19.3.5 Ecological Resources

This section describes the terrestrial and aquatic communities within the ROI (8 km [5-mi] radius from the proposed RPF) and provides a baseline characterization of the site ecology prior to any disturbances associated with the construction and operation of the proposed facility. Prior environmental disturbances not associated with the proposed facility are considered when describing the baseline condition. Consultations with the Missouri Department of Conservation (MDC) and U.S. Fish and Wildlife Service (USFWS) were initiated for information regarding ecological resources within the ROI (Haass, 20014a, Haass, 2014b). The consultation process was used to obtain agency input regarding threatened and endangered species, sensitive habitats, commercial and recreational species, and other ecological characteristics of the ROI. Ecological resources described herein are based on recorded information from resource agencies.

19.3.5.1 Wetlands

Wetlands are classified by the EPA as "areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants (hydrophytes) and promote development of characteristic wetland (hydric) soils" (EPA, 2013a).

According to MDNR Water Resources Report No. 39 (Epperson, 1992), the amount of wetland loss in Missouri has exceeded the national average, and 87 percent of the state's original 1.9 million ha (4.8 million acres) of wetlands have been destroyed. Of the original 9.7 million ha (2.4 million acres) of forested wetlands in southeast Missouri, less than 24,281 ha (60,000 acres) or 2 percent remain intact. Statewide, 13 percent of the original wetland resources remain. These remaining wetlands account for 1.4 percent of the land surface.

Detailed discussions of natural wetland types and locations within the ROI are discussed in Sections 19.3.5.3 and 19.3.5.5.

19.3.5.1.1 Surface Water Runoff Protection

Wetlands have important filtering capabilities for intercepting surface water runoff from higher dry land before the runoff reaches open water. As the runoff passes through, the wetlands retain excess nutrients and some pollutants, and reduce sediment loads that would otherwise deposit and clog waterways, affecting fish and amphibian egg development. "In performing this filtering function, some wetlands maintain stream flow during dry periods, and many replenish groundwater supplies" (EPA, 2013a).

19.3.5.1.2 Flood Water Protection

According to the EPA, "Wetlands function as natural sponges that trap and slowly release surface water, rain, snowmelt, groundwater, and flood waters. Trees, root mates, and other wetland vegetation also slow the speed of flood waters and distributes them more slowly over the floodplain. This combined water storage and braking action lowers flood heights and reduces erosion" (EPA, 2013a).

Wetlands within and downstream of urban areas are particularly valuable, counteracting the greatly increased rate and volume of surface water runoff from impervious surfaces. In addition, the holding capacity of wetlands helps control floods and prevents water-logging of crops.

19.3.5.1.3 Fish and Wildlife Habitat

More than one-third of the U.S. threatened and endangered species live only in wetlands. EPA states the following:

> *For many animals and plants, like wood ducks, muskrat, cattails, and swamp rose, inland (non-tidal) wetlands are the only places they can live. Many of the U.S. breeding bird populations including ducks, geese, woodpeckers, hawks, wading birds, and many song-birds feed, nest, and raise their young in wetlands. Migratory waterfowl use coastal and inland wetlands as resting, feeding, breeding, or nesting grounds for at least part of the year. An international agreement to protect wetlands of international importance was developed because some species of migratory birds are completely dependent on certain wetlands and would become extinct if those wetlands were destroyed.* (EPA, 2013a)

19.3.5.2 Offsite Areas

The EPA has established a spatial network of ecoregions for the research and monitoring of ecosystems. Ecoregions are areas of relatively uniform ecological systems that have similar vegetation, climate, geology, and physiology. Missouri is divided into seven Level III Ecoregions, of which two occur in the ROI. Ecoregions within the ROI are the Central Irregular Plains and Interior River Valleys and Hills. These Level III Ecoregions are further subdivided into Level IV Ecoregions or subregions. The subregions that occur in the ROI are the Claypan Prairie and River Hills. Figure 19-38 illustrates the location of the ROI in relation to the ecoregions and subregions. Descriptions by Chapman et al. (2002) for each of the subregions are used to evaluate the current ecological condition of the ROI.

The subregion Claypan Prairie of the Central Irregular Plains Ecoregion is characterized by well-developed claypan soils located on gently rolling topography (Chapman et al., 2002). Vegetation communities that are common to this subregion include white oak dry woodland, hardpan prairies lowland flatwoods, and ephemeral marshes. Historically, the region was mostly tall grass prairies with seasonally inundated wetlands (Nigh and Schroeder, 2002). After European settlement, the region experienced a conversion to cropland and pasture because of the gently rolling topography and soil with little natural vegetation remaining (Chapman et al., 2002; Nigh and Schroeder, 2002). The Claypan Prairie subregion covers approximately 52 percent of the ROI.

The subregion River Hills of the Interior River Valleys and Hills Ecoregion is characterized by forested river side-slopes and bluffs, some loess-covered hills, and areas with karst features located on a smooth to moderately dissected topography. This subregion lies along the Missouri River and is a transition zone between the flatter plains to the north and the Ozark Highlands to the south (Chapman et al., 2002). The Missouri River is not located within the ROI. Vegetation communities that are common to this subregion include white oak forests, oak savannas, and sugar maple mesic forests. Historically, this region was covered in timber with glades and sinkhole ponds (Nigh and Schroeder, 2002). After European settlement, many areas remained forests, especially rugged areas, with some of the mixed hardwood forests converted to pasture (Chapman et al., 2002). The River Hills subregion covers approximately 48 percent of the ROI.

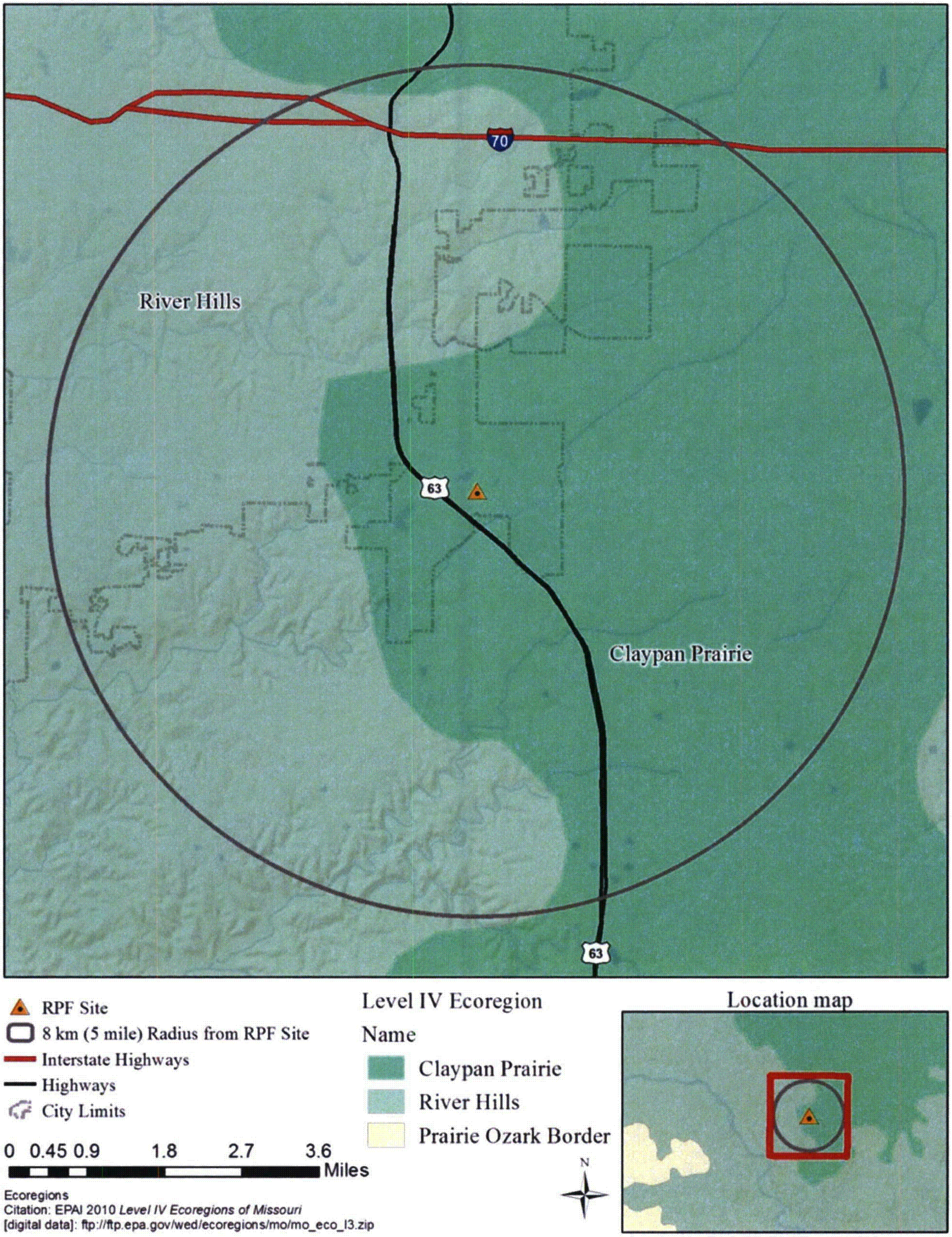

Figure 19-38. Region of Influence in Relation to Ecoregions and Subregions

19.3.5.3 Onsite Areas

The proposed RPF site is located within a 3 ha (7.4-acre) parcel in Discovery Ridge. Because of continuous land disturbance associated with agricultural practices, the site is devoid of natural landscapes such as forests, prairies, and other natural plant communities. Within the 2.99 ha (7.4-acre) parcel there are no ephemeral, intermittent, or perennial streams and associated riparian zones.

Land cover within the ROI is discussed in detail in Section 19.3.1.1, and is illustrated in Figure 19-15. Urban development accounts for approximately 5,059 ha (12,500 acres), or 25 percent, of the ROI. Developed lands include lands mapped as open spaces, low intensity, medium intensity, and high intensity.

Agricultural pasture land and cultivated crops account for approximately 8,013 ha (19,800 acres), or 39 percent, of the ROI. Pasture land within the ROI consists of property that is used for the raising of livestock or hay production. Cultivated crops consist of soybeans, corn, wheat, and sorghum.

Forested habitats account for approximately 6,758 ha (16,700 acres), or 33 percent, of the ROI. This land consists of deciduous forests, evergreen forests, and mixed forests. The majority of this land is the deciduous forests that account for 31 percent of the ROI. These deciduous forests are comprised of white oak forests, oak dry woodlands, and black oak woodlands. These forests are located in the river side-slopes and bluffs and mixed throughout the developed areas.

Wetlands within the ROI were mapped using the USFWS National Wetlands Inventory data (USFWS, 2010) and are discussed in detail in Section 19.3.5.1. Figure 19-39 shows known wetlands and water bodies located in the ROI. Based on the inventory data, wetlands make up approximately 168 ha (415 acres), or less than 1 percent, of the total ROI. Forest/shrub wetlands and freshwater emergent wetlands make up the mapped wetlands. A total of 306 ha (755 acres), or 1.5 percent, were mapped as open water. Grassland resources account for 140 ha (345 acres), or less than 1 percent, of the ROI. Scrub and barren lands account for less than 1 percent of the ROI.

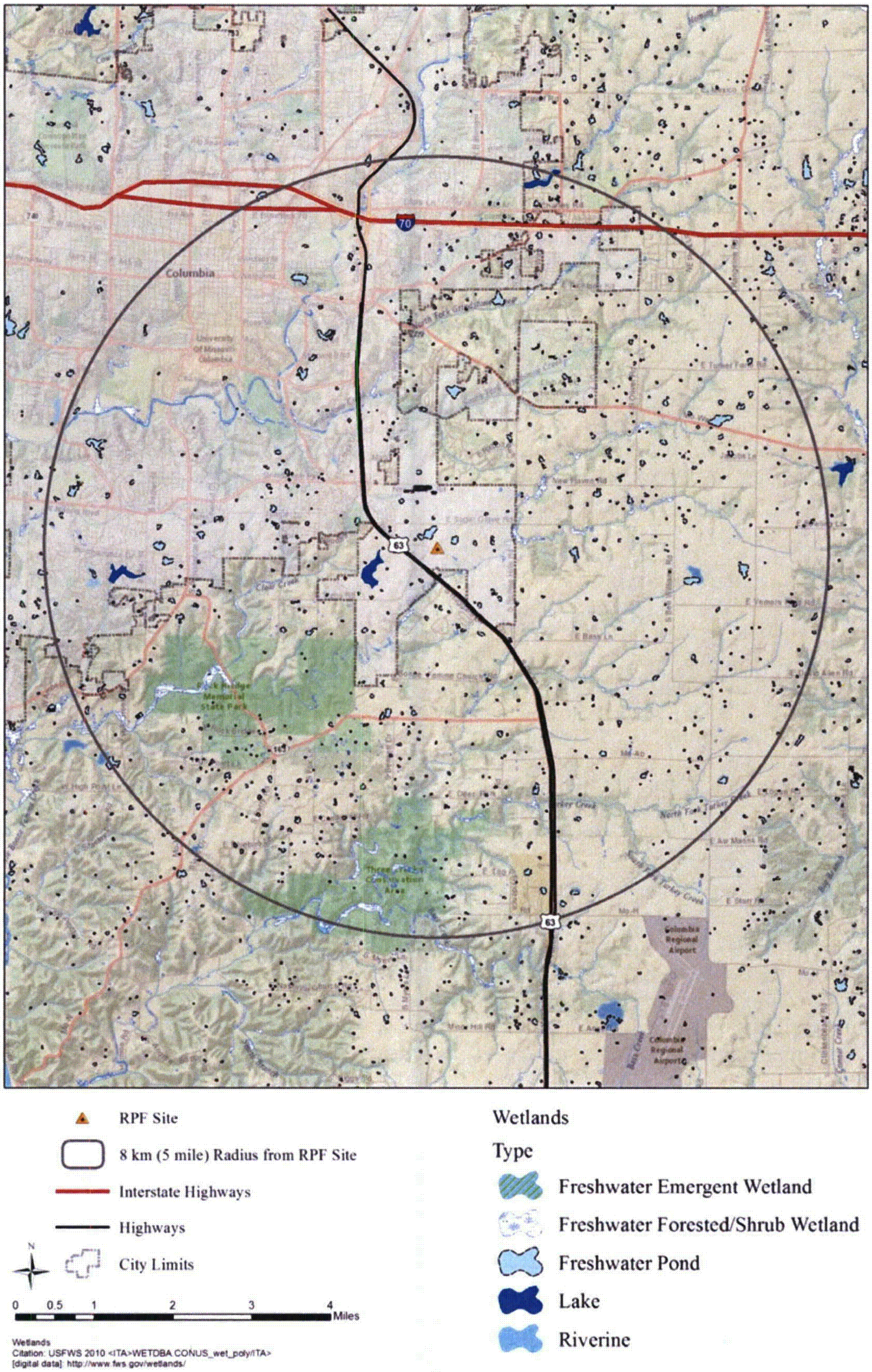

Figure 19-39. Wetlands Map

19.3.5.4 History

As discussed in Section 3.1.1, the ROI is located in the Claypan Prairie and River Hills subregions of the Central Irregular Plains and the Interior River Valleys and Hills ecoregions, respectively. Before European settlement, these areas consisted of tall grass prairies, seasonally inundated wetlands, and oak woodlands. The encroachment of forests into native grasslands would have been limited by fire, grazing, and periodic ponding water (Nigh and Schroeder, 2002). After European settlement, much of the natural vegetation in the tall grass prairies and oak savannas were cleared for agricultural and urban development. Oak woodlands in rugged areas located in drainages were mostly left intact. Few remnant tall grass prairies and oak savannas remain as the rest has been developed. As part of agricultural development, many of the existing wetlands were drained and surface water was channelized. The proposed RPF site is zoned for agricultural use, indicating that the site has been used for the cultivation of crops and pasture land.

