designated uses and applicable surface water quality standards when assessing impacts to nearby surface water bodies.

KEY CONSIDERATIONS

Soil Assessment Strategy

Work plans developed for the investigation of sites where soil contamination by nitrate and/or ammonia is known or suspected should be prepared and implemented to fully delineate the horizontal and vertical extent of nitrate and ammonia soil contamination in order to estimate the volume of soil requiring excavation. If delineation is not accomplished during the initial investigation, then additional investigations and work plan addenda will likely be necessary to fully satisfy investigation objectives. Up front delineation before excavation activities
commence is the preferred approach to best ensure a “turn-key” effort and minimize equipment/personnel downtime.

Other contaminants, such as herbicides/pesticides, volatile organic compounds (VOCs), metals, chlorides and petroleum hydrocarbons, may also be present in soil, groundwater and surface water at agricultural facilities in addition to nitrogen fertilizer. KDHE generally requires that soil and groundwater be sampled for all chemicals believed to have been used, sold, or stored at the facility at least in the areas where chemicals may have been spilled or leaked to the ground. Therefore, all chemicals known or suspected to have been handled or stored at the facility must be assessed during the site investigation with collection of both soil and groundwater samples (initially utilizing direct push methods) in both biased and unbiased locations. Particular attention should be given to the areas around liquid and bulk storage tanks and buildings used to store chemicals or fuels. These areas should be investigated by soil borings and groundwater probes to delineate the extent of contamination. The level of effort related to investigation of non-fertilizer contamination will be determined on a site-specific basis with consideration of existing data as well as current and past storage and handling activities.

If a source area is directly adjacent to a railroad or some other restricted corridor (i.e., utility easement with aboveground or subsurface restrictions), delineation on the opposite accessible side of the restricted corridor may be required. KDHE-BER recognizes that residual contamination left in place within a restricted corridor may continue to further impact soil and groundwater; however, KDHE-BER understands that obtaining access to restricted corridors may be both costly and time consuming. Thus, sample collection on the opposite accessible side will best ensure that the full extent of contamination is reasonably delineated.

KDHE believes that continuous coring using direct push equipment works well in most soils and will provide a sufficient amount of soil information to determine excavation dimensions. Besides biased sample locations in areas of suspected or known impact, unbiased sample locations (e.g., sample grid) should also be identified to sufficiently cover the remaining area of concern. Borehole spacing should be determined by the potential size of the area of concern with flexibility for minor adjustment in the field. Unless otherwise approved by the KDHE-BER project manager, soil borings should be advanced at least to 15 or 20 feet in depth, or to the water table, whichever is encountered first, and sampled, at a minimum, near the surface and at every 5 feet in depth. Soil borings deeper than 20 feet below ground surface may be required and will be determined on a site-specific and KDHE-BER program basis. Although important to collect sufficient samples with depth to determine the vertical extent of impact, if the near surface and 5-foot samples are both confirmed to not exceed corresponding threshold levels, then a determination may be made in consultation with the KDHE-BER project manager to not analyze the remaining samples collected at depth within a particular boring. This decision-based sampling and analysis strategy is a possibility as long as sample holding times are met. It may be advantageous to collect samples on closer horizontal or vertical spacing to limit excavation dimensions.
Soil Sampling and Analysis

Nitrate concentrations in soil can be field screened using readily available field kits and confirmed by laboratory analysis. Use of field screening can help determine the lateral and vertical limits of nitrate contamination and guide the collection of additional data points as needed during the investigation.

Field kits for on-site analysis of nitrate in soil are commercially available. They generally require extracting nitrate from a specified weight of soil by using a potassium chloride solution or deionized water and testing of the extract with colorimetric test strips or other appropriate method. The extract may need to be filtered prior to nitrate determination. The implementing party should choose the field kit most suitable to their needs and develop a standard operating procedure (SOP) for field analysis including laboratory confirmation and correlation. Actual field analyses utilizing a specific kit or sampling technique should be thoroughly correlated to laboratory analytical data before finalizing the SOP. Correlation may consist of collecting a sample for both field screening with the kit and analysis by a laboratory. This can be done to determine correlation between laboratory analytical results and field screening results and determine whether the use of the kit is adequate for field screening purposes. The general expectation is that a minimum of ten percent of the samples (representing high, medium and low field screen results) be sent to an off-site laboratory for confirmation purposes. Commercial mobile laboratories are also available and will provide more definitive results than field kits. Similar to field kit screening, if a mobile laboratory is utilized, a minimum number of samples (e.g., ten percent) must be verified by an off-site fixed laboratory.

