Ecological Risk Assessment at Urban and Industrial Sites Discussion Paper

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This discussion document was developed by the USEPA Ecological Risk Assessment Forum and provides information that can be helpful to consider when performing ecological risk assessments at urban or industrial sites. The implementation of the approaches suggested by this document are at the discretion of the site's ecological risk assessors and the risk management team. This document does not substitute for CERCLA, RCRA, or EPA regulations or guidance, nor is it a regulation. Thus, it cannot impose legally binding requirements on EPA, the States, or the regulated community and may not apply to a particular situation based on the circumstances.

Introduction

Urban and industrial properties can – intentionally or inadvertently – attract ecological receptors to them, and in some cases the ecological use of such areas can rival nearby "natural" areas and habitats. This can be an undesirable occurrence if the urban or industrial areas contain contamination that can pose risks to the visiting wildlife. To assess the potential risks to wildlife on such properties, ecological risk assessment (ERA) is often utilized, but the ERA considerations for urban and industrial sites are usually different than for "natural" or less developed/undeveloped sites or areas. A primary reason for this is that in natural settings as well as at many sites that are slated for return to ecological use as the primary end state, full ecological function[1] is expected, and management of the site and remedial activities usually reflect this expectation. At urban and industrial sites however, the expected use of the site usually has less to do with ecological function but rather involves human related habitation and/or use. For urban or developed sites where human recreation (e.g. golfing) or human residential uses are the primary end use/management goals, ecological function is usually not a primary goal but may be a secondary goal, or may just be an unplanned occurrence. For developed sites where some sort of ecological function is expected, only portions of the area may be expected to have ecological function, and even in those areas the expected ecological function may have more to do with aesthetics for human use rather than be primarily for ecological benefit. At industrial properties, where the site use and expected function is as an industrial facility, there usually isn't any desired or expected ecological function. Industrial facilities might have areas on them (e.g. wastewater ponds) that do experience some ecological

[1] In this document "ecological function" refers to the biological processes occurring in an ecosystem. For "full ecological function" at a site or portion of a site, one would expect all of the biological processes to be occurring that would occur in a healthy, natural ecosystem of the type in question, representing trophic levels from microbiological up to birds, mammals, reptiles, etc.. On urban or industrial sites, "expected ecological function" may only include sufficient functioning of select trophic levels, or there may not be an expectation of any ecological function other than the protection of wildlife that come from offsite and use or are exposed to the site in some fashion.

use or provide some ecological functions, but this is usually incidental to the area's intended use and ecological use of these areas is often not desired and may be actively discouraged as a facility management practice. So depending on the type and intended uses of an urban/developed site or industrial site in question, the expectations concerning ecological functioning on that site can range from full (rarely) to some limited level of ecological functioning to no expected or desired ecological functioning. This is important to consider when designing an ecological risk assessment on an urban/developed or industrial site, as ERAs performed on such sites can differ significantly depending on the level and types of ecological functions that are expected or desired on the site.

This document will discuss some of the considerations regarding site use/expected ecological functions that ecological risk assessors and risk managers may want to think about when framing and performing an ecological risk assessment at urban or industrial sites. It is assumed that users of this document are familiar with the ERAGS (EPA 1997) and Guidelines for ERAs (EPA 1998) documents and the practice of ecological risk assessment in general. It should be noted that ecological risk assessment at urban and industrial sites follows Agency Guidance on conducting ecological risk assessments. This document is to be used in conjunction with the ERAGS (EPA 1997) as the ERAGS (EPA 1997) document covers the ecological risk assessment process in detail, therefore the details of the ecological risk assessment process are not covered in this document. This document is only intended to present various considerations specific to conducting ecological risk assessments at urban or industrial sites. For a discussion of considerations applicable to conducting ecological risk assessments involving non-site urban or developed waterways, the reader is advised to consult the document "Considerations for Scoping/Designing Ecological Risk Assessments Involving Urban or Developed Waterways".