19.3.5.5 Places and Entities of Special Interest

This section provides information relative to ecological resources of special interest within the ROI. Ecological resources of special interest include (1) identified natural ecological communities, (2) sensitive or susceptible areas, and (3) important ecological systems. These resources are discussed in the following subsections.

19.3.5.5.1 Ecological Communities

The Missouri Heritage Program identifies and tracks high-quality terrestrial natural communities because they provide diverse assemblages of native species. High-quality communities include those that are intact and represent the least distressed examples of ecosystems that existed prior to European settlement. Terrestrial natural communities that are ranked as critically imperiled, imperiled, or vulnerable are considered to be communities of conservation concern (MDC, 2013). The "Missouri Electronic Field Office Technical Guide" was used to identify communities of conservation concern within the ROI (USDA, 2013b). There are four listed terrestrial and aquatic natural communities within the ROI:

- **White oak forests** – The white oak forest communities have been classified as imperiled by the Missouri Heritage Program. These forest communities usually occur on relatively steep slopes above river corridors and extend from the valley bottoms to ridge tops. These areas have a well-developed forest canopy and subcanopy dominated by a mixture of white oak (*Quercus alba*), sugar maple (*Acer saccharum*), pawpaw (*Asimina triloba*), and other hardwoods (USDA, 2013b). Common shrubs and forbs include fragrant sumac (*Rhus aromatic*), wild blue phlox (*Phlox divaricata*), and woodnettle (*Laportea canadensis*) (USDA, 2013b). Common wildlife species include white-tailed deer (*Odocoileus virginianus*), great crested flycatcher (*Myiarchus crinitus*), and ringed salamander (*Ambystoma annulatum*) (MDC, 2010).
- **Mixed oak loess/glacial till woodlands** – The mixed oak loess/glacial till woodland communities have been classified as imperiled by the Missouri Heritage Program. These woodland communities usually occur adjacent to the Missouri River floodplains on upland summit crests (USDA, 2013b). They have a well-developed forest canopy that consists of white oak (*quercus alba*), black oak (*Quercus velutina*), and post oak (*Quercus stellata*). Common shrubs and forbs include American hazelnut (*Corylus Americana*), elm-leafed goldenrod (*Solidago ulmifolia*), and smooth blue aster (*Aster laevis*) (USDA, 2013b). Common wildlife species include wild turkey (*Meleagris gallopavo*), red-headed woodpecker (*Melanerpes erythrocephalus*), and tiger salamander (*Ambystoma tigrinum*) (MDC, 2010).

- **Loess/glacial till prairies** – The loess/glacial till prairie communities have been classified as imperiled and critically imperiled by the Missouri Heritage Program. These prairie communities usually occur in areas of low relief with low slope gradients and narrow drainages (USDA, 2013b). They are characterized by tall grass prairies that area dominated by little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), and sideoats grama (*Bouteloua curtipendula*). Post oak (*Quercus stellata*), American hazelnut (*Corylus Americana*), and prairie willow (*Salix humilis*) occasionally occur in small groves. Common shrubs and forbs include lead plant (*Amorpha canescens*) and purple prairie clover (*Dalea purpurea*). Common wildlife species include white-tailed deer (*Odocoileus virginianus*), upland sandpiper (*Bartramia longicauda*), and western slender glass lizard (*Ophisaurus attenuates*) (USDA, 2013b).
- **Emergent wetlands and shrub swamps** – As stated in Section 19.3.5.1, the majority of designated wetlands within the ROI are freshwater ponds, lakes, and rivers. Approximately 168 ha (415 acres) of the ROI consist of emergent wetlands (marshes and fens) and forested/shrub wetlands (shrub swaps). Emergent wetlands have standing water for long periods during the growing season. Plant species include cattails (*Typhaceae latifolia*), bulrushes (*Schoenoplectus* spp), and sedges (*Cyperaceae* spp). Wildlife species that are common to emergent wetlands include bitterns (*Botaurus lentiginosus*), pied-billed grebes (*podilymbus podiceps*), and muskrats (*Ondatra zibethicus*). Shrub swamps are wetland thickets with buttonbush (*Cephalanthus occidentalis*) and willows (*Salix* spp). Common wildlife species include yellow warblers (*Dendroica petechia*) and green herons (*Butorides virescens*) (Leahy, 2010).

Due to the urban and agricultural development in the ROI, these listed communities and their remnants are likely to occur in protected areas such as parks and conservation areas.

There are three State and Federally protected areas within the ROI: Rock Bridge State Park, Three River Conservation Area, and the northwest corner of the Mark Twain National Forest. The Rock Bridge State Memorial Park is an 858 ha (2,120-acre) park managed by the MDNR that consists of karsts, grasslands, and oak woodlands and forests. This state park also contains the Gans Creek Wild Area. The Three River Conservation Area is a 607 ha (1,500-acre) natural preserve managed by MDC that consists of mostly of oak forests and woodlands, with similar plant and wildlife species as described for those communities. A small portion of the Mark Twain National Forest, Cedar Creek Ranger District, is also located within the ROI. The forest consists of tall grass prairies and shortleaf pine-oak woodlands, with plants and wildlife species as described for those communities.

Given the current conditions of the proposed site, the area appears to have been prairie habitat before its conversion to agriculture. However, because the site has been used for agriculture and other developed uses for many years, none of the habitat types discussed in this section are present on the proposed RPF site or immediately adjacent to the site.

19.3.5.5.2 Other Sensitive or Susceptible Areas

There are several parks, natural areas, and nature trails within the city limits of Columbia, Missouri. The Grindstone Natural Area and Waters Moss Memorial Wildlife Area are Colombia city park and recreation areas in the southeastern part of the city and consist mostly of white oak forests and woodlands with common plants and wildlife species as described for those communities. Philips Park and Gans Creek Recreation Area lie directly to the west of the proposed site and consist of mix oak woodlands, tall grass prairies, and a lake. Wildlife and plant species that occur in these communities are similar to the described communities in Section 19.3.5.5.1, in addition to fish species such as channel catfish (*Ictalurus punctatus*) and black bass (*Micropterus* spp). Nature trails include MKT Trail and Hinkson Creek Trail. These trails are located in terrestrial communities similar to the Grindstone Natural Area.

19.3.5.5.3 Important Ecological Systems

The ROI is located along the Mississippi flyway (USFWS, 2013a). Natural habitats (e.g., wetlands, creeks, lakes, and tall grass prairies) within the ROI are useful to migrating birds for resting, feeding, and foraging. These natural areas are used by neotropical birds during migration and as potential habitats for nesting and nursery areas. Habitats of the proposed site are dominated by agricultural and developed uses and are not considered high value for migrating birds. There are several areas adjacent to the proposed site that include surface water (e.g., lakes, stormwater discharge areas) and other surface water locations that could be used by migrating birds.

19.3.5.6 Aquatic Communities and Potentially Affected Water Bodies

There are no aquatic resources or water bodies present on the proposed RPF site. The water bodies in the ROI are within the Bonne Femme and Hinkson Creek watersheds. These areas contain several water bodies, including Philips Lake, Gans Creek, Hinkson Creek, Clear Creek, and several others. Specific information on water bodies within the ROI is provided in Section 19.3.4.

Based on topographic maps of the proposed site, the majority of site runoff flows into designated stormwater management areas. These areas are not expected to provide ideal habitat for many aquatic species because the water is intermittent.

Water bodies within the ROI are not expected to contain Federally listed threatened or endangered fish species. However, perennial streams have a diverse mix of invertebrate and vertebrate species. Invertebrate species include mayflies, stoneflies, caddisflies, dragonflies, beetles, small crustaceans, and snails. Based on stream monitoring surveys, 18 to 27 invertebrate species are estimated to inhabit streams within the Bonne Femme Watershed. The estimated number of fish species within the Bonne Femme Watershed ranges from 11 to 17 species of shiners, suckers, redhorse, sunfish, bass, darters, and stonerollers. An indicator of good aquatic community health is strong diversity of species or high species richness. Previous sampling events conducted by MDNR at streams and other water bodies near the proposed site were at least partially biologically supporting (i.e., contained sufficient species to indicate good water quality) (BFSC, 2007).

The closest water body to the proposed RPF site is Gans Creek, which is located approximately 0.5 km (0.3 mi) to the south. Gans Creek, like most of the streams within the ROI, contains a rocky substrate free of sediment. The MDNR has listed Gans Creek as an impaired water body. Specific information on Gans Creek is provided in Section 19.3.4. No Federally listed threatened or endangered fish species is known to exist in Gans Creek, but the creek has a diverse mix of invertebrate and vertebrate species (BFSC, 2007). Because of the existing stormwater management system near the proposed site, impacts on Gans Creek from construction or operational activities are not anticipated.

Wetlands are transitional ecosystems between aquatic and terrestrial systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al., 1979). Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. The CWA defines a wetland as "...those areas that are inundated or saturated by surface or groundwater at a frequency or duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." Based in the USFWS National Wetlands Inventory data, there are no recognized wetlands within the proposed site (USFWS, 2010). Figure 19-39 shows the locations for wetlands near the proposed RPF site.

19.3.5.7 Terrestrial Communities

This section provides a description and characterization of terrestrial communities identified at the proposed RPF site and within the ROI.

19.3.5.7.1 Plant Communities

The proposed site is located in a developed industrial park that was historically used as cultivated cropland and pasture. The current vegetation at the site consists of mostly grasses reminiscent of open pastureland. Potential native plant species that may occur within the proposed site include those associated with tall grass hardpan prairie (Nigh and Schroeder, 2002). These prairies are dominated by medium-tall grasses and forbs with scattered shrubs and forbs (Faber-Lagendoen, 2001). Representative plant species include little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), winter bentgrass (*Agrostis hyemalis*), and Atlantic camas (*Camassia scilloides*) (Nigh and Schroeder, 2002; Faber-Lagendoen, 2001).

As discussed here and in Section 19.3.1.1, the land cover types found in proximity to the site are mainly urban developed species, cultivated crops, and pastureland. There are several areas within the ROI that are covered with deciduous forests, evergreen forests, and mixed forests. Most forested areas are protected in parks and conservation areas.

19.3.5.8 Wildlife

The following subsections discuss mammal, bird, amphibian, and reptile species that may occur within or near the proposed RPF site. The potential for these species to occur within or near the site is based on resources available to the wildlife species. Representative mammal, bird, amphibian, and reptile species are discussed in relation to potential habitat within ecological communities that occur in the ROI. Ecological communities are defined in Section 19.3.5.5.1.

19.3.5.8.1 Mammals

Mammal species are not anticipated to be present at the proposed RPF site because of agricultural and urban development. Available resources (i.e., food, water, and cover) are not present year-round at this location. Mammal occurrence on the site is likely driven by the presence and life stage of the surrounding agricultural crops. Typical mammal species that have the potential to occur include species that are typical for wildland/urban interface. These species include the white-tailed deer (*Odocoileus virginiaus*), eastern cottontail (*Sylvilagus floridanus*), eastern chipmunk (*Tamias striatus*), raccoon (*Procyon lotor*), and red fox (*Vulpes vulpes*) (Pitts and McGuire, 2000). No protected mammal species are known to occur at the proposed RPF site.

In the area surrounding the proposed RPF site (within the 8 km [5-mi] radius ROI), opportunities for mammal occurrence is similar to the proposed site because the land cover is comprised of mostly agricultural and urban development. However, some areas have deciduous forests, evergreen forests, and mixed forests that provide suitable habitat for mammal species. These areas are located in Rock Bridge State Memorial Park, Three Rivers Conservation Area, and several other parks and protected areas. These areas are used for recreational hunting, especially for white-tailed deer and squirrel. Mammal species that occur in these areas include the white-tailed deer (*Odocoileus virginiaus*), eastern gray squirrel (*Sciurus carolinensis*), raccoon (*Procyon lotor*), eastern spotted skunk (*Spilogale putorius*), and several species of bats, including the gray bat (*Myotis grisescens*) and Indiana bat (*Myotis sodalist*) (MDC, 2013; Pitts and McGuire, 2000). The gray bat and Indiana bat are listed as endangered by the USFWS and Missouri (USFWS, 2013b; MDC, 2013). Listed species are discussed in Section 19.3.5.9.

19.3.5.8.2 Birds

The bird species observed at the proposed RPF site are anticipated to be transients because of the lack of permanent cover and other important resources. Typical bird species that may occur at the RPF site include:

- Game species – Northern bobwhite (*Colinus virginianus*), wild turkey (*Meleagris gallopavo*)
- Migratory waterbirds – Sora (*Porzana Carolina*), common snipe (*Gallinago gallinago*), Virginia rail (*Rallus limicola*)
- Migratory birds – American bittern (*Botaurus lentiginosus*), sedge wren (*Cistothorus platensis*), horned lark (*Eremophilia alpestris*), eastern meadowlark (*Sturnella magna*), field sparrow (*Spizella pusilla*), common yellowthroat *Geothlypis trichas*)
- Overwintering birds – Short-eared owl (*Asio flammeus*), Le Conte's sparrow (*Ammodramus leconteii*) (USDA, 2013b).

The American bittern is listed as a State endangered species (MDC, 2013). Listed species are discussed in Section 19.3.5.9.

In the area surrounding the proposed RPF site (within the 8 km [5-mi] radius ROI), opportunities for bird species to inhabit the area are similar to the proposed site because the land cover is mostly agricultural and urban development. Bird species are known to inhabit these areas and will become habituated to urban and agricultural activities. Some areas have deciduous forests, evergreen forests, and mixed forests that provide suitable habitat for bird species. Bird species associated with these forested areas include the indigo bunting (*Passerina cyanea*), red-headed woodpecker (*Melanerpes erythrocephalus*), eastern bluebird (*Sialia sialis*), northern bobwhite (*Colinus virginianus*), eastern wood-pewee (*Contopus virens*), broad-winged hawk (*Buteo platypterus*), great-crested flycatcher (*Myiarchus crinitus*), summer tanager (*Piranga rubra*), and red-eyed vireo (*Vireo olvaceus*) (USDA, 2013b). As stated in Section 19.3.5.5.3, the proposed RPF site is located in the Mississippi Flyway. With open surface water within the ROI, Canada geese and other migratory waterfowl are expected to use these areas for a temporary stopover location. There are no documented rookeries near the proposed site or ROI.