KDHE-BER has determined that composite soil samples may produce adequate results for nitrate-contaminated soil when determining an appropriate excavation volume; however, discrete interval sampling may yield the best results for determining the volume horizontal and vertical extent of contamination. A sample interval from a core or several grab samples from an excavation face can be placed in a plastic bag and thoroughly mixed before the specified weight of sample is removed for field analysis or the laboratory sample is taken. This technique allows for determination of an average nitrogen concentration per volume of soil. Analyzing soil samples for ammonia in addition to nitrate is important since the nitrate converted from the ammonium form is also leaching to groundwater. Quantification of ammonia contamination in soil is also necessary since the Kansas Risk-Based Standards RSK Manual requires that nitrate plus ammonia as N be below 40 mg/kg. Composite sampling may also be necessary to calculate the average pounds of nitrogen being applied per acre. Discrete confirmation, split, or verification samples may be required by certain KDHE-BER programs and will be determined on a site-specific basis. Evaluation of available sample results may serve as the basis for KDHE-BER request for additional excavation or delineation.

Quantification of nitrate and ammonia as N in soil without the quantification of nitrite as N (in soil) is generally acceptable at most nitrate and ammonia contamination sites since nitrite is fairly unstable. Quantification of nitrite as N generally requires an analytical method with a much shorter holding time (48 hours versus 28 days). Some methods can quantify the concentration of nitrate plus nitrite as N and allows for a longer holding period. Minimally, nitrate and ammonia as N in soil should be submitted for laboratory analysis. All fixed
laboratory analysis of nitrate and/or nitrite as N in soil must be conducted by a KDHE-certified laboratory. KDHE does not certify laboratories for the analysis of ammonia in soil. Specific analytical methods for nitrate, nitrite, and ammonia must be approved by the KDHE-BER project manager on a site-specific basis. KDHE-BER may request the quantification of nitrite in soil and groundwater, as necessary. If an analytical method is selected for the analysis of nitrate and nitrite where the holding time for the sample is 48 hours and the holding time is not met, the sample may be analyzed by a method using a longer holding time, but this change must be noted in the corresponding report. Methods using the longer holding time will not yield a quantified concentration of nitrite as N, but will yield a quantified concentration of nitrate plus nitrite as N. A reasonable effort should be made to meet the 48 hour holding time if the analytical method is approved by KDHE-BER and/or is outlined in the pertinent work plan. All soil data should be reported on a dry weight basis rather than a wet-weight basis (since may be biased low).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EPA Water Method #</th>
<th>Standard Method #</th>
<th>Container</th>
<th>Volume Needed (mL)</th>
<th>Preservative</th>
<th>Maximum Hold Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen, Ammonia</td>
<td>350.1/350.2/350.3</td>
<td>4500-NH3</td>
<td>Plastic or Glass</td>
<td>500</td>
<td>pH&lt;2 H2SO4, 4°C</td>
<td>28 days</td>
</tr>
<tr>
<td>Nitrogen, Nitrate</td>
<td>352.1/353.2/353.3</td>
<td>4500-NO3</td>
<td>Plastic or Glass</td>
<td>100</td>
<td>4°C</td>
<td>48 hours</td>
</tr>
<tr>
<td>Nitrogen, Nitrite</td>
<td>354.1</td>
<td>4500-NO2</td>
<td>Plastic or Glass</td>
<td>100</td>
<td>4°C</td>
<td>48 hours</td>
</tr>
<tr>
<td>Nitrogen, Nitrate and Nitrite</td>
<td>353.2</td>
<td>4500-NO3</td>
<td>Plastic or Glass</td>
<td>100</td>
<td>pH&lt;2 H2SO4, 4°C</td>
<td>28 days</td>
</tr>
<tr>
<td>Nitrogen, Organic</td>
<td>351.3</td>
<td>4500-Norg</td>
<td>Plastic or Glass</td>
<td>100</td>
<td>pH&lt;2 H2SO4, 4°C</td>
<td>28 days</td>
</tr>
</tbody>
</table>

* The KDHE Project Manger must approve all proposed analytical methods.

**Construction Debris, Rocks or Other Contaminants in Soil**

Direct push borings may not necessarily indicate the presence of construction debris or rocks in the soil. Rocks and/or construction debris may render soil unsuitable for application to agricultural fields. Contaminated soil containing rocks or debris may need to be disposed of as a special waste at an appropriately licensed landfill. If shallow bedrock or construction debris is suspected at a property, test pit excavations may be necessary to confirm the suitability of the material for excavation. Soil contaminated with herbicide/pesticides, metals, chloride, VOCs, petroleum hydrocarbons, or other contaminants may also not be suitable for land application. Several soil samples from each proposed excavation site should therefore be analyzed for non-fertilizer contamination before land application is approved by KDHE-BER.