A summary of the key points discussed in this document is as follows:

- Decide among stakeholders what the site use (current and reasonably anticipated future use) is and what the associated expected/desired ecological functions for the site are within problem formulation;[2]
- Use the current/anticipated site use and associated expected ecological functions to:
    - determine what type(s) of ecological receptors are to be protected/managed for on the site, or what the receptors of concern are that may be exposed to the site;

[2] In cases where the reasonably anticipated future use of the site is uncertain, and/or depends on the degree of ecological risk present and the potential remedial costs associated with addressing that risk, performing a risk assessment based upon an expectation of "full ecological function" may provide the most decision relevant information.

    - choose assessment endpoints to reflect the expected ecological functions and associated relevant receptors of concern;
    - determine appropriate exposure routes through the exposure assessment;
- Use this information to design the ecological risk assessment to provide decision-relevant information to risk assessors and risk managers for the site; consider non-traditional risk management options as warranted and appropriate.[3]

Something to note is that it should be anticipated that the conclusions of urban or industrial site ERAs may include an acceptance of higher residual contaminant concentrations than would be acceptable in fully functioning ecosystems. For this reason it is important that an evaluation of areas that could represent secondary sources of contamination to other areas should be conducted. This secondary source assessment should evaluate the potential for contaminant migration as well as contaminant concentration and mass.

Framing the Risk Assessment/CSM Development: (1) Expected/Desired Ecological Function

As a basic tenet of the approach discussed in this document, perhaps the most critical aspect of designing an ecological risk assessment at an industrial facility or a site in an urban setting is for the relevant stakeholders to establish what the expected/desired ecological function of the site, or portions of the site that are being assessed, is to be (e.g. see Section 2.2 in EPA 1998). Relevant stakeholders can be representatives of the facility/site owner, State or federal trustees responsible for protection of the ecology of the area, EPA, others responsible for deciding what the site function is to be, and perhaps the public if warranted. A key question to be answered is: what is the current and reasonably expected future site use and expected function, including the expected/desired ecological function, of or at the site to be? Site use could be completely industrial, with no ecological function expected, or it could be a mixed use, for example a stormwater retention basin whose primary purpose is stormwater retention but which is also desired to function as some sort of migrating waterfowl habitat. Urban areas could include, as an example, managed lawn areas for recreation that can have some incidental ecological function but are not particularly managed to provide ecological habitat or support ecological receptors. Large sites often have several different areas that may have different expected uses or functions, with some areas having no ecological function observed or desired

[3] It should be agreed to that in the future if the intended use of the site changes and that change results in increased ecological use of or exposure to the site or includes a desire for the site to support an increased level of ecological function, the potential for ecological risk at the site would need to be reassessed given the new potential for ecological exposure and/or the increase in desired ecological function.

and some having a mixed use. An ERA can and usually should look somewhat different between situations where the expected ecological functions are, as examples, “full ecological function” vs. “only partial or particular ecological functions supported” vs. “no expected ecological functions”. In most cases it is critical for an efficient ecological risk assessment process at these types of sites that agreement is made regarding the expected/desired ecological functions for the site and/or each separate portion or decision unit of the site so that there is a common ecological protectiveness goal in mind at the beginning of the process.

Some questions to help better define the expected site use and desired ecological function involve the consideration of monetary or resource expenditure in order to support the stated use/function. If something happened to lessen the utility of the area on the site for ecological use, for example, would efforts be made to rehabilitate the area for ecological use again? Or would the efforts be to restore some other use, with ecological use of that area being incidental to the primary use or function? The implication is that if an area has an expected ecological function, efforts would likely be made to restore the ability of the area to support the expected ecological function if it had become compromised. If instead no efforts would be made to restore the ability of the area to support ecological functions, then the implication is that the ecological functioning in the area is incidental to the area’s intended use. Similarly, an area may “look” like habitat, but if it is on an industrial property for example where the land has a different intended use and there is not an expectation of ecological function, there may not be a need (or desire) for the area to “function” like habitat. In these cases if there is concern regarding ecological exposure to contamination in the area, an “attractive nuisance” scenario may be appropriate to consider. An “attractive nuisance” as used in this document is an area/feature that is not intended to function as ecological habitat but has attributes that attract wildlife. In addition to attracting wildlife the area would also contain contaminants at concentrations that could be a hazard to ecological receptors that use the area/feature. See EPA (2007) for additional information on attractive nuisances.