19.3.5.8.3 Amphibians and Reptiles

Potential amphibians and reptiles that may occur near the proposed RPF site are those typically found in upland prairie/tall grass prairie habitats. These species include the eastern tiger salamander (*Ambystoma tigrinum tigrinum*), western chorus frog (*Pseudacris triseriata triseriata*), northern crawfish frog (*Rana areolata circulosa*), ornate box turtle (*Terrapene ornate ornate*), western slender glass lizard (*Ophisaurus attenuates attenuates*), eastern yellow-bellied racer (*Coluber constrictor flaviventris*), prairie ring-necked snake (*Diadophis punctatus arnyi*), and bullsnake (*Pituophis catenifer sayi*) (USDA, 2013b). These species are typically found in prairie habitats with nearby ponds/pools, which the stormwater drainage ponds would provide at the proposed RPF site (USDA, 2013b).

Potential amphibian and reptile species that may occur outside of the proposed site are those typically found in oak woodlands and forests. These species include the eastern tiger salamander (*Ambystoma tigrinum tigrinum*), ornate box turtle (*Terrapene ornate ornate*), northern fence lizard (*Sceloporus undulatus*), five-lined skink (*Eumeces fasciatus*), broad-headed skink (*Eumeces laticeps*), flat-headed snake (*Tantilla gracilus*), and rough earth snake (*Virginia striatula*) (USDA, 2013b).

None of the potential amphibian or reptile species are Federal or State listed species (MDC, 2013).

19.3.5.8.4 Invasive Species

Nonnative species, as defined by Executive Order 13112 (1999), are species "whose introduction does or is likely to cause economic or environmental harm or harm to human health." Also defined in the Order, nonnative species include alien species that are defined as species that are not native to a particular ecosystem and include ant seeds, eggs, spores, or other biological material capable of propagating that species.

Per Executive Order 13112, Federal agencies are mandated to prevent the introduction of invasive species, detect and control populations, monitor invasive species populations, and restore native species in ecosystems that have been invaded.

Because there are no ponds, streams, or other water bodies on the proposed RPF site, aquatic invasive species are not present. Terrestrial invasive species that have the potential to occur on the site include tall fescue (*Festuca arundinacea*), Canada thistle (*Cirsium arvense*), crown vetch (*Securigera varia*), and feral hogs (*Sus Scrofa*). The MDC has recommendations for managing these invasive species.

19.3.5.8.5 Procedures and Protocols

The proposed RPF site has been used for agricultural development for several decades. As such, the site has a history of frequent ground disturbance and herbicide applications to maximize row crop production. There are no ecological procedures or management plans for the proposed site.

19.3.5.8.6 Studies and Monitoring

The MDNR maintains a water quality monitoring program that conducts aquatic biological and water quality assessments throughout Missouri. The biological assessments are evaluations of the condition of water bodies using surveys and other direct measurements of macroinvertebrates, fish, and plants. Near the ROI, Cedar Creek is regularly sampled as part of the MDNR biological assessments (MDNR, 2011). Cedar Creek is located along the border of eastern Boone County and northwestern Callaway County, east of the ROI. Section 19.3.4 provides additional information on water quality studies within the ROI.

19.3.5.9 Protected Species and Habitats

Federal and State listed species within Boone County that are endangered, threatened, or are of special concern are listed in Table 19-44. There are no designated critical habitats within the ROI. The 10 plant, fish, bird, and mammal species that are Federal or State listed are discussed in the following subsections.

Table 19-44. Federal and State Listed Endangered/Threatened, or Species of Special Concern

Common name	Scientific name	[a]Federal status	[b]State status
Pallid sturgeon	*Scaphirhynchus albus*	Endangered	Endangered
Topeka shiner	*Notropis topeka*	Endangered	Endangered
Running buffalo clover	*Trifolium stoloniferum*	Endangered	Endangered
Indiana bat	*Myotis sodalist*	Endangered	Endangered
Gray bat	*Myotis grisescens*	Endangered	Endangered
Black-tailed jackrabbit	*Lepus californicus*		Endangered
Plains spotted skunk	*Spilogale putorius interrupta*		Endangered
Bald eagle	*Haliaeetus leucocephslus*	Threatened	Endangered
American bittern	*Botaurus lentiginosus*		Endangered
Northern harrier	*Circus cyaneus*		Endangered
Northern long-eared bat	*Myotis septentrionalis*	Proposed endangered	

[a] USFWS, 2013b, "Missouri: County Distribution of Federally Listed Threatened, Endangered, Proposed, and Candidate Species," www.fws.gov/midwest/endangered/lists/missouri-cty.html, U.S. Fish and Wildlife Service, Columbia, Missouri, updated August 2013.

[b] MDC, 2013, *Missouri Species and Communities of Conservation Concern Checklist*, p. 52, Missouri Department of Conservation, Jefferson City, Missouri, January 2013.

19.3.5.9.1 Pallid Sturgeon

The habitat of the pallid sturgeon includes large, free-flowing rivers that contain warm water and high turbidity. Within these river systems, pallid sturgeons use areas of chutes, backwaters, islands, sandbars, floodplains, and main-channel waters as macrohabitats. Historically, the Missouri River, where pallid sturgeons can be found, was an ideal habitat for this species because of the constant state of change (MDC, 2000a). Due to human development, the Missouri River and other suitable rivers are less dynamic and provide less suitable habitat. The pallid sturgeon is limited to the Missouri River, which is not located within the ROI and, therefore, is not likely to occur within the ROI.

19.3.5.9.2 Topeka Shiner

The habitat of the Topeka shiner includes small prairie streams (or in areas of former prairies). Within these streams, Topeka shiners inhabit pools of clean water in little to no turbidity (MDC, 2000b). The preferred substrates are sand or clean rock and gravel. Most of the streams inhabited by this species flow year-round, but some may not. These streams must be supplied enough groundwater seepage for the fish to survive. There is a potential for this species to occur in several of the streams within the ROI.

Topeka shiner populations are adversely affected by increased sedimentation and turbidity entering waterways caused by the removal of riparian and upland vegetation. This species is reliant on good water quality and habitat. Pollution runoff from adjacent lands into streams containing the Topeka shiner reduces the viability of this species. The Topeka shiner is an excellent indicator species for water quality because of its sensitivity to habitat changes (MDC, 2000b).

19.3.5.9.3 Running Buffalo Clover

Running buffalo clover habitat includes moderately moist areas with some sunlight, where moderate disturbances such as grazing or mowing takes place periodically (MDC, 2000c). Historically, this species was often found in prairie/forest ecotones. Running buffalo clover is thought to have once been dependent on large grazing animals (e.g., elk, deer, or bison) for the dispersal of seeds and disturbance to the soil. This species has the potential to occur within the ROI in areas of open woodlands and stream banks that experience moderate disturbance (e.g., mowing, trampling, or grazing).

The loss of bison and other large ungulates has contributed to the population decline of running buffalo clover because these animals provided seed dispersal and soil scarification. Other potential causes for the population decline include competition from invasive species, reduced fire frequency, and excessive grazing (MDC, 2000c). Limited used of herbicides near potential clover habitat and mowing during the period of sexual reproduction help maintain suitable habitat for running buffalo clover.

19.3.5.9.4 Indiana Bat

Indiana bats use two types of habitat depending on the season. During summer months, their habitat consists of wooded or semi-wooded areas, often along streams, floodplains, or riparian areas where they forage on insects (MDC, 2000d). During this time, female bats form maternity colonies to bear their offspring in hollow trees or under loose bark of living or dead trees. During the winter months, Indiana bats hibernate in caves, karsts, or mines. These areas are chosen depending on the microclimate inside the cavity. These species require very low and stable temperatures during hibernation to conserve body fat (MDC, 2000d). Both of these types of habitat occur within the ROI; therefore, the Indiana bat has the potential to be found in the area. Due to the urban and agricultural development throughout the ROI, the Indiana bat is anticipated to be limited to the protected areas in oak woodlands and forests.

Human disturbance during hibernation adversely affects this species. When hibernating bats are disturbed, their metabolism increases and they use valuable fat reserves that must last them through the entire winter. This often causes disturbed bats to leave hibernation sites too soon, which can result in the death of the bat. Interaction with humans can make the bats susceptible to white nose syndrome, a disease that can cause mortality among bat species. Another limiting factor is the decline of habitat due to deforestation and channelization within the bats' range. Forested riparian areas are foraging areas for this species and may also be roost areas in the summer (MDC, 2000d).

19.3.5.9.5 Gray Bat

Gray bats are cave-dependent species that use caves for roosting throughout the year (MDC, 2000e). Gray bat colonies migrate between winter caves and summer caves. Winter caves tend to be deep caves that are almost vertical and trap cold air. These caves provide very low and stable temperatures in which the cold helps to conserve body fat, and the bats are able to hibernate. Summer caves typically have domed ceilings or restricted rooms so that the combined body heat of the colony is trapped in the cave. Summer caves are typically used as roosting sites for maternity colonies. Summer caves are generally located near riparian areas with aquatic insects (MDC, 2000e). Potential summer caves exist within the ROI, but gray bats are anticipated to be limited to the protected areas with riparian areas.

Human disturbance, disturbance to cave habitat, deforestation between caves and rivers, and pesticides are factors limiting this species. Human disturbance during hibernation adversely affects this species. When hibernating bats are disturbed, their metabolism increases and they use valuable fat reserves that must last them through the entire winter. This often causes disturbed bats to leave hibernation sites too soon, which can result in the death of the bat. Interaction with humans can also make these bats susceptible to white nose syndrome. The use of pesticides and insecticides reduces the food supply and has the potential to poison the food chain (MDC, 2000e).

19.3.5.9.6 Northern Long-Eared Bat

Northern long-eared bats are similar to the Indiana bat except that they typically roost in smaller numbers, prefer a cooler microclimate, and are more flexible for ideal roost tree features. The Northern long-eared bat uses underground caves and cave-like structures for winter habitat, while during the summer these bats roost in cavities, crevices, underneath bark, or hollows of both live and dead trees and/or snags. This species of bat appears to be opportunistic in selecting roosting sites; however, the bats prefer cooler places with high humidity. Potential summer roost sites and winter hibernation exist within the analysis area, but these bats are anticipated to be limited to areas with ideal habitat conditions, namely cave-like structures or suitable sized trees.

The only immediate threat to the northern long-eared bat is white-nose syndrome (USFWS, 2014). Since the first symptoms of the disease were observed in 2006, the overall population of this bat has declined (USFWS, 2014). Other threats to this bat include disturbance of the species while in hibernaculum, which can cause the bats to leave hibernation too soon, which usually results in the death of the bat, and removing suitable forest summer habitat.

19.3.5.9.7 Black-Tailed Jackrabbit

The black-tailed jackrabbit is a State-listed endangered species that resides in open plains, pastures, hay fields, and cultivated areas (MDC, 2000f). Jackrabbits are dependent on vegetation and eat herbaceous plants and grasses, twigs, roots, and bark. Potential jackrabbit habitat is found throughout the ROI.

Human disturbance and habitat loss are factors limiting this species. The loss of native tall grass prairies and agricultural development has caused a decrease in jackrabbit populations. Furthermore, humans have historically eliminated jackrabbits when they occur near cropland.

19.3.5.9.8 Plains Spotted Skunk

The plains spotted skunk is a State-listed endangered species found in open grasslands, shrublands, and cultivated areas (MDC, 2000g). These skunks are omnivorous and eat insects, mice, rats, birds, and vegetation. They create dens belowground in grassy banks, rocky crevices, or aboveground in hay stacks, woodpiles, or hollow trees. This potential habitat is found throughout the ROI.

Declines to the spotted skunk population can be attributed to agricultural development that removed habitat and cover. The use of pesticides has also limited the amount of available food resources for these skunks.

19.3.5.9.9 Bald Eagle

Bald eagles are a riparian-dependent species. They are frequently found in or near riparian areas where they forage on waterfowl and fish (MDC, 2012). Some eagles will inhabit terrestrial environments and feed on small game. Nesting bald eagles are predominantly associated with lakes or rivers. Missouri has estimated winter populations in the state to be approximately 2,660 eagles, with a summer population of approximately 600 eagles. Only two eagle nests have been identified within Boone County (MDC, 2012). Bald eagles have the potential to be found within the ROI, but are unlikely to be permanent residents.

The most limiting factor to this species is loss of habitat. Increased development and the modification of wildland have had a cumulative adverse impact on this species. Human disturbance, in the form of direct mortality, application of pesticides, and removal of nesting sites, has also had a limiting factor on the population.

19.3.5.9.10 American Bittern

The American bittern is a State-listed species primarily found in wetland and riparian areas with tall emergent vegetation from spring to late fall. These birds will nest in thick vegetation several inches above water. American bitterns typically prey on large insects, small fish, mammals, amphibians, and crayfish (MDC, 2000h). The American bittern is likely to occur in wetlands within the ROI, but for only a short period of time during nesting.

The loss of wetland habitat is the main limiting factor on American bittern populations, along with chemical contamination.

19.3.5.9.11 Northern Harrier

The Northern Harrier is a State-listed species primarily found in undisturbed marshes, prairies, and pastures with low shrubby vegetation, tall weeds, or reeds. These birds prefer to nest on elevated ground in colonies late in the spring. Northern Harrier prey on small mammals, birds, insects, reptiles, and amphibians (MDC, 2000i). The Northern Harrier is likely to occur within the ROI during the spring and fall, in areas that will provide ideal nesting and foraging habitat. Due to the developed nature of the ROI, the northern harrier is anticipated to be found in the less populated undisturbed parts of the area.

19.3.6 Historical and Cultural Resources

The ROI for historic, archaeological, and cultural resources was established as the spatial area used to assess the potential direct and indirect impacts in which a proposed project could alter characteristics of a historic, archaeological, or cultural resource. The ROI for the proposed RPF is defined as portions of Lot 15 identified for ground disturbance activities at Discovery Ridge and areas immediately adjacent to this area. Various methods were used to assess potential resources within the ROI.

The cultural resource analysis was performed for the proposed RPF site in compliance with NRC-2011-0135 (NRC, 2012a) guidance. Construction and decommissioning activities would largely occur within the area of Lot 15.

19.3.6.1 Cultural Setting

The proposed RPF site is located in the Central Missouri Drainage Basin. The Environmental Research Center of Missouri conducted cultural research in 2012 for a communications project in this basin (ERC, 2012). Because the proposed site lies within the same drainage basin, the cultural setting information for the basin is summarized in this report to describe the historical cultural setting for the site.