**Cost-Benefit Analysis**

The NPR Investigation Report should include a series of contoured site maps showing the concentration of nitrate plus ammonia as N at each 5-foot (or other selected) depth interval in the
soil. The maps can then be used to determine the total volume of removable soil and the weight (as pounds of nitrogen) potentially removable by excavation at each depth interval and in total.

An evaluation of costs versus benefits should be presented in the NPR Action Plan, as this is an important tool to evaluate the actual volume of soil to be excavated. Excavation costs are dependent on soil volume, depth of excavation, haulage distance, and land application, among other factors. KDHE-BER suggests that a table be prepared for each depth interval and contaminant concentration level that is demarked by the contour maps presented in the NPR Investigation Report. The table should present depth, concentration, total weight of nitrogen to be removed, and estimated removal cost. By doing so, costs for removal can be compared to the amount of nitrogen to be removed.

The Kansas Risk-Based cleanup goal for nitrate plus ammonia as N in soil is 40 mg/kg. It is unlikely to be cost effective to excavate all soil at a property having nitrogen levels above 40 mg/kg. Therefore, the purpose of the table is to compare the costs of removing, hauling and land applying all soil that can reasonably be excavated from the 0 to 5 foot depth interval (or other selected depth interval) that has nitrate plus ammonia as N level above 40 mg/kg, above 100 mg/kg, above 200 mg/kg, above 400 mg/kg, etc. Using the total cost determined for the volume of soil in each concentration interval, a cost per pound of nitrogen removed can be determined. When results for each depth interval have been tabulated (the excavation costs per cubic yard of soil will increase with each deeper interval, while the haulage and land application costs remain the same), the data can be used to determine the most cost-effective excavation plan for each property.

KDHE-BER expects that the above determinations will vary with the individual site-specific physical conditions and location of each property. With KDHE-BER approval, the implementing party may choose different limits of excavation depending on their individual circumstances. KDHE-BER experience to date indicates that removal of as much soil as possible above 200-400 mg/kg (N) can be cost-effective.

The following are several of many factors that likely could affect the cost of excavation:

- **Choice or availability of equipment should not be limited to that on-hand at the facility. Instead, equipment should be selected to achieve the objectives identified in the NPR Action Plan.** Tractor-mounted backhoes may be useful for small excavations but may limit excavation depth to 10 or 12 feet. Larger track hoes increase the depth and speed of excavation. Other earth-moving equipment, such as front-end loaders, may be useful for large excavations.

- **Minimizing soil handling and the avoidance of staging soil, either at the excavation site or in the field, will save costs.** Using excavation equipment to directly load an application vehicle suitable for both hauling the soil to the application site and spreading soil on a field will generally result in the most economical operation. Vehicles used for spreading dry fertilizer or feedlot wastes on fields have proven to be practical in actual use.
• If separate vehicles are used to haul the soil to the application site, staging at the site and reloading into application vehicles with a front-end loader will increase costs. Remember that, until the soil is applied to the land at agricultural rates, it is classified as a special waste. Care, such as placing the excavated soil on plastic sheeting and surrounding it with berms of clean soil to control run-off, and covering the excavated soil with plastic sheeting will be necessary to prevent contaminating clean soil, groundwater, and surface water.

• Obviously, finding agricultural land suitable for land application with an owner willing to accept the nitrate and ammonia contaminated soil as close to the excavation as possible is imperative to keep haulage costs under control. Local road fees or weight limitations may regulate access to some potential land application sites.

• The optimal time for land application of nitrate and ammonia contaminated soil to row crops is in the spring when soil is being prepared for planting. Perhaps a more reliable window of opportunity exists for land application to winter wheat land between harvest and fall planting. The generally dryer conditions in July and August in Kansas favor use of wheat land for land application purposes over spring-planted crops. The generally accepted rate of fertilizer application for wheat is 50 pounds of nitrogen per acre. Best management practices recommend other application rates for corn, beans, milo, and pastureland. These values must be used along with agronomic assessment of the existing field-soil conditions in determining acreage needed to receive the excavated soil. The services of a Kansas Certified Crop Advisor may be obtained to assist with determining appropriate rates of application.

• The boundaries of the excavation should be set back from structures and rights-of-way to avoid damage to foundations, roads, and utilities. Deep excavations may need to be stepped for stability. The opinion of a Kansas Licensed Engineer may be necessary to prepare some excavation plans. Excavation depths should be limited to prevent infiltration of groundwater.