Framing the Risk Assessment/CSM Development: (2) Determination of Assessment Endpoints

When the expected overall ecological function(s) and level of ecological protectiveness for the site/portions of the site have been decided upon, it can be determined what particular ecological functions and types of ecological receptors are to be protected if they use the areas on the site. These then can become the Assessment Endpoints for an ecological risk assessment if one is warranted. Some example considerations for on-site areas:

A. Fully Functioning Habitat: If the area is to be fully functioning ecological habitat, then all levels of ecological function would warrant protection. Health of plant, microbe and invertebrate communities, as well as mammals/birds and/or fish communities would probably be relevant assessment endpoints. EXAMPLES: Natural wetlands/marshes on a site where the habitat is highly valued, or maybe areas of a site that are to be "returned to nature" as conservation land or something equivalent.

B. Moderate/Limited Ecological Function: Perhaps an area is managed primarily for something other than ecological habitat but some ecological function is desired. It could be that an area of a site provides unique or otherwise important support for animals of interest, such as certain types of birds for example. In this case, the health of the resident/visiting birds and maybe also the presence of "a" plant and invertebrate community that provides food or nesting resources might be relevant endpoints. "A" community implies that the plants or invertebrates present may not necessarily have to be "The" types of communities that would exist in a natural system in the area, but as long as the nesting resources and food base are sufficient to adequately support the birds of interest, that is acceptable. This could mean that the bird community health would be an assessment endpoint, and for invertebrates and plants, a sufficiency of plants/invertebrates to provide food/cover/nesting resources and having the food resources not be significantly contaminated would be the appropriate assessment endpoints for those trophic levels. EXAMPLES: A golf course or recreation area that considers "nature" and the presence of "charismatic megafauna" part of the aesthetics that give the recreational area additional value, or a wastewater/stormwater retention pond that provides valuable habitat to migrating (or even resident) birds (like a retention pond located in an otherwise arid area). The desire to provide habitat/support for threatened or endangered species that happen to use the site would fall into this category.

C. No Expected Ecological Function, But Attractive Areas Present: If an area is not to be managed for ecological use and no appreciable ecological function is desired, but the area is attractive to wildlife, then a sort of "attractive nuisance" scenario may be present. Assessment endpoints might include protection of visiting mammalian/avian wildlife, but would likely not include protection of fully resident organisms such as invertebrates, fish or plants. EXAMPLES: Sports fields consisting of mowed/maintained grass, unused fields on industrial sites, landfill covers, industrial or municipal stormwater/wastewater ponds, or even some water drainage conveyances in urban/industrial settings. These areas are not typically managed for ecological function, but can be attractive to wildlife and can present exposure hazards if contaminants are present.

    1. A special consideration under this category would be how site resident animals with very small home ranges, such as voles/shrews/rats/mice and similar animals, would be viewed. If these animals nest in and spend their entire lives in the area that is not being managed for wildlife use and where no ecological

function is desired, then their presence may in many instances be able to be considered incidental to the site's function and purpose and protection of them may not be warranted as far as risk assessment or mitigation. In this case including them as an assessment endpoint, with an area use factor of 100% onsite, may not be warranted or supportable. This would not apply to animals that have appreciable interaction with offsite areas, but only to wholly site resident animals.

D. No Expected Ecological Function, No Attractiveness of the Site: If an area is not managed for ecological use and no ecological function is expected/desired and there is no appreciable ecological attractiveness, then an assessment of ecological risk in that area may not be warranted at that time (based on no appreciable ecological exposure from no appreciable ecological use). Depending on the situation, the lack of appreciable ecological use of the area may be something that needs to be validated (through observation, studies/surveys, etc.) as opposed to merely assumed.