19.3.6.1.1 Prehistoric Populations

The occupation of Missouri by prehistoric populations has been generally established to include nine traditions (Chapman, 1975 and 1980). These traditions apply in varying degree to the entire state, with some traditions often not accounted for in specific drainages. These traditions are incorporated in what is called the cultural sequence, which is a major factor used in the interpretation of cultural data, particularly regarding National Register of Historic Places (NRHP) significance. The following traditions are summarized below in the sequence provided by Chapman (1975, 1980):

- Paleo-Indian (12000–8000 B.C.)
- Dalton (8000–7000 B.C.)
- Early Archaic (7000–5000 B.C.)
- Middle Archaic (5000–3000 B.C.)
- Late Archaic (3000–1000 B.C.)
- Early Woodland (1000–500 B.C.)
- Middle Woodland (500 B.C. to A.D. 400)
- Late Woodland (A.D. 400 to 900)
- Mississippian (A.D. 900 to 1400)

Paleo-Indian – The Paleo-Indian period is generally accepted as marking the earliest known human occupation of Missouri. The specialized hunters of this period lived in small nomadic bands or family groups and left some traces of their transitory settlement pattern in the forms of hunting camps, kill sites, quarry sites, and possibly small base camps. The major diagnostic materials associated with the occupation include the Clovis and Folsom fluted spear/knife points. Most fluted point finds have been located along major river valleys (e.g., Missouri River), although some have been recovered along streams such as the Moreau River. These finds suggest that the nomadic hunters and gatherers followed these streams in their movement through the Midwest area.

Dalton – The Dalton period is characterized as a time of transition from Paleo-Indian big game hunting to the hunting-foraging subsistence strategy of the following Archaic period. All known Dalton sites in Missouri are small camps, and all apparently represent short-term utilization. The basic Paleo-Indian tool kit was still in use during Dalton times, although tools associated with plant food processing were added. Point types with long flutes were replaced by types with basal thinning and/or short flutes. The major diagnostic includes the Dalton Serrated and perhaps the Dalton Adze. Population distribution roughly parallels that of the Paleo-Indian occupation.

Early Archaic – The transition to a subsistence pattern of occupation based on foraging was well underway by the time of the Early Archaic period. Hunting and gathering continued as the major economic activities, but emphasis was placed on aquatic resources and vegetal foods. Although nomadic wandering was being replaced by specific base campsites that were returned to at regular intervals, the typical Early Archaic site continued to be a small hunting and/or collecting camp.

These sites are found in a variety of environmental settings throughout Missouri, including upland ridges near small ephemeral streams, upland bluff edges, rock shelters, and the margins of high bottomland terraces. Diagnostics of Early Archaic include Graham Cave Notched points that have been recovered in the general area. Hardin Barbed points are also generally associated with Early Archaic occupation.

Middle Archaic – This period was basically a continuation and expansion of a forager tradition begun in the Dalton and Early Archaic periods. A drying climate forced greater reliance on collecting vegetal foods and small animals as opposed to wet environment subsistence. Sites continued to be small, exhibiting semi-nomadic or seasonal occupation. The tool kit continued to expand, depending on the extraction activity in the specific niche. The drying climate was reflected in the marked tendency for Middle Archaic sites to be located almost exclusively in or very near bottomland settings.

Late Archaic – This period is better known than earlier traditions as a result of the greater population apparently represented, which resulted in more expansive and numerous occupations. This period generally lacks the small dart point of the earlier traditions, which suggests that hunting had become less important for subsistence. Tool kit function also appears to have expanded, suggesting reliance on a much larger variety of potential foods requiring varied extraction and processing techniques. The Late Archaic period began toward the climax of a warming trend that reached its height around 2000 B.C., with a resultant diminishing of the faunal and floral forest species. The Late Archaic population had to adapt to new ecological niches with the associated changes in subsistence-related artifacts. Late Archaic occupations are one of the more commonly identified traditions in the drainage.

Early Woodland – This period is identified by the presence of Black Sand Incised pottery and is poorly represented throughout most of Missouri. In spite of intensive surveys in various areas of the state, only a few unquestionable Early Woodland sites have been identified.

Middle Woodland – The occupation during this period in northern Missouri is focused on three related regional centers: Havana in the Lower Illinois River Valley and adjacent Mississippi River Valley in the northeast, Kansas City Hopewell on the Missouri River, and Big Bend on the Missouri River. Analyses of pottery from the three centers indicate there was an intrusion of people into the Big Bend and Kansas City Hopewell centers from the Havana center to the east. Although the initial intrusion appears to have been related to subsistence and/or political stress in the Havana center, contacts among the three centers was maintained throughout the Middle Woodland period. Evidence for a Middle Woodland occupation is sparse outside of the areas noted. Some rock shelters and open habitation sites in the general area have produced Middle Woodland diagnostics and Chapman (1980) identified south Boone County as a major Middle Woodland center. However, there has been no corroborating evidence to support that identification through field investigations.

Late Woodland – This period exhibits the most numerous defined components (elements) within prehistoric sites in the general basin area. The occupation in this portion of Missouri has sometimes been defined as a regression from the preceding traditions, in that emphasis on horticulture developed earlier in the Woodland was supplanted by earlier hunting subsistence reliance. This pattern is seen in the increase in small temporary camps, along with use of a bow and arrow. Diagnostics include grit- and limestone-tempered pottery, arrow points, burial mounds, and shallow side-notched points. Several Late Woodland sites have been identified in Boone County, including open habitation sites and burial mounds.

Mississippian – This period is not well-documented in the general area of the proposed site. Diagnostics for this period include small triangular arrow points and shell-tempered ceramics. Early Mississippian Steed-Kisker people apparently abandoned the Kansas City area around A.D. 1250, and around A.D. 1350, the Oneota cultural tradition appeared suddenly in the Big Bend area near the junction of the Grand, Chariton, and Missouri Rivers. The most prominent Oneota village in the Big Bend area is the Utz site in Saline County, and it was there that the Utz phase, which documents the Oneota culture of the area, was defined.

The Utz phase, and the Oneota occupation, began at about A.D. 1350 and lasted to the end of the Mississippian period (A.D. 1700), when Oneota blends into what is recognized as the Historic Missouri Indian tribe.

19.3.6.1.2 Historic Period

During the period from 1730 to 1790, the Missouri tribe was being depleted by smallpox and its power was continually being tested by its enemies to the north. By the 1780s, the Missouri tribe became heavily dependent on their allies the Osage for protection; however, the Sac and Fox tribes conquered and dispersed the Missouri tribe in the 1790s. Those who were not killed joined the Osage, Kansas, and Oto tribes. The great smallpox epidemic of 1823 reduced the Missouri tribe numbers to less than 100, and the Missouri as a distinct cultural entity became extinct. The last full-blood Missouri Indian died on the Oto reservation in 1907.

The land in which the proposed RPF site lies was but a tiny portion of North American territory claimed by France until 1762, when the land was transferred to Spain by secret treaty. Spain retroceded the land to France in 1801, and France ended up selling it to the U.S. in 1803 as the Louisiana Purchase. The U.S. Congress created the Territory of Missouri in 1812, and in 1821, Missouri was recognized as the 21st state.

In general, the post-1800 history of central Missouri reflects both the general patterns of agricultural developments in the Midwest and specific influences that shaped the region. The process of early settlement and the struggle to produce beyond a meager subsistence, the expansion of the agricultural and commercial activities and creation of a stable society, followed by an era in which regional concerns were shaped by state and national trends, are all recognized as part of the evolution of the Midwest. In the case of northern Missouri, an understanding of its Euro-American past requires recognition of the influence of the settlers themselves and of the land that they occupied. The early settlers came primarily from the upper south, especially Kentucky, Tennessee, and Virginia. Prior to the Civil War, tobacco and corn played an important role in the agricultural economy of the region. The first permanent settlers began entering the area in the early 1800s, a process that primarily started after the acquisition of the Louisiana Territory.

The rapid development from uncharted wilderness to statehood stemmed directly from the massive westward movement of population during the early nineteenth century. Most of the settlers who came to mid-Missouri were attracted to the land. A rich, friable loam predominated, with substantial stands of timber that provided building materials and generally reminded the immigrants of the lands that they had left behind. The background of the settlers made them receptive to cultivating a crop that would reproduce the agricultural patterns of their native states. Most of the early settlers came from the upper south, which included slave-holding states. Major crops included hemp and tobacco; these crops, particularly tobacco, demand intensive labor for productivity. Tobacco was generally favored as a cash crop in that tobacco produced a greater value in proportion to bulk when compared to grain crops.

While not well-documented, agricultural pursuits were almost entirely geared toward corn and wheat by the time of the Civil War. Slave holding had also begun to drop at a relatively high rate prior to the Civil War. The land and its location then became major shaping forces of the economic system of the area, altering the previous patterns established in the southeast and brought to the Midwest. The coming of the railroad in the 1850s through the 1870s opened the interior to greater trade and agricultural products, which have been the major source of livelihood in the general area since.

19.3.6.1.3 Recent History – Columbia

From its beginnings, the economy of Columbia, Missouri, has rested on education. Columbia also benefited from being a stagecoach stop of the Santa Fe and Oregon Trails, and later from the Missouri Kansas Texas Railroad. Columbia was incorporated in 1826, five years after Missouri became the 24th state. The city's progress can be traced through the development of its institutions. In 1824, Columbia was the site of a new courthouse; in 1830, the first newspaper was published; in 1832, the first Missouri theater was opened in Columbia; and in 1834, a school system began to serve its 700 citizens. Missouri's first agricultural fair was held in Columbia in 1835. A school for girls was opened in 1833, and an institution called Columbia College (unrelated to the present school) was opened in 1834.

One of the finest U.S. portrait artists, George Caleb Bingham, opened a studio in Columbia in 1834. In 1841, MU was built in Columbia after Boone County outdid several competing counties in raising money and setting land aside. In 1851, Christian Female College was established. The college became a coed school in the 1970s and changed its name to Columbia College. In 1855, Baptist Female College, now known as Stephens College, was established. By 1839, the population and wealth of Boone County, with 13,000 citizens, was exceeded only by that of St. Louis County.

Slavery was a largely accepted practice in Columbia in its early days, and the slave population had reached more than 5,000 by the beginning of the Civil War. Before the Civil War, many Columbians were very nationalistic and supported the Missouri Compromise. That agreement admitted Missouri into the Union as a slave state, but placated northerners with the admission of Maine as a free state and the establishment of the rest of the Louisiana Purchase (north and west of Missouri's southern border) as free territory. Early in the Civil War, Union forces secured the area and enforced a mandatory draft into the local militia. Although Missouri was officially a Union state, residents were in reality sharply divided and supported both sides with supplies and men.

Since the turmoil of the Civil War and Reconstruction, Columbia's history is marked by steady and quiet growth and prosperity, based on its roots in education, along with health care and insurance. The health care business can be said to have started in 1822, when Dr. William Jewell set up a hospital in his own home. Today, Columbia is among the top cities in the nation for medical facilities per capita. The insurance industry also has its roots in Columbia's early days, when pragmatic local businessmen started a fund to aid one another in case of fire.

19.3.6.2 Recent History – Discovery Ridge

The Phase I environmental site assessment for Discovery Ridge (Terracon, 2011a) included results of record searches and interviews with personnel associated with the site to document its most recent history. Findings resulting from those efforts are summarized in the following sections.

Based on review of the historical information, the Discovery Ridge site has predominately been vacant farmland consisting of both row crop production and livestock pasture from at least 1934 to 2006. The western portion of the site has been used as a developing research park from approximately 2006 to present. The eastern portion of the site has always been used as farmland and livestock pastureland. The northern portion of the site is currently used as the MU plant genetic research farm. A residential structure was located at the genetics farm on the northern portion of the site, from approximately 1945 to 2001, at which time the residential structure was demolished. Multiple small, machine-shed structures have been located at the genetics farm (on the northern portion of the site) from at least 1956 to the mid-2000s, with two small machine-shed structures still present. A large, machine shed structure located at the genetics farm was added in approximately 2007. A Quonset hut structure used by the USDA has been in place on the western portion of the site from approximately 1965 to present. A residential structure was located on the western portion of the site, east of the current Quonset hut, from approximately 1945 to the 1980s. A small, log cabin-type structure was located on the central portion of the site from approximately 1945 to 1980.

19.3.6.3 Previous Investigations

Cultural resources are comprised of both historic properties and archaeological artifacts. In accordance with Section 108 of the National Historic Preservation Act of 1966 (16 U.S.C. § 470 et seq.), a cultural resource assessment (Section 106 review) of the site was conducted by the MDNR State Historic Preservation Office for 15 lots, including Lot 15 (Terracon, 2011a). That assessment reported that, "the Section 106 Review form, signed by Mark Miles, Deputy State Historic Preservation Officer, dated March 7, 2011, states that 'an adequate cultural resource survey of the project area has been previously conducted. It has been determined that for the proposed undertaking there will be no historic properties affected'" (Terracon, 2011a).

19.3.6.4 Recent Cultural Resources Surveys

NWMI conducted an investigation in October 2013 to inventory and evaluate cultural resources within the designated project zone through the use of currently accepted Phase I survey techniques and review of records and literature. The study was initiated to carry out Federally mandated Section 106 compliance regulations. The scope of work placed emphasis on identification of cultural resources within the project area, along with recovery of sufficient data to allow the Missouri State Historic Preservation Office (SHPO) to make an informed determination of possible significance of those resources. The investigation included (1) a pre-field evaluation of pertinent literature and records from which the field survey techniques and site designation criteria were developed, (2) an intensive pedestrian survey of the project area, (3) an attempt to recover sufficient data for site designation and evaluation in terms of NRHP eligibility requirements, (4) notation of locational information regarding site provenience and physiographic setting, (5) post-field activities involving data analysis, and (6) report preparation.

19.3.6.5 Literature Review

A review of relevant publications and records prior to the field component of the study was important in establishing an understanding of the sequence and types of cultural resources that might be expected to occur. The process began with review of cultural resource management reports that have been produced for the areas near the RPF project zone. These reports are housed in MDNR SHPO, Jefferson City, Missouri, and are catalogued by county and author. The repository also includes historic architecture site forms for the State, NRHP forms for Missouri, and correspondence regarding the proposed project. Archaeological Survey of Missouri records located at the SHPO were also reviewed.

The Archaeological Survey of Missouri files for reported Missouri archaeological sites contain data that has been gathered for over 70 years. The data is catalogued by county and section, township, and range, and the Universal Transverse Mercator coordinates. The SHPO Geographical Information System (GIS) data includes overlays illustrating recorded archaeology sites and areas that have been the subject of previous cultural resource surveys. Other consulted resources with important data include the State library and State archives in Jefferson City, local historic societies when available, and the Missouri historic society in Columbia. Other archaeologists and architectural historians, particularly those employed by Missouri who are involved with Section 106 procedures, were consulted regarding their knowledge of significant cultural resources in the project area.