• Depending on the size of the area to be disturbed, a stormwater construction permit may be required by the KDHE-Bureau of Water to minimize surface water runoff impacts.

**Excavation Backfilling**

Only clean natural soil containing less than 40 mg/kg of nitrogen is suitable for backfilling an excavation. Refer to BER Policy Number BER-RS-048, “Consideration and Selection of Borrow Sites,” to determine appropriate backfill material. Backfilling with gravel, sand, or waste material must be approved on a project-specific basis by the KDHE-BER project manager. Proposed backfill must be sampled for nitrate and ammonia before use at a rate approved by the KDHE-BER project manager. Soil removed from ponds during cleaning or enlarging may contain high nitrogen levels and may not be suitable backfill material. Sampling the material that will be used to fill the excavation should be completed and results should be provided to the KDHE-BER project manager prior to backfilling the excavation. Once KDHE-BER has concurred that the proposed backfill material is acceptable, based upon review of the analytical results, the implementing party may then backfill the excavated area. Leaving excavations open invites injury, unauthorized waste disposal or the accumulation of water. Backfilling should begin as soon as the excavation is completed and verification samples taken/analyzed.
Laboratory sample analysis may require an expedited turn-around time. Compaction testing should be conducted as necessary to ensure that the backfilled excavation is sufficiently compacted to deter the possibility of future subsidence.

**Beneficial Reuse**

As discussed earlier, in order for a nitrate/ammonia-contaminated site to be eligible for a beneficial reuse remedial alternative, there must be analytical documentation ensuring that no additional contaminants are present in the media of interest at levels exceeding the Tier 2 levels as specified in the *Risk-Based Standards of Kansas RSK Manual*, or other agronomic application rates approved by KDHE-BER.

The proposal for beneficial reuse must identify and address any permit requirements. For short-term land-application proposals, a KDHE-BER *Land Application Work Plan, Land Application Calculation Form*, and *Land Application Agreement Form* must be completed and approved prior to the land application of nitrate/ammonia contaminated soil and/or water. The *Land Application Work Plan* and *Land Application Calculation Form* are intended to ensure that contaminated soil and/or water is applied at rates that do not exceed normal and acceptable application rates for healthy fertilization of crops, while protecting surface water and groundwater from runoff, and minimizing infiltration of excessive amounts of dissolved nitrate/ammonia beyond root zone depths. The *Land Application Agreement Form* ensures that the landowner of the land receiving the contaminated media for beneficial reuse is in agreement with the application and also agrees to ensure that the application is made in accordance with reasonable and prudent crop nutrient application practices. The *Land Application Work Plan, Land Application Calculation Form*, and *Land Application Agreement Form* are available at [http://www.kdheks.gov/remedial/scu/nitrate_contaminated_sites.htm#nitrate](http://www.kdheks.gov/remedial/scu/nitrate_contaminated_sites.htm#nitrate). If pesticides or herbicides are present, even at very low concentrations, the KDHE-BER project manager must coordinate with the Kansas Department of Agriculture (KDA) Pesticide and Fertilizer Program staff in advance to determine if land application is an appropriate option.

**Land Application Process**

A separate land application work plan must be completed for each land parcel to which soil and groundwater will be applied. The land application work plans must be submitted to the KDHE-BER project manager and approved before excavation or groundwater extraction begins. Generally, the selection of the location for land application will be finalized and the forms submitted to KDHE-BER at the same time as the NPR Action Plan. Facility owners and their consultants and contractors should ensure that they have obtained access to a sufficient area of land to receive the estimated volume of soil or groundwater to be excavated or extracted and have obtained the KDHE-BER project managers approval. In KDHE-BER’s experience, locating land suitable for land application and obtaining landowner/operator approval is best accomplished by consulting local residents familiar with agricultural practices in the immediate site vicinity.

Each land application work plan contains a section requiring calculation of application rates for the expected crop based on analyses contained in the NPR Action Plan. If the soil is
heterogeneous, average values may not be very useful. Blending at the application site may be needed to get a relatively uniform application rate otherwise several different application rates may be needed to get a relatively uniform application. The application rate for groundwater is determined the same way as soil application rates with the appropriate conversions. A value for total nitrogen should be used for all application rates for soil and groundwater. A limited number of samples of excavated soil and/or extracted groundwater for land application must be analyzed for other agricultural chemicals including but not limited to pesticides, herbicides, and VOCs. Where pesticides or herbicide contamination is present, regardless of concentration, land application proposals must be coordinated by KDHE-BER with the KDA to determine appropriate application rates and minimum acreage required.