Considerations for Performing the Ecological Risk Assessment Itself

As noted above, ecological risk assessments at urban and industrial sites should generally follow the 8 Step process using the 1997 Guidance (EPA 1997) as well as other relevant Agency guidance. However, there are specific considerations at most urban and industrial sites which will be different from those at areas where full ecological function is expected. The specific ecological functioning expected/desired may result in the use of different exposure/assessment parameters or the use of a smaller set of potential receptors as assessment endpoints within the urban and industrial site ERA than ERAs at other sites. These differences are consistent with the intended use of the ERA process in the ERAGS Guidance. A note for the exposure assumptions used in urban and industrial site ERAs is that even though the expected site function may result in a limited expected/desired ecological function, and thereby support the use of only selected assessment endpoints, to address current site risks the exposure assumptions for those receptors/assessment endpoints should reflect the current condition and current exposures that are occurring at the site for the assessment endpoints of concern. Site modification reflecting intended site use might later result in reduced ecological exposure to the site, and an ERA designed to look at risks under those future predicted conditions could incorporate reductions in the exposure assumptions to reflect those anticipated reduced exposures, etc., but the exposure assumptions used in an ecological risk assessment addressing current risks to the selected receptors should reflect the current site conditions and ecological exposures for those receptors that are occurring at the site.

While not all scenarios at urban and industrial sites can be anticipated, a number of expected situations and how these situations might be handled within the ERA are presented below.

A) Screening Level Ecological Risk Assessment (SLERA)

The SLERA is intended to be an ERA tier which increases the efficiency of the ERA process. The goal of a SLERA may be to identify which of the contaminants present at a site may be eliminated from further consideration in the ERA. Additionally, the SLERA can be used to complete all or a portion of the ERA if it can be documented that exposures are not expected to exist independent of the degree of contamination.

Step 1: Screening Problem Formulation: An initial step in the screening problem formulation is the development of a conceptual site model (CSM). For urban or industrial sites, the CSM developed at this stage often should be more detailed than for ERAs at "natural" sites at this stage, to allow the ERA to be "customized" or streamlined from the beginning of the process if there is a desire to do so. In this context, it is usually recommended that for urban and industrial site ERAs the completed preliminary CSM of Step 1 should identify the current and future expected site function, desired ecological functioning, and the associated types of receptors to be protected. This information can then be used to properly scope the ERA.

Despite having the CSM for the site, often within the SLERA "default" assessment endpoints are used to provide warranted conservatism to the screening step. However at urban and industrial sites, "default" assessment endpoints representing full ecological function may not always be the most appropriate to use, especially if there is a desire to streamline the assessment. As discussed above, the expected site use and the expected/desired ecological functions should be decided upon within step 1 of the ERA process and reflected in the CSM. Using this information may mean that rather than using default assessment endpoints in the screening step, using alternative assessment endpoints (e.g. bird and mammal protection instead of endpoints representing full ecological function) may be more appropriate, even at the screening stage if it makes sense to do so.

The second aspect of Step 1 is the preliminary toxicity assessment. The toxicity assessment assumptions at the SLERA stage are usually conservative which culminates in the use of screening values or benchmarks that represent protection of full ecological function. Within an

urban and industrial ERA it may still be appropriate and valuable to conduct the SLERA using this conservative toxicity assessment as this will likely result in unequivocal elimination of some ecological COPCs. As discussed above however, in other circumstances it may be appropriate to use potentially less conservative toxicity benchmarks that represent the more limited ecological function that may be expected or desired for the site. This is not to imply that the toxicity benchmarks should be less protective of the types of ecological receptors that are determined to warrant protection from harm at the site, but rather that at many urban or industrial sites the ecological functions that are valued at the site or at least are to be assessed for risk might not include the ecological functions that the most sensitive benchmarks represent. For example in an attractive nuisance scenario it may be appropriate to use benchmarks protective of birds and mammals (rather than soil invertebrates or plants in this case) as these benchmarks will be linked to the selected assessment endpoints and desired ecological function as well as the exposure assessment in Step 2.