There are no previously recorded prehistoric archaeology sites within the proposed project boundaries (Figure 19-40). [Proprietary Information]. The proposed RPF site contains no recorded historic architecture or possibly significant historic events. Review of 19th and 20th century plat maps and 20th century USGS topographic quadrangles found no evidence of structures within the project area. The 1967/81 USGS topographic quadrangle does not illustrate any structures on the proposed RPF site.

[Proprietary Information]

Figure 19-40. Archeology and Survey Layers Map in Relation to the Radioisotope Production Facility Site

19.3.6.6 Pedestrian Survey

19.3.6.6.1 Methodology

The archaeological field component of the investigation involved pedestrian coverage of the defined RPF site. The transect width used ranged from 5–15 m (16–49 ft), depending on visibility and the potential for the presence of prehistoric features based on terrain, streams, and other factors that have been shown to correlate with site presence or absence (e.g., presettlement prairie or woodland setting). All vegetation-free zones were observed for the presence of prehistoric cultural materials. Throughout most of Missouri, these cultural finds can include lithic debitage (chert flakes and shatter), fire-cracked rock, pottery shards, occasional bone and shell fragments, and features such as fire hearths and burial mounds.

Where vegetation covered the surface for over 10 m (33 ft), shovel tests were conducted. This effort involved removal of an area of sod of approximately 50 x 50 cm (20 x 20-in.) and then controlled removal of the subsurface soil matrix to depths of up to 50 cm (20 in.) below-ground surface. Soils were carefully observed to determine the presence or absence of cultural evidence. Where soil conditions allowed, soils were screened through a portable ¼-in. screen. Shovel testing that did not include screening of the soil matrix was conducted where larger numbers of shovel tests were necessary and surface visibility conditions were poor. In this instance, the soil matrix was removed by shovel and carefully scraped with a trowel to look for prehistoric and early historic evidence.

While subjective, the archeologist has developed a set of criteria for determining the presence of an archaeological resource, which is currently accepted by the SHPO as appropriate. These criteria are not presented as appropriate for all situations, but as the general practice followed by the archeologist in making decisions regarding the presence or absence of archaeological resources for cultural resource compliance purposes. One extreme records a site where any evidence of cultural activity occurs. The other extreme requires a significant cultural resource to be present to record the site. The present approach attempts to find a middle ground, which allows further consideration for both the cultural resource and the proposed project action prior to threat to either.

An archaeology site is designated when evidence of prehistoric and/or early historic land use is present and at least one of the following specific criteria is met:

- A prehistoric feature is present
- Two or more artifacts are identified within a 10 x 10 m (33 x 33-ft) (or smaller) area
- A shovel test recovers two or more artifacts

Where a site is identified and when the landowner grants permission, materials recovered by the field investigation are placed in collection bags marked with field site numbers. If permission is not attained, materials are observed and potential diagnostics and tools area measured, photographed, and left in place or given to the landowner (when requested). When a permanent site number is assigned, retained materials are curated with the site designation. Where material density at a site is obviously high, only a representative sample is retained. Historic architecture resources include structures and features. Where there are structures over 45 years old or that exhibit some form of possible exceptional significance, the structures are photographed and a description of the architectural features is prepared, with preliminary evaluation of NRHP eligibility when located within a direct impact project zone.

Historic structures are not recorded where obvious that the structures are less than 45 years old and not otherwise significant. Where an "area of potential effect" has been established beyond the physical area of potential effect, architectural resources obviously 45 years or older are photographed and located on report maps.

The significance of cultural resources is interpreted from the following NRHP eligibility criteria:

> *The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling and association, and:*
>
> A. *That are associated with events that have made a significant contribution to the broad patterns of our history; or*
>
> B. *That are associated with the lives of persons significant in our past; or*
>
> C. *That embody the distinctive characteristics of type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant distinguishing entity whose components may lack individual distinction; or*
>
> D. *That have yielded, or may be likely to yield, information important in prehistory or history.* (36 CFR 60.6, "Nominations by the State Historic Preservation Officer under Approved State Historic Preservation Programs")

Cultural resources that are identified during a Phase I survey are evaluated in terms of meeting one or more of the 36 CFR 60.6 criteria. In general, archaeological sites most often are evaluated with reference to Criterion D. A statewide planning document was prepared by the Missouri Department of Natural Resources Historic Preservation Program that allows minimal means for evaluation of potential significance of cultural resources (Weichman and Weston, 1986). The statewide plan includes information regarding traditions, types of traditions expected, forms of data that may be important, and research questions that can be incorporated in the interpretation of cultural resource significance where available.

A cultural resource is generally evaluated on the (1) basis of types of materials recovered (uniqueness, affiliation, type), (2) resource integrity (degree of disturbance), and (3) material/feature density (density and quantity of artifacts, and the presence and number of potentially extant features such as hearths, house sites, and burial tumuli). If an archaeological site exhibits sub-plow zone integrity and produces diagnostic artifacts or features, the site is usually interpreted as significant if considered likely to contain sufficient data to contribute to the understanding of the cultural history of the area and meet NRHP eligibility Criterion D. The consultant makes recommendations regarding NRHP eligibility. The determination of eligibility process requires consultation with the SHPO and the Federal agency involved in the project.

19.3.6.6.2 Findings

The Phase I field investigation was carried out under generally mixed to poor surface visibility conditions, averaging less than 20 percent in a grass/hay setting. Shovel tests were used to interpret the presence or absence of cultural resources, as described in Section 19.3.6.6.1. The presence of erosion cuts and paths, along with shovel tests, allowed for a sample of the subsurface soil matrix for interpretation of the potential for the presence or absence of buried cultural resources.

No evidence of prehistoric occupation of the area was found. Such evidence typically includes the presence of chert debitage, fire-cracked rock, lithic artifacts, and occasionally ceramics. No prehistoric sites were recorded.

Historic resources include recently constructed roads that do not meet the investigators' historic site designation criteria. No historic sites were recorded. The survey concluded that Lot 15 in the Discovery Ridge development contains no possibly significant cultural resources.

19.3.6.7 Previously Recorded Historic Structures and Districts

Historic and archaeological resources that are listed, or eligible for listing, in the NRHP are protected by Federal law, primarily the National Historic Preservation Act and its implementing regulations, specifically 36 CFR 800, "Protection of Historic Properties." Under the authority of Section 106 of the National Historic Preservation Act, Federal agencies must take into account the potential effects an undertaking may have on properties listed in or eligible for listing in the NRHP.

The NRHP was consulted to identify historic and architectural structures. There are 50 NRHP sites in Boone County (Table 19-45), with the vast majority of them located in and around Columbia. There are no historic or architectural resources located within the ROI.

The closest site to the ROI is the Maplewood House, which was built in 1877 by Slater Ensor Lenoir and his wife Margaret Bradford Lenoir. The original farmstead included 173 ha (427 acres) surrounding the house to the east and west. A large pond was situated south of the house. In addition to the family home, buildings on the property included the separate summer kitchen (which later served as a cottage for family serving staff), a four-bay carriage house with storage and living quarters above, a utility house, a hay barn, and a large animal barn. Only four people lived in the home: the Lenoirs, their daughter Lavinia, and later Lavinia's husband, Dr. Frank G. Nifong. In 1970, the City of Columbia bought 24 ha (60 acres) of the original farm with the house, the remaining furnishings, and the adjacent farm buildings. The animal barn was converted to a summer theater playhouse after the property was purchased by the city of Columbia. The building was lost to fire in 2011 and rebuilt and dedicated in 2012. The area was named the Frank G. Nifong Memorial Park and today is called Historic Nifong Park in recognition of the work of historic preservation undertaken by the Columbia Parks and Recreation Department and the Boone County Historical Society (Boone County Historical Society, 2013). Table 19-45 lists Boone County NRHP listings.

Table 19-45. Boone County Listings on the National Register of Historic Places (3 pages)

	Historical site	Address	Date of listing
1	Ballenger Building	27-29 S 9th St., Columbia	1/21/04
2	Bond's Chapel Methodist Episcopal Church	4 km (2.5 mi) NE of Hartsburg, Hartsburg vicinity	9/9/93
3	John W. Boone ("Blind") House	4th St. between E Broadway and Walnut, Columbia	9/4/80
4	Central Dairy Building	1104-1106 East Broadway, Columbia	1/20/05
5	Albert Bishop Chance House and Gardens	319 E Sneed St., Centralia	7/3/79
6	Chatol (F. Gano Chance House, Chance Guest House)	543 S Jefferson, Centralia	4/20/79
7	Coca-Cola Bottling Co. Building	10 Hitt St., Columbia	2/14/06
8	Columbia Cemetery	30 East Broadway, Columbia	2/1/07
9	Columbia National Guard Armory	701 E Ash St., Columbia	3/25/93
10	Sanford F. Conley House	602 Sanford Pl., Columbia	12/18/73
11	Fred Douglass School	310 N Providence Rd., Columbia	9/4/80

Table 19-45. Boone County Listings on the National Register of Historic Places (3 pages)

	Historical site	Address	Date of listing
12	Downtown Columbia Historic District	Parts of 7th, 8th, 9th, 10th, E Broadway, Cherry, Hitt, Locust, and E. Walnut Streets, Columbia	11/8/06
13	Downtown Columbia Historic District	1019, 1020, 1023, and 1025-33 E. Walnut St., Columbia	5/8/08
14	East Campus Neighborhood Historic District	Roughly bounded by Bouchelle, College, University, and High Streets, including parts of Willis, Bass, Dorsey, and Anthony Streets, Columbia	2/16/96
15	Eighth Broadway Historic District	800-810 E Broadway Blvd., Columbia	4/22/03
16	Samuel H. and Isabel Smith Elkins House	315 N 10th St., Columbia	9/12/96
17	First Christian Church	101 N 10th St., Columbia	10/29/91
18	Francis Quadrangle Historic District	Bounded by Conley Ave., Elm, 6th and 9th Streets, Columbia	12/18/73
19	Frederick Apartments	1001 University Ave., Columbia	4/16/13
20	David Gordon House and Collins Log Cabin	2100 E Broadway, Columbia	8/29/83
21	Gordon Tract Archaeological Site	Address restricted	3/16/72
22	Greenwood (Greenwood Heights)	3005 Mexico Gravel Rd., Columbia	1/15/79
23	David Guitar House	2815 Oakland Gravel Rd., Columbia	9/9/93
24	Samuel E. Hackman Building	30 S St., Hartsburg	12/10/98
25	Hamilton-Brown Shoe Factory	1123 Wilkes Blvd., Columbia	7/19/02
26	William B. Hunt House	8939 W Terrapin Hills Rd., Columbia vicinity	1/9/97
27	Kress Building	1025 E. Broadway, Columbia	3/9/05
28	Maplewood House	Nifong Blvd. and Ponderosa Dr., Columbia	4/13/79
29	McCain Furniture Store	916 E. Walnut, Columbia	8/17/05
30	Missouri, Kansas and Texas Railroad Depot	402 E Broadway, Columbia	1/29/79
31	Missouri State Teachers Association	407 S 6th St., Columbia	9/4/80
32	Missouri Theater	201-215 S 9th St., Columbia	6/6/79
33	Missouri United Methodist Church	204 S 9th St., Columbia	9/4/80
34	Mount Zion Church and Cemetery	11070 Mount Zion Rd., Hallsville vicinity	1/14/13
35	North Ninth Street Historic District	5-36 North Ninth St., Columbia	1/21/04
36	Payne, Moses U., House	201 N Roby Farm Rd., Rocheport vicinity	10/7/94

Table 19-45. Boone County Listings on the National Register of Historic Places (3 pages)

	Historical site	Address	Date of listing
37	Pierce Pennant Motor Hotel (Candlelight Lodge)	1406 Old Hwy. 40 W, Columbia	9/2/82
38	Rocheport Historic District	MO 240, Rocheport	10/8/76
39	St. Paul's African Methodist Episcopal Church	501 Park St., Columbia	9/4/80
40	Sanborn Field and Soil Erosion Plots	University of Missouri Campus, Columbia	10/15/66; NHL 7/19/64
41	Second Baptist Church	407 E. Broadway	9/4/80
42	Second Christian Church	401 N 5th St., Columbia	9/4/80
43	Senior Hall	Stephens College Campus, Columbia	8/2/77
44	Stephens College, South Campus	1200 E. Broadway, Columbia	11/25/05
45	John N. and Elizabeth Taylor House	House, 716 West Broadway, Columbia	5/25/01
46	Tiger Hotel	23 S 8th St., Columbia	2/29/80
47	Virginia Building	111 S 9th St., Columbia	3/13/02
48	Wabash Railroad Station and Freight House (Norfolk and Western Depot)	126 N 10th St., Columbia	10/11/79
49	West Broadway Historic District	300–922 W. Broadway (except 800, 808, 812), Columbia	4/27/10
50	Wright Brothers Mule Barn	1101–1107 Hinkson Ave. and 501–507 Fay St., Columbia	11/1/07

Source: MDNR, 2013i, "Boone County National Register Listings," www.dnr.mo.gov/shpo/Boone.htm, Missouri Department of Natural Resources, Jefferson City, Missouri, accessed September 2013.

19.3.6.8 Native American and State Agency Consultation

NWMI initiated consultation with six tribes that are Federally recognized in Missouri. Copies of the consultation letters are provided in Appendix A. No responses have been received.

NWMI forwarded the cultural resource investigation for Lot 15 of the Discovery Ridge property to the Missouri State Historical Preservation office on October 7, 2013 (ERC, 2013). NWMI received notification from the Missouri State Historical Preservation office on October 10, 2013, stating that the office concurred that the cultural resources survey was thorough and adequate and that there would be no historical properties affected by the proposed RPF project (DNR, 2013).

19.3.7 Socioeconomics

This section describes the social and economic characteristics of the ROI, defined as Boone County for the socioeconomic resource. Information is provided about population, including minority and low-income areas, economic trends, housing, and community services in the areas of education, health, public safety, and transportation. The primary labor market for the proposed project is assumed to come from Boone County.

The proposed RPF site is located in Boone County, Missouri, as shown on Figure 19-5, which shows the 8 km (5-mi) area surrounding the proposed site. The figure also shows the city of Columbia, Missouri. Boone County was selected as the primary ROI, and the locations where impacts could occur were identified with the project being located in Boone County. An assumption is also made that the primary labor market for the project would likely come from this county.

19.3.7.1 Boone County

19.3.7.1.1 History

Boone County was organized in 1820 from a portion of the territorial Howard County and named for Daniel Boone. Boone County was settled primarily from the upper south states of Kentucky, Tennessee, and Virginia. The settlers brought slaves and slaveholding with them, and quickly started cultivating crops similar to those in middle Tennessee and Kentucky, namely hemp and tobacco. Boone County was one of several counties settled by southerners to the north and south of the Missouri River (Moser, 2013).