For soil that is not impacted by other agricultural chemicals a conservative application rate of 50 pounds per acre of total nitrogen will be allowed. However, the application rate needed may be lower, depending on the crop. Application rates higher than 50 pounds of total nitrogen per acre must be approved by KDHE-BER. Ammonia in soil may readily volatilize during land application from soil or groundwater and mass lost from volatilization depends on many factors such as temperature and pH. For this reason, KDHE-BER will require that application of ammonia-impacted media be applied at a conservative application rate assuming a zero volatilization factor. In these cases, the application rate may need to be lower depending on the crop and season to minimize overall volatilization effects. Other details on application requirements are outlined in the Land Application Work Plan form available on the KDHE-BER website.

The Land Application Work Plan and Land Application Agreement Form requires the approval and signature of the landowner where the nitrate and/or ammonia enriched soil or groundwater is to be applied. All requirements described in the land application form package must be satisfied. The completed and signed Land Application Work Plan form(s) may be submitted to the KDHE-BER project manager simultaneously with the NPR Action Plan or after plan approval but prior to initiation of any excavation activities.

Once the targeted land application location is identified, it is recommended that soil sampling be conducted to establish a baseline total nitrogen or herbicide/pesticide levels in the receiving parcels before the land application proposal is approved. For nitrogen-only land application proposals, if there has been no nitrogen fertilizer applied within the previous two-year timeframe, the application rate of 50 pounds of total nitrogen per acre is sufficiently conservative to negate the need for such soil sampling. Post-land application sampling of the agricultural field is typically not needed unless required by National Pollution Discharge Elimination System (NPDES) permit conditions. In some cases, it may be appropriate to obtain assistance for determining application rates from a Kansas Certified Crop Advisor. A list of Kansas Certified Crop Advisors can be obtained from the KDHE-BER project manager.

**Groundwater Assessment Strategy**

Nitrate and ammonia impacts to groundwater must also be delineated during the initial investigation. The KDHE-BER project manager may determine that nitrite analysis is also necessary to evaluate the geochemical conditions of the groundwater or to determine whether
nitrite poses a risk at the site. A presumptive remedy approach for remediating and monitoring nitrate/ammonia-contaminated groundwater has also been developed by KDHE-BER, which includes the extraction and containment of contaminated groundwater and the beneficial reuse of that water. Sufficient information should be obtained during the initial investigation to determine groundwater flow direction, the hydraulic gradient and the full horizontal and vertical extent of any groundwater plume, both on- and off-property. The groundwater data will be used to select locations for monitoring wells and extraction/recovery wells, if needed for remediation purposes. If a groundwater extraction/recovery system is proposed or required, a plan outlining the design, implementation, and a performance evaluation must be submitted for KDHE-BER review and approval. In the event that upgradient source(s) of nitrate, nitrite, and/or ammonia are suspected, the upgradient contribution should be adequately evaluated and documented, which may include installing wells upgradient of known on-site contamination. If off-site upgradient sources of nitrate, nitrite, and/or ammonia are contributing the groundwater plume associated with the nitrate presumptive remedy source area(s), KDHE-BER will determine whether groundwater remedial goals should be re-evaluated and/or adjusted.

Beneficial reuse of contaminated surface water or groundwater for irrigation may require approval, oversight, or permits from the KDHE-Bureau of Water (KDHE-BOW) and/or the KDA Division of Water Resources (DWR). For example, while a land application permit allows for the beneficial reuse of extracted/recovered water, the permit is finite in nature. Instead of a land application permit, a National Pollution Discharge Elimination System (NPDES) permit from KDHE-BOW is required for any long-term application of contaminated water. Also, extraction or recovery of contaminated water may require a water appropriation or term permit from the KDA-DWR.

**Investigation-Derived Waste**

Investigation-derived waste (IDW) is often generated during investigation and testing at NPR sites. Typically, soil and water IDW is of finite quantities generated from sampling, soil boring, well installation, and well development or purging. Soil cuttings and well development or purge water can generally be managed consistent with KDHE-BER SOP guidance on management of IDW. No land application paperwork would be necessary for such *de minimis* IDW management. For larger volumes of IDW (e.g., groundwater generated from aquifer testing), unless there are provisions to safely and securely store a large volume from a 24 to 72 hour aquifer test to be used for makeup water over time, the *Land Application Work Plan* could be completed to allow for irrigation beneficial reuse. In some cases where there are low levels of herbicides/pesticides detected, this may not pose an issue from a RSK standpoint, but may be of concern to KDA. It may be appropriate to return low-level IDW to the ground surface on land used for non-agricultural purposes, but KDA should be consulted prior to implementation.