The approach used for the SLERA (standard or traditional screen using the standard benchmarks for all compounds analyzed for vs. a more focused screen for a narrower range of compounds and/or using selected assessment endpoint screening criteria) will largely depend on the role the SLERA will play in the site assessment. If the ERA is being engaged at the beginning of the process, or if not much is known about the potential contaminants associated with the site, a traditional complete screen may be most appropriate as this will help identify the primary chemicals of concern and hopefully eliminate compounds with little impact on site risks. Often however, particularly on industrial sites, the ERA process is engaged after some site work has been performed, such as preliminary site investigations or similar efforts, and the site team has narrowed the list of potential chemicals of concern to a certain set of compounds and this list is provided to the ecological risk assessor when she/he is brought into the project. In these cases, if the project team decides to have the ERA focus on the certain set of chemicals, the ecological risk assessor should document that the list of compounds to be assessed has been decided upon by project management prior to the ERA screen. If there is a concern from the ecological risk assessor that additional compounds should be included in the ERA, this should be noted and discussed with project management.

Step 2, Screening Exposure Estimate and Risk Calculation: The screening level exposure assessment can be a critical element within an urban and industrial site ERA. This is particularly true in instances where the use of areas is directly managed with respect to ecological use/function. For example if the nesting or feeding behavior of birds is actively discouraged it may be inappropriate to use a 100% area use factor (AUF) or home range when calculating exposure. On the other hand, using such assumptions may provide a level of conservatism that is desired at this stage of the assessment, or it may simply be appropriate if the site is heavily used by wildlife. It is important for the risk assessment team to decide on the appropriate

exposure parameters to use in the risk calculations and level of conservatism desired in the assessment at this stage in order to provide useful information for risk-based decision making at the site.

An example of a potential initial risk characterization process at an urban or industrial site: An attractive nuisance scenario is agreed to within the conceptual site model, and the protection of populations of birds and mammals (and herptiles) that may come onto the site from offsite to feed on the site represent the assessment endpoints. And the chemicals of potential concern have been narrowed to a fairly small number of chemicals (e.g. metals). In this case, using food chain models, with appropriately conservative assumptions as a first run of the models, may serve as the most appropriate screening mechanism to provide COPEC/risk information relevant to the decisions for the site or area being investigated. This screen would in this example take the place of the typical screening using the traditional screening benchmarks, for the compounds that are amenable for food chain modeling. It may be appropriate to assume a 100% AUF and 100% bioavailability of contaminants from prey items and sediments, depending on the conservatism desired. This conservative screen using pertinent receptors can then in this scenario be considered protective for the expected/desired ecological functioning and associated assessment endpoints chosen.

The Scientific/Management Decision Point (SMDP) at the end of Step 2 in an urban and industrial site ERA is fundamentally the same as described in the ERAGS Guidance (EPA 1997): 1) “there is adequate information to conclude that ecological risk is negligible and therefore no need for remediation on the basis of ecological risk; 2) the information is not adequate to make a decision at this point, and the ecological risk assessment process will continue to Step 3; or 3) the information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted”.

B) Baseline Ecological Risk Assessment (BERA)

Steps 3 and 4: Baseline Problem Formulation: Following the ERAGS Guidance (EPA 1997), Steps 3 and 4 expand upon the preliminary Problem Formulation of Steps 1 and 2. As with "traditional ERAs" (ERAs performed to assess full ecological function), the refined Problem Formulation and study design will reflect the CSM developed in Steps 1 and 2, but the Step 3 Problem Formulation will be more specific to the site and will even more reflect the expected/desired ecological function for the site and the site’s current and anticipated use, especially if this was

not done in the SLERA. This step is also used to further investigate those pathways of potential risk identified in the SLERA. As an example: in a constructed urban pond designed for stormwater management and not for ecological use, the assessment of risks to fish and aquatic invertebrates may not be of practical value (despite their incidental presence in the pond) given the expected/desired ecological function and current/future use of the pond, which in this case really would likely not include any desired ecological function. But there may be "attractive nuisance" concerns if there is contamination present and wildlife are using the pond. Because of management practices such as mowing edges around the pond, or the presence of no appreciable littoral zone due to the pond having steep banks, the "habitat" present may restrict the types of avian species that would feed in the pond. Because of the pond's purpose, configuration and how it is maintained, an example risk assessment endpoint representing protection of "insectivorous/piscivorous birds" may be the only appropriate endpoint, however the only appropriate receptor types might be diving ducks, osprey and/or kingfishers, and not wading birds due to the lack of wadable areas in the pond. These habitat and receptor specific considerations affect the exposure assessment within Step 3 and follow to the Step 4 measures of effect (the parameters used in the uptake/exposure models).