19.3.7.1.2 Census-Based Population/Demographic Information

Boone County has a total area of 1,790.5 km^2 (691 mi^2), of which 1,775.3 km^2 (685 mi^2) is land and 15.2 km^2 (5.88 mi^2) is water. The estimated population density, based on the 2010 Census, is 91 people per km^2 (237 people per mi^2) (USCB, 2010c).

In the 2010 Census, there were 162,642 people making up 69,551 households residing in the county. There were 64,077 housing units. The racial makeup of the county includes 82.8 percent White, 9.3 percent Black or African American, 3 percent Hispanic or Latino, 0.4 percent Native American, 3.8 percent Asian, 0.06 percent Pacific Islander, 0.9 percent from other races, and 2.8 percent from two or more races.

The 2010 Census documents 64,077 households, out of which:

- 27.0 percent had children under the age of 18
- 42.1 percent were married couples living together
- 10.7 percent had a female household with no husband present
- 3.8 percent had a male household with no wife present
- 43.3 percent were nonfamilies.

A total of 28.7 percent of all households were made up of individuals, and 6.6 percent had someone living alone who was 65 years of age or older. The average household size was 2.4 individuals, and the average family size was 2.96.

The 2010 Census county population includes 21.1 percent under the age of 18, 26.6 percent from ages 18 to 24, 26.6 percent from ages 25 to 44, 22.1 percent from ages 45 to 64, and 9.2 percent age 65 and older. The median age was 29.6 years.

19.3.7.1.3 Income

The 2010 Census median income for a household in the county was $47,123, and the median income for a family was $66,943. The per capita income for the county was $25,970 (USCB, 2010c).

19.3.7.1.4 Residents Below the Poverty Threshold

In the 2010 Census, approximately 9.9 percent of families and 19.2 percent of the population were below the poverty line, including 17.8 percent of those under age 18 and 10.3 percent of those ages 65 and over (USCB, 2010c).

19.3.7.1.5 Housing

The 2010 Census reports a total of 69,551 housing units, of which 64,077 are occupied and 5,474 are not occupied. The homeowner vacancy rate is 2.5 percent, and the rental vacancy is 8.5 percent. The median home value is $156,600 (USCB, 2010c).

19.3.7.1.6 Civilian Labor Force/Unemployment

The civilian non-farm labor force for Boone County is estimated at 93,602, with an unemployment rate of 4.9 percent in July 2014 (USDOL, 2014).

19.3.7.1.7 Population Growth

Table 19-46 provides the Boone County population over the past 50 years and projections for the next 20 years. The projections are based on growth estimated in the current City of Columbia comprehensive land use plan (City of Columbia, 2013c) of 1.5 percent annually or 16.1 percent over 10 years.

Table 19-46. Population Growth in Boone County from 1960 (Estimated) through 2030

Census year	Boone County	
	Population	Increase over previous 10 years
1960	55,202	--
1970	80,911	46.6%
1980	100,376	24.1%
1990	112,379	12.0%
2000	135,454	20.5%
2010	162,642	20.1%
2020	188,753	16.1%
2030	219,055	16.1%

Source: USCB, 2010c, "U.S. Census 2010," factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml#none, U.S. Census Bureau, Reston, Virginia, accessed March 12, 2013.

19.3.7.1.8 Transient Population

A detailed analysis of the transient population is provided in Chapter 2.0, Section 2.1.2.2.

19.3.7.1.9 Water Supply

19.3.7.1.9.1 City of Columbia Water

The Columbia Water Treatment Plant is owned by the City of Columbia and operated by the Water and Light Department. The system supplies water to approximately 45,500 customers. The water system has approximately 46,250 service connections and the average daily consumption is 47.7 ML/day (12.60 Mgal/day) (CSWP, 2013).

The service territory of the Columbia Water Treatment Plant lies in Boone County, including Columbia, where the majority of customers reside. Through cooperative service connections, the city has emergency ties to Public Water Districts No. 1 and No. 9, along with MU.

Columbia's water is pumped from 15 shallow wells in the McBaine bottoms that tap into the McBaine aquifer, a water-filled bed of sand and gravel beneath the bottom land bordering the Missouri River just southwest of the city (CSWP, 2013). Columbia's water treatment plant and well water source is located 16 km (10 mi) south of Columbia on Route K, near the small town of McBaine. The plant is approximately 2.4 km (1.5 mi) from the Missouri River. The 15 wells are situated on seven sites that are separated by a minimum of 762 km (2,500 ft) to reduce the possibility of wells competing for the same water area. These wells average 29 m (95 ft) in depth (20 km [65 ft] of well column and 9.1 m [30 ft] of stainless steel screen). Each of the wells is capable of pumping approximately 7.6 ML/day (2 Mgal/day) (CSWP, 2013).

The water treatment plant is a lime-softening and iron removal plant and includes the addition of chlorine and ammonium sulfate before the water is pumped to three water towers in the city. A series of pumps in each of these pumping stations then sends the water out into the distribution system (CSWP, 2013).

In 1904, a series of 366 m deep (1,200-ft deep) wells were constructed into the Roubidoux formation; however, the formation could not support the continued withdrawals. Seven of the original deep wells are still listed by MDNR as part of the Columbia water system, although most of the wells have been inactive for decades. Several of the wells are operational and are identified as emergency backup sources (CSWP, 2013).

Deep Wells #8 and #10 have been renovated and brought back into service as aquifer storage and recovery wells. Well #7 at the West Ash Pumping Station and Well #5 at the northeast booster station are candidate sites for future aquifer storage wells (CSWP, 2013).

The Crump, El Ray, and Prathersville wells were acquired by the Columbia Water and Light Department in the 1990s. Like the majority of the remaining old deep wells, these water district operations are not a source of supply for Columbia. The Crump well is operational (CSWP, 2013).

19.3.7.1.9.2 Consolidated Public Water Supply District #1

Consolidated Public Water Supply District #1 of Boone County was created in 1975 with the consolidation of three public water supply districts that originally formed in the 1960s. This marked the first consolidation of water districts in Missouri. After subsequent consolidations and the annexation of the town of Rocheport, Consolidated Public Water Supply District #1 now encompasses approximately 995 km^2 (384 mi^2) in portions of Boone, Howard, and Callaway Counties. The district provides service to the rural and suburban areas surrounding the southern and western borders of Columbia.

Consolidated Public Water Supply District #1 serves a population of approximately 21,000 through more than 8,500 service connections, with a total average daily water consumption of 5.49 ML/day (1.45 Mgal/day). The distribution system is comprised of 13 deep wells with a total pumping capacity of over 41.6 ML/day (11 Mgal/ day), 12 water storage facilities with a total capacity of 212 ML/day (5.6 Mgal/day), and over 966 km (600 mi) of water mains. Numerous interconnections with the cities of Columbia and Ashland and with adjoining water districts provide additional water sources in case of emergencies.

19.3.7.1.9.3 Public Water Supply District #9

Public Water Supply District #9 provides service to the northeast portion of the proposed RPF site. The distribution system includes approximately 161 km (100 mi) of water line, one elevated 189,270 L (50,000-gal) water tower, five standpipes, and four deep wells with pumps and pump houses. The district owns the land where the wells, standpipes, and towers are located. The district serves approximately 4,000 customers in an area of approximately 272 km^2 (105 mi^2) (PWSD9, 2013).

19.3.7.2 Local Schools

The Columbia Public School District services the population within the 8 km (5-mi) radius of the proposed RPF site. Total district enrollment is 17,722, with 6,171 students enrolled in the schools within the ROI (CPS, 2012).

Table 19-47 provides additional information on each district school.

Table 19-47. Public Schools and Enrollment within an 8 km (5-mi) Radius of the Proposed Radioisotope Production Facility Site

Facility	Grades taught	Number of students
Benton	PK–5	299
Cedar Ridge	PK–5	193
Grant	PK–5	281
Lee	PK–5	294
New Haven	PK–5	287
Rock Bridge	PK–5	594
Shepard Blvd.	PK-5	597
Rock Bridge High	PK and 10–12	1,744
Gentry Middle	6–7	899
Jefferson Jr.	8–9	817
Douglass	8–12	166
Total		6,171

Source: CPS, 2012, "Columbia Public Schools 2012-13 Enrollment (Head Count)," Columbia Public Schools, Columbia, Missouri, September 26, 2012.

19.3.7.3 Population Map

Two Missouri cities, Columbia and Ashland, represent the population centers in the ROI (8 km [5-mi] radius) (see Figure 19-4). As of the 2010 Census, Columbia had a population of 108,500, which increased 20.5 percent over the 10 preceding years, and Ashland had a population of 3,707 (USCB, 2010a). While the proposed site is in Columbia, the city population resides primarily to the north-northwest. Ashland is approximately 10 mi south of the site. Figure 19-5 is a map of the 8 km (5-mi) radius area surrounding the proposed site, including the highest population areas.

19.3.7.4 Transportation Systems

19.3.7.4.1 Local Road Networks

The proposed RPF site in Discovery Ridge is just north of Discovery Ridge Drive within Columbia city limits. Discovery Drive and Discovery Parkway would provide access to the proposed site. Discovery Parkway intersects with U.S. Highway 63 approximately 0.4 km (0.25 mi) to the south. U.S. Highway 63 proceeds north and intersects U.S. Interstate 70 approximately 7.64 km (4.75 mi) to the north. U.S. Highway 63 continues to Jefferson City, Missouri, approximately 50 km (31 mi) to the south. U.S. Interstate 70 proceeds approximately 201 km (125 mi) east to St. Louis, Missouri, and 201 km (125 mi) west to Kansas City, Missouri. Figure 19-4 shows the 200 km (124-mi) radius with cities and roads. Figure 19-5 shows the road adjacent to the proposed RPF site. Current traffic volume for the nearby road systems is summarized in Table 19-48. Additional information regarding corridor dimensions, corridor uses, and traffic patterns and volumes is provided in Section 19.4.10. No current traffic data exists for Discovery Drive or Discovery Parkway.

Table 19-48. Traffic Volume on Local Road Systems

Road	Section	[a]Volume (annual average daily traffic)
Discovery Parkway	South of Discovery Lane	644
Discovery Parkway	South of U.S. 63(traffic heading north)	141
Discovery Parkway	South of U.S. 63(traffic heading south)	205
Gans Road	East of Bearfield road	237
Ponderosa Street	South of Nifong Blvd	1025
U.S. Highway 63	South of Mo 740 (traffic heading north)	20,684
U.S. Highway 63	South of Mo 740 (traffic heading south)	22,994
U.S. Highway 63	South of Mo 740 (traffic heading north)	13,955
U.S. Highway 63	South of Grindstone Parkway (traffic heading south)	14,243

[a] MoDot, 2009, "Columbia Traffic Count Summary," Missouri Department of Transportation, Transportation Planning, Jefferson City, Missouri, July 8, 2009.

19.3.7.4.2 Rail

Missouri is home to the second- and third-largest rail centers in the U.S., in Kansas City and St. Louis, respectively. Union Pacific operates approximately 85 trains each day (UP, 2013). The nearest Union Pacific siding is in Jefferson, approximately 32 km (20 mi) south of the proposed RPF site.

COLT Transload operates on the Columbia branch short line and provides rail transportation to Columbia. COLT Transload is owned by the City of Columbia and operated by the Water and Light Department. The track is rated Federal Railroad Administration Class II, which allows for a 40 km/hr (25 mi/hr) train speed. The rail line generally parallels State Highway B to Hallsville and State Highway 124 to Centralia. In Columbia, the rail line is located just west of the Highway B industrial area, crosses U.S. Highway 63 approximately 4 km (2.5 mi) north of U.S. Interstate 70, and ends south of Rogers Street near the center of town, approximately 7.2 km (4.5 mi) northwest of the proposed RPF site.

COLT Transload provides service for industrial land uses along the Route B corridor in northeast Columbia. Other land uses served include the Columbia Municipal Power Plant and a commercial lumber facility to the north of downtown Columbia. The vast majority (97 percent) of the rail traffic is inbound. Typical usage is approximately 1,500 cars per year. The primary freight includes coal for the City Power Plant, chemicals, petroleum, steel for several manufacturing facilities, and lumber for several commercial facilities. COLT Transload, a Class III railroad, moves over 1,500 cars a year with two locomotives (CTR, 2013).

The Columbia Star Dining Train provides dining and entertainment on vintage 1930s and 1940s railroad passenger cars pulled by 1950s streamlined locomotives. The roundtrip route (approximately 3-hr) runs between Columbia and Centralia on Friday and Saturday evenings, with a brunch run on Sundays.

The nearest station for passenger rail service is Amtrak in Jefferson City (Amtrak-JEF), approximately 26 mi (42 km) to the south (MU, 2006a).

19.3.7.4.3 Air

The nearest airport is the Columbia Regional Airport approximately 10.5 km (6.5 mi) south of the RPF site. The Columbia Regional Airport is used by commercial and privately owned aircraft. The airport is situated on approximately 0.532 ha (1,314 acre) and is owned and operated by the City of Columbia. It is the sole public use airport located in Boone County for which records are kept. The airport has two aircraft runways:

- A 1,982 × 46 m (6,501 × 150-ft) concrete strip that supports most of the commercial air traffic
- A smaller 1,341 × 23 m (4,401 × 75-ft) crosswind runway primarily for private aircraft

For the 12-month period ending October 31, 2013, the airport had 16,610 aircraft operations for an average of 46/day that were 80 percent general aviation, 3 percent military, 16 percent air taxi, and 1 percent air carrier. At that time, there were 36 aircraft based at the airport that were 47 percent single-engine, 25 percent multi-engine, 22 percent jet, and 6 percent helicopter (AMR, 2014).

Two small private airports are located within 16 km (10 mi) of the RPF site. These airports include the Cedar Creek Airport, approximately 9.7 km (6 mi) east of the RPF site, and the Sugar Branch Airport, 16 km (10 mi) to the west of the RPF site. Operations data for these airports is not available.

Three helicopter ports are located with 16 km (10 mi) of the RPF site. These heliports support hospital operations and include the University Hospitals and Clinics heliport located 6 km (3.7 mi) northwest, MU heliport located 6 km (3.7 mi) northwest, and Boone Hospital Center heliport located 6.3 km (3.9 mi) northwest. No operations data are available for these heliports.

19.3.7.5 Taxes

The Missouri personal income tax rates range from 1.5 to 6 percent, assessed over 10 income brackets. The rates start at 1.5 percent on the first $1,000 of taxable income. The rate increases 0.5 percent on each additional $1,000 up to $9,000. The tax rate for income above $9,000 is 6 percent (MDOR, 2013).

Missouri has a State sales tax of 4.225 percent that is levied on the purchase price of tangible personal property or taxable services sold at retail. Columbia has an additional sales tax of 3.375 percent (MDOR, 2013) to support capital needs for public safety, parks, transportation, and maintenance (City of Columbia, 2013e). Boone County collects an additional 1.375 percent sales tax that supports infrastructure (MDOR, 2013).

Missouri charges what is called a transactional privilege tax, considered a sales tax on all sellers for the privilege of engaging in business in Missouri. Thus, additional fees on a sale (e.g., administrative fees for a service, such as auction fees) can be considered taxable (MDOR, 2013).

The Missouri corporate tax rate is 6.25 percent. Only income earned in Missouri is taxed. Two allocation options are offered for calculating this income: (1) the three-factor formula, based on sales, property, and payroll; or (2) the single-factor formula, based only on sales. Missouri is the only state that permits companies to choose the formula that results in the lesser corporate income tax liability. Thus, companies are not penalized for locating property and jobs in Missouri as they are in the other states (MDOR, 2013).

Missouri local governments rely on property taxes levied on real property (real estate) and personal property. The Missouri State Tax Commission oversees the property assessment system. The amount of property taxes imposed on any taxpayer is determined by two separate factors (MDOR, 2013):

1. The assessed value of their taxable property, as established by the local assessor.
2. The total of the tax rates that have been set by the governing bodies of local governments where the property is located, plus the $0.03 State tax rate. In 2013, Boone County levied a property tax of $0.2846. Columbia assessed a tax of $0.4100. In addition, Columbia Public Schools collect $5.4019. The valuation for determining the taxes mentioned above is determined by dividing the assessed value by $100 (BCC, 2013).

Real property is assessed based on its use. Residential property is assessed at 19 percent of value, agricultural is 12 percent of value, and commercial is 32 percent of value (MDOR, 2013).

Some personal property is exempt, including household goods, inventories, apparel, and items of personal use and adornment. Exempt real estate includes property owned by governments and property used as nonprofit cemeteries, exclusively for religious worship, for schools and colleges, and for purely charitable purposes (MDOR, 2013).

19.3.7.6 Public Recreation Facilities

The parks and open spaces within the ROI (i.e., Boone County) are listed in Table 19-49, along with their approximate distance from the proposed RPF site.

Table 19-49. Parks within an 8 km (5-mi) Radius of the Radioisotope Production Facility Site

Park/Open space	Approx. distance from proposed site km	Approx. distance from proposed site (mi)	General direction	Park/Open space	Approx. distance from proposed site km	Approx. distance from proposed site (mi)	General direction
A. Perry Philips Park	1.1	0.7	West	Rock Bridge Park	5.9	3.7	Northwest
Gans Creek Recreation Area	2.1	1.3	Southwest	Cliff Drive Park	5.9	3.7	Northwest
Nifong Park	1.8	1.1	Northwest	Shepard Park	4.5	2.8	North
Rock Bridge Memorial State Park	3.2	2.0	Southwest	Old Hawthorne Golf Club	4.2	2.6	Northeast
Rock Quarry Park	3.2	2.0	Northwest	Oakwood Hills Park	7.2	4.5	Northwest
Grindstone Nature Area	4.5	2.8	Northwest	A. L. Gustin Golf Course	6.6	4.1	Northwest
Waters-Moss Memorial Wildlife Area	3.5	2.2	Northwest	Grasslands Park	7.2	4.5	Northwest
Cosmo-Bethel Park	5.8	3.6	West	Paquin Park	6.8	4.2	Northwest
Capen Park	4.9	3.1	Northwest	Willis Quad	6.8	4.2	Northwest
Three Creeks Conservation Area	5.1	3.2	South	Woodridge Park	6.1	3.8	North
Highpointe Park	5.1	3.2	Northwest	Forum Nature Area	8.0	5.0	Northwest
Old 63 Roadside Park	4.8	3.0	Northwest	Peace Park	6.9	4.3	Northwest
Stephens Lake Park	5.8	3.6	North	Flat Branch Park	7.4	4.6	Northwest
American Legion Park	4.6	2.9	North	Columbia Country Club	6.4	4.0	North
Eastport Park	5.8	3.6	Northeast	McKee Street Park	7.7	4.8	North

In addition to the parks, several other public facilities, summarized below, are located within the ROI.

Aquatic centers – The Columbia Parks and Recreation Department manages four outdoor and two indoor pools. Only two of these facilities, Douglass Family Aquatic Center and Stephens Lake Swimming Beach and Spraygrounds, are located within the ROI.

The Douglass Family Aquatic Center is an outdoor facility that consists of an 18 m (20-yd) recreational pool, a double-loop slide, and a spray park. The Stephens Lake Swimming Beach and Spraygrounds consists of a 4.5 ha (11-acre) lake with unguarded swimming only allowed in designated areas. The park also includes a spraygrounds.

Columbia Area Seniors Center – The Columbia Area Seniors Center offers services and activities for seniors, including meals, computers, and meeting places for activities.

Armory Sports & Recreation Center – This indoor facility is used for basketball, volleyball, meetings, aerobics, and other programs. The facility includes a gymnasium, classroom, meeting room, aerobics room, a cardio/strength training area, computer room, general recreation room, and locker rooms.

19.3.8 Human Health

This section describes the current environment associated with human health for the proposed RPF site. The ROI is defined as the 8 km (5-mi) radius surrounding the RPF site.

19.3.8.1 Sensitive Receptor Locations

In accordance with the requirements of Section 19.3.8 of NRC-2011-0135 (NRC, 2012a), Figure 19-41 shows the location of the proposed RPF and distances to the following locations:

- Nearest site boundary (fence and lot boundaries) from the centerpoint of the facility (Figure 2-4)
- Nearest full-time residence
- Nearest drinking water intake
- Nearby sensitive receptors (schools, hospitals, public parks, and recreational areas)

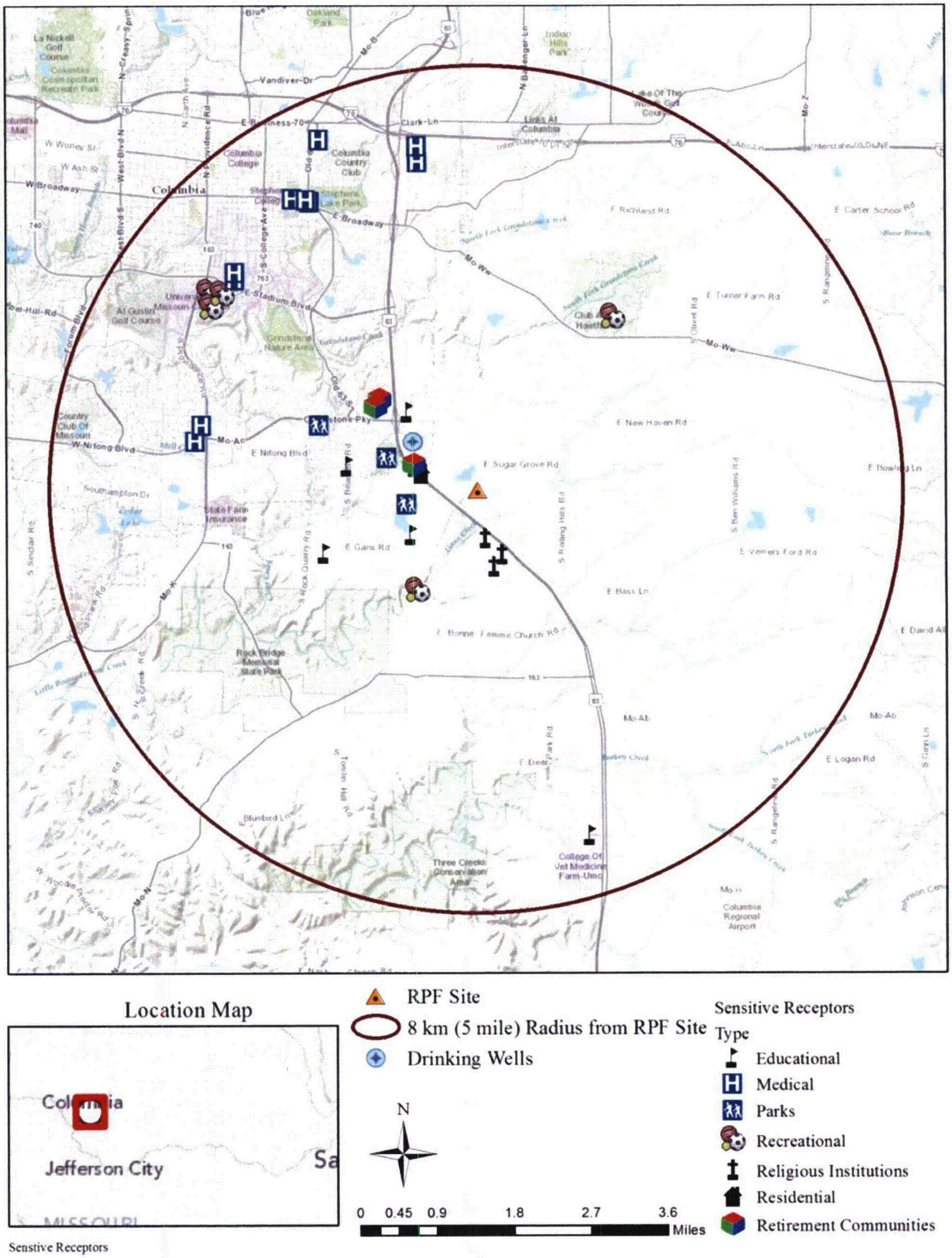

Figure 19-41. Sensitive Receptors

19.3.8.2 Major Sources and Levels of Background Radiation

Existing sources of background radiation near the proposed site are associated with both natural and human-made sources. These sources include naturally occurring, medical, nuclear reactors, and industrial and commercial sources.

Environmental data and historical doses for these sources are described in the following sections. Based on this information, there are no significant abnormal radiation hazards in the vicinity of the proposed RPF. The background radiation exposure is equivalent to the average radiation dose in the U.S. of approximately 6.2 mSv/yr (620 mrem/yr) (NRC, 2013a).

19.3.8.2.1 Naturally Occurring Background Sources

There are three sources of naturally occurring radiation: cosmic, terrestrial, and internal. Cosmic radiation comes from the sun and stars, and the dose received differs with weather and elevation. The elevation of Columbia is approximately 238 m (780 ft) above mean sea level, so the average annual dose from cosmic radiation is 0.28 mSv (28 mrem) (NRC, 2013b).

Terrestrial radiation comes from naturally occurring radionuclides in soil, water, and air. Exposure to airborne radon accounts for the majority of natural radiation sources in the U.S., accounting for 2.0 mSv (200 mrem) of the 3.2 mSv (320 mrem) annual dose from naturally occurring sources. Higher doses of radiation are usually observed in areas with higher soil concentrations of uranium and thorium (NRC, 2013c). Missouri has average background concentrations of uranium and thorium (ORNL, 1981), so the average dose resulting from terrestrial radiation at the proposed site is 2.28 mSv/yr (228 mrem/yr) (EPA, 2013b).

Internal radiation comes from the radionuclides potassium-40 (^{40}K) and carbon-14 (^{14}C), which are naturally occurring inside the human body (NRC, 2013c). This source accounts for an average dose of 0.4 mSv/yr (40 mrem/yr) (EPA, 2013b).

19.3.8.2.2 Human-Made Sources

Human-made sources of radiation are discussed in the following subsections. These radiation sources include medical, nuclear power, industrial and commercial, and radioactive waste. Nearly all the annual radiation dose from human-made sources comes from medical procedures. The remaining sources account for less than 5 percent of the annual dose (NRC, 2013d). As discussed in the following sections, there are no significant sources of radiation in the vicinity of the proposed RPF site; the average dose from human-made sources is 3.1 mSv/yr (310 mrem/yr) (NRC, 2013d).

19.3.8.2.2.1 Medical Sources

There are numerous medical facilities in the ROI that use ionizing radiation for imaging and treatment services. These facilities are listed in Table 19-9. Patients receiving imaging or treatment services involving ionizing radiation receive an average dose of 2.98 mSv/yr (298 mrem/yr), which accounts for 96 percent of the annual dose from human-made sources (NRC, 2013d).

Employees of these medical facilities may be exposed to higher levels of radioactivity than members of the public employed at locations where radiation is not used. 19 CSR 20-10 outlines maximum permissible exposure limits and dosimetry requirements for occupational exposure to ionizing radiation and lists a maximum limit of 50 mSv/yr (5,000 mrem/yr) (whole body dose). Medical facility employees in Columbia do not receive doses in excess of these limits.

19.3.8.2.2.2 Nuclear Reactors

10 CFR 50.47, "Emergency Plans," requires that the emergency planning zone surrounding nuclear power reactors includes the area within an 80 km (50-mi) radius of the reactor. There are two nuclear reactors within 80 km (50 mi) of the proposed RPF site: the MURR and the Callaway Energy Center.

Both reactor facilities maintain a radiological environmental monitoring program and report annual radioactive effluent releases to monitor for any increases in radioactivity resulting from reactor activities. As discussed in the following paragraphs, there were no abnormal radiological releases from either nuclear reactor in 2012, and the average annual dose from living near a nuclear reactor of less than 0.01 mSv (1 mrem) is applicable to the proposed RPF site (EPA, 2013b).

MURR – MURR is located on the MU campus in Columbia. According to the MURR 2012 Annual Report (MURR, 2013), the radiological environmental monitoring program at MURR entails semi-annual collection of soil, water, vegetation, and air samples. During each sampling event, soil and vegetation samples are collected at eight locations, and water samples are collected at three of those locations. Air samples are collected from environmental monitors placed within 0.8 km (0.5 mi) of MURR, and from two control monitors placed 16 km (10 mi) from MURR.

Air monitoring results showed doses of approximately 0.14 mSv/year (14 mrem/year), or less, at all except two monitor locations. Both of those monitors are located near loading docks where radioactive materials are loaded for transport, and elevated doses recorded at these locations are likely the result of packaged material and not related to MURR operation. The facility also reported sanitary sewer and stack effluent monitoring results for calendar year 2012 (MURR, 2013). For the sewer effluent, a total activity of 0.18 curies (Ci) was released to the sanitary sewer, with tritium accounting for 0.16 Ci of the activity. All sewer effluents were in compliance with the limits outlined in 10 CFR 20. A total activity of 1,220 Ci was released via stack effluent, with the majority of the activity coming from argon-41 (^{41}Ar) releases. All stack effluent releases were compliant with the MURR license technical specifications (MURR, 2013). Results from environmental monitoring during calendar year 2012 demonstrated there were no environmental impacts from MURR operations (MURR, 2013).

Callaway Energy Center – Callaway Energy Center is located 65 km (40 mi) southeast of Columbia near the town of Fulton. The center is operated by Ameren Missouri and provides power for 780,000 households annually (Ameren, 2013a). The Callaway Energy Center 2012 Annual Report (EIML, 2013) outlines the Radiological Environmental Monitoring Program. The monitoring program includes collection of water, terrestrial, air, and biological samples.