Another example of how the expected ecological function and assessment endpoint attributes could alter the measures of effect is in the case of a waterbody that may be municipal or even industrial in use, but for some reason it provides an important and desired resource to migrating waterfowl for nesting and feeding (similar to what is described in "B. Moderate/Limited Ecological Function" in the Section "Framing the risk assessment/CSM development: (2) Determination of Assessment Endpoints"). In this case, the desire to have a benthic community that provides a sufficiently uncontaminated and adequate food base for the birds might be important, but the actual "structure" of that benthic community might not be important, unlike in a "natural" setting where the structure of the benthic community in itself would likely be important. In this municipal/industrial case, a sufficiently abundant food resource for waterfowl might be the assessment endpoint for the benthic community, and a measure of the biomass available for waterfowl food could be the measurement endpoint. For the birds, the assessment endpoint would likely be no impacts to survival, growth or reproduction of the birds feeding in the pond, and the measurement endpoint could be the contaminant dose estimates obtained through food chain modeling compared to TRVs.

As can be seen from these examples, the ERA process is essentially the same between "traditional ERAs" and those conducted at urban and industrial sites. A key difference however is that expected site use and expected/desired ecological function can vary at urban and industrial sites, and these will (or usually should) influence the assessment and measurement endpoints used in the ecological risk assessment.

Steps 5-7, Field Investigation and Risk Characterization: These steps are the same for both "traditional" ERAs and those conducted at urban and industrial sites.

Step 8, Risk Management: Risk management can be significantly different for urban and industrial sites versus sites for which natural ecosystem function is expected. At sites where full ecosystem function is desired, the expectation is that chemical contamination posing the risk will be remediated to a point where the ecosystem can function in a manner similar to that in a similar but uncontaminated, natural setting. Since ecosystem functions are usually incidental/unintended when a site is used for or even simply zoned/designated for urban or industrial purposes, remediation of contamination is sometimes not the selected risk mitigation option, or at least is not the only option chosen. Some of the other options include elimination of the attractiveness or exposure route(s) of an area so that exposure to contaminants is stopped (such as by graveling or paving a contaminated terrestrial area, or removing shoreline habitat/steepening the banks along an aquatic area, or wildlife hazing). In certain circumstances, additional options can include actions such as removal of key parts of the food chain at a site if risk from food chain uptake of contaminants is found to be unacceptable, such as by removing fish or aquatic invertebrates from an aquatic system such as a wastewater pond to break the food chain and eliminate attractiveness of the area as well as stop food chain uptake of contaminants by receptors.

At times there are situations where unacceptable ecological risk is identified in an area on an urban or industrial site where redevelopment towards a site's designated and intended use will be occurring, and the redevelopment activities will adequately address the risks identified (such as a contaminated field will be paved or have a building built on it, or a contaminated pond will be filled in as a site is leveled). When considering risk mitigation to address unacceptable ecological risks in such areas, there is often a balance between the degree of risk posed by the contamination in the area in its current state versus the amount of time that will pass before the redevelopment is to occur. Sometimes the degree of risk posed and the estimated ecological impacts are such that for example 2 years in the current situation is acceptable, but 10 years is not. Other times the risks may be substantial enough that even a one-year delay might not be acceptable, and some interim action would have to be considered, such as covering the contaminated area with a cover material or some other interim approach to lessen the exposure of receptors to the contamination for the time period before redevelopment occurs. These situations will usually involve negotiations/discussions between risk assessors, risk managers and other stakeholders to determine the most appropriate path forward.

Conclusions

This discussion document offers suggestions for consideration when performing ecological risk evaluations at urban or industrial sites and is not prescriptive. The implementation of the approaches suggested by this document are at the discretion of the ecological risk assessors and the risk management team, and can and should vary from site to site depending on the particular attributes, situations and management goals at each site.

References

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