Surface water, groundwater, drinking water, and sediment samples are collected and analyzed for gamma isotopes, and water samples are also analyzed for tritium. These samples are collected on either a monthly, quarterly, or semi-annual basis. Low-level tritium activity was detected at two surface water locations and in several groundwater monitoring wells; the remaining isotopes were not detected. Low-level cesium-137 (^{137}Cs) activity was noted in both control sediment samples and one indicator sediment sample, and ^{40}K activity was noted in all sediment samples. No radionuclide activity was detected in any drinking water samples.

Soil samples are collected annually from two control locations and seven indicator locations and subsequently analyzed for gamma isotopes (EIML, 2013). Soil samples for 2012 exhibited positive ^{137}Cs and ^{40}K activity (EIML, 2013).

Continuous air monitoring is performed at five locations and analyzed for iodone-131 (^{131}I) and other gamma isotopes on a weekly basis. Air monitoring results for 2012 demonstrated average activities of 0.23 picocurie/cubic meter (pCi/m^3) for beryllium-7 (^7Be). There were no positive detections of radionuclides from facility operations (EIML, 2013).

Direct ambient gamma radiation is monitored at three control locations and 40 indicator locations using thermoluminescent dosimeters (TLD). The TLDs are analyzed on a quarterly basis. For the reporting period (2012), the average dose for the indicator locations was 16.0 mrem/quarter (64 mrem/yr), and was 15.3 mrem/quarter (61.2 mrem/yr) for the control locations. These dose levels were similar to historical TLD results (EIML, 2013).

Biological sampling includes collection of milk, fish, and vegetation tissue. Milk samples are collected at least once per month and also analyzed for ^{131}I and other gamma isotopes. Fish samples are collected on a semi-annual basis and analyzed for gamma isotopes. Edible vegetation is collected monthly during the summer months and analyzed for ^{131}I and other gamma isotopes. Soybeans are also collected from four locations (one control location, and three locations on Ameren property) and analyzed for tritium and gamma isotopes (EIML, 2013). Positive detections of ^{40}K, which is a naturally occurring isotope, were noted in all 2012 biological samples. There were no other positive radioisotope detections.

The results reported for all environmental samples are consistent with historical data at the site. The results for the reactor facility reported no samples above background radiation levels outside of the facility boundary in 2012; therefore, there are no environmental impacts resulting from facility operations during 2012 (EIML, 2013).

Doses to members of the public from gaseous plant effluent, facility activities, and inhalation of ^{14}C are outlined in Table A-5 of the *Callaway Energy Center 2012 Annual Radioactive Effluent Release Report* (Ameren, 2013b). The whole body dose (0.0000771 mSv/yr [0.00771 mrem/yr]), thyroid dose (0.000077 mSv/yr [0.0077 mrem/yr]), and maximum other organ dose (0.000161 mSv/yr [0.0161 mrem/yr]) were well below the allowable doses outlined in 10 CFR 20.1301(e), "Dose Limits for Individual Members of the Public," and 40 CFR 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

19.3.8.2.2.3 Industrial and Commercial Use of Radiation

ABC Laboratories – ABC Laboratories operates at two locations near the proposed RPF site. The nearest location is on Lot 1 of the Discovery Ridge development, approximately 152 m (500 ft) from the proposed site, and the second location is approximately 8 km (5 mi) northwest of the site. ABC Laboratories has a radiological material license with the NRC (No. 24-13365-01). Radiological materials at ABC Laboratories are used for animal studies, sample analysis and cleaning in gas chromatographs (nickel-63 [^{63}Ni]), calibration of liquid scintillation counters (^{137}Cs), and research and development purposes. Occupational doses at ABC Laboratories are monitored using dosimetry. Biological monitoring is also conducted for personnel performing duties for field studies or for animal studies involving more than 10 millicurie (mCi). Doses to personnel are managed in accordance with 10 CFR 20.1203, "Determination of External Dose from Airborne Radioactive Material" (ABC Laboratories, 2007).

MU Pickard Hall – Pickard Hall is on Francis Quadrangle at MU and currently houses the Museum of Art and Archaeology. The building was formerly used as the university chemistry laboratory building, where radioactive material separation activities were conducted from the early 1900s through the 1930s (MU EH&S, 2013). These activities resulted in legacy radium contamination of subsurface soil in the immediate vicinity of Pickard Hall, original flooring and ceiling material in several rooms within the building, original ventilation system components, steam tunnel, and sanitary sewer lines associated with the building. The MU Radiation Safety Program has implemented an internal standard operating procedure to limit land and building use at Pickard Hall to reduce public exposure to and environmental releases of radiological contamination (MU EH&S, 2013). The operating procedure includes exposure monitoring for selected Pickard Hall faculty and staff, and periodic radiation surveys and monitoring of the building.

Areas of the building with residual contamination have controlled access, so members of the public may not enter these areas without an escort. Faculty and staff working in controlled areas of Pickard Hall may have higher radiation doses than the general public, but these doses are not higher than the ALARA level for dosimetry monitoring of 0.25 mSv (25 mrem) per quarter (1.0 mSv [100 mrem/yr]) as outlined in the standard operating procedure (MU EH&S 2013).

19.3.8.3 Major Sources and Levels of Chemical Exposure

The areas bounding the proposed RPF site have roadways, buildings, and open agricultural fields. These areas are maintained in accordance with MU policies and procedures. The site has not been used for storage of chemicals; however, the use of chemicals for maintenance is expected. Weed killer and fertilizer are expected to be used on or near the site. No other commercial chemicals are expected to be on the site. The only source for chemical exposure appears to be topical applications of commercially available pesticides.

Nonradioactive liquid, gaseous, and solid waste effluents from facilities within the Discovery Ridge development are required to report hazardous effluents to the MDNR and the EPA.

19.3.8.3.1 Hazardous Waste Management and Effluent Control Systems

MU does not operate any hazardous or radioactive waste disposal sites. Nearby sources that manage hazardous waste include ABC Laboratories, RADIL, and the MU School of Agriculture, all located in the Discovery Ridge development near MU. The following subsections provide further detail on these sources.

19.3.8.3.1.1 Discovery Ridge Development

According to the 2011 Phase I environmental site assessment conducted at Discovery Ridge:

> *[There is] no knowledge of any aboveground or underground storage tanks for chemicals or petroleum, past use, treatment, disposal or generation of hazardous materials or petroleum products, polychlorinated biphenyl (PCB) equipment, solid waste disposal, or any pending, threatened, or past litigation, administrative proceedings, violations of environmental laws, or possible litigation relating to hazardous substances or petroleum products associated with the subject site.* (Terracon, 2011a)

The MU School of Agriculture, ABC Laboratories, and RADIL have existing facilities in the Discovery Ridge development and use/dispose of radioactive and/or hazardous wastes. Waste handling, transport, and disposal activities are performed in accordance with 10 CFR 71; Appendix T of NUREG-1556, Volume 11, *Consolidated Guidance about Materials Licenses, Program-Specific Guidance about Licenses of Broad Scope* (specific to ABC Laboratories, 2007); MDNR regulations; and DOT regulations.

19.3.8.3.2 University of Missouri Research Reactor

The MURR Health Physics Branch has a Radioactive Waste Management Program that manages airborne, liquid, and solid radioactive waste materials. Management and disposal activities for each type of waste are discussed in the following subsections. MU also has a separate hazardous waste management facility, the Resource Recovery Complex. The complex is located approximately 0.48 km (0.3 mi) northeast of MURR on the MU campus and handles all non-MURR-related waste generated by MU operations.

19.3.8.3.2.1 Solid Waste

Solid low-level radioactive waste is temporarily stored on the belowgrade level of the MURR laboratory prior to shipment. No solid waste is permanently stored onsite. Waste is monitored prior to shipment to identify radioactive and nonradioactive waste to ensure proper disposal of waste and to help reduce the volume of waste by identifying items that may be reused. Radioactive waste is typically packaged in sealed metal drums and processed for shipping by the MURR Health Physics Branch in accordance with DOT requirements. Waste containers are either shipped directly to a waste disposal site or transferred to an authorized radioactive waste vendor. High-level radioactive waste shipments are planned and handled in accordance with NRC and DOT regulations (MU, 2006a).

During 2012, MURR shipped 19.9 m^3 (703 cubic feet [ft^3]) of low-level radioactive waste that contained 3,097 mCi of activity (MURR, 2013).

19.3.8.3.2.2 Liquid Waste

Radioactive liquid waste is sent to a liquid waste retention and disposal system that is also located on the belowgrade level of the MURR laboratory building. The system consists of tanks, pumps, filter banks, and piping/valves, and uses both chemical and filtration treatment methods to reduce radioactivity levels. Assay monitoring is used to record liquid waste activity levels. When activity levels are below those specified in 10 CFR 20, liquid waste is discharged into the sanitary sewer (MU, 2006a).

19.3.8.3.2.3 Gaseous Waste

The majority of gaseous waste consists of ^{41}Ar, which is released through the facility ventilation exhaust stack. Exhaust air from the reactor is mixed with uncontaminated air to dilute the concentration of radioactive gases emitted into the atmosphere. The discharge rates do not exceed the limits outlined in the technical specifications (MU, 2006a).

19.3.8.3.3 Historical Releases and Exposure

Historical releases of hazardous materials may have occurred at the ABC Laboratories location, 8 km (5 mi) northeast of the proposed RPF. This site is currently undergoing decommissioning under the NRC (NRC, 2013e), as discussed below.

The ABC Laboratories site consists of commercial buildings and three sanitary lagoons. Two historical lagoons were used between 1968 and 1986, after which they were backfilled. The NRC approved the unrestricted release of both lagoons in 2011, along with four buildings onsite (NRC, 2013e).

A third sanitary surface lagoon was constructed in 1986 and operated until 2004. The lagoon received sewer waste and rinsates from the laboratories that primarily contained ^{14}C. The lagoon effluent was discharged to the site under a NPDES permit (MO-0104591) via pipe and gravel beds. In 2011, the lagoon was drained and then backfilled in February 2012. Soil samples collected from the lagoon discharge areas showed an average activity of 6 pCi/gram (g), which is below the screening value of 12 pCi/g required in NUREG-1757, Volume 2, *Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria*. Detectable radiological activity was not noted in subsurface soils below the clay liner of the lagoon. Modeled doses resulting from residual radioactive contamination in the lagoon were calculated to be 0.002 mSv/yr (0.2 mrem/yr). The average concentration in groundwater from the site was 126 pCi/L, with the highest concentrations noted in the shallow water table, which is not available for drinking water according to 10 CSR 23-3.090, "Regionalization." Based on this data, the NRC issued a Finding of No Significant Impact with regard to the former sanitary lagoon at ABC Laboratories (NRC, 2013f).

Positive detections of methylene chloride and 2-methyl-4-chlorophenoxyaceticacid were noted in the sediment and clay layer of the lagoon. A minimum of 0.9 m (3 ft) of cover soil was placed in these areas to effectively eliminate potential human contact. Based on this data, the NRC issued a Finding of No Significant Impact with regard to the former sanitary lagoon at ABC Laboratories (NRC, 2013f).

To-date, there are no additional records of any historic recordable incidences of releases to the general public in the vicinity of the proposed RPF site. Radiological exposure of MURR staff as a result of routine tasks is discussed in Section 19.3.8.4.

19.3.8.4 Occupational Injury Rates

The occupational injury rate of workers associated with the proposed RPF is expected to be similar to the MURR facility or other MU research facilities currently operating in the vicinity of the proposed RPF site. While the isotope extraction process may be continuous, the preliminary design of the systems and components of the facility call for many tasks to be automated. The goal is to reduce human error, while also reducing occupational risk from many process activities. In addition, occupational dose received by RPF workers will be maintained ALARA, in accordance with an approved ALARA/Radiation Protection Program, similar to the ALARA Program for MURR (MU, 2006a).

Occupational dose received by students and faculty while performing activities associated with the MURR are maintained ALARA. The MURR ALARA Program has been established in accordance with 10 CFR 20.1101, "Radiation Protection Programs" (MU, 2006b) to ensure that doses from radiation and gaseous effluents are maintained ALARA. Occupational doses at MURR for calendar year 2012 are shown in Table 19-50.

Table 19-50. Total Personnel Dose to University of Missouri Research Reactor Facility Employees

Dosimetry group	Maximum radiation levels			
	Whole body		Extremities (mrem/yr)	
	mSv/yr	(mrem/yr)	mSv/yr	mrem/yr
Analytical Chemistry	0.27	27	3.43	343
Business & Central Services	0.86	86	3.43	343
Director's Office	0.06	6	NR	NR
Shops & Support	0.72	72	1	100
Hot Cell/Shipping	9.81	981	25.25	2,525
Health Physics	4.68	468	8.34	834
Irradiations	0.58	58	NR	NR
Nuclear Analysis	1.18	118	34.66	3,466
Neutron Scattering	2.16	216	5.09	509
Operations	12.75	1,275	31.22	3,122
Isotope Processing	5.16	516	53.61	5,361
Quality Assurance	1.09	109	6.29	629
Research	1.12	112	13.85	1,385
Radiopharmaceutical	0.87	87	19.95	1,995
Silicon	8.42	842	13.33	1,333
Trace Elemental Epidemiology	0.17	17	1.82	182
Work Control	2.92	292	52.72	5,272

Source: Section IX of MURR, 2013, *University of Missouri Research Reactor, Reactor Operations Annual Report, January 1, 2012 – December 31, 2012*, MURR Research Reactor Staff, Columbia, Missouri, February 26, 2013.

The highest occupational whole body radiation doses at MURR were noted for those employees working in operations (12.75 mSv [1,275 mrem/yr]) and hot cell/shipping (9.81 mSv [981 mrem/yr]). Radiation doses for body extremities were highest for isotope processing (53.61 mSv [5,361 mrem/yr]) and work control employees (52.72 mSv [5,272 mrem/yr]). These exposures were less than the occupational exposure limits outlined in 10 CFR 20.1201, "Occupational Dose Limits for Adults" (MURR, 2013).

19.3.9 Connected Action – University Reactor Network

Irradiation of LEU targets at the university research reactors is key component of the NWMI process. For a specific university reactor to irradiate LEU targets for NWMI, an amendment to the university's 10 CFR 50 NRC license and an analysis of site-specific environmental impacts related to such an amendment would be required. For the purposes of complying with NEPA's requirements to analyze connected actions, the following sections describe the affected environment at each of the proposed university reactors.

19.3.9.1 University of Missouri Research Reactor

The University of Missouri Research Reactor (MURR) is a pressurized, reflected, light-water moderated, open pool-type research reactor. The reactor is used to conduct experiments, irradiate materials, and produce isotopes for use in various fields of medicine. In addition, the reactor is used for training, research, and demonstration purposes associated with undergraduate and graduate-level degree programs. MURR is located in University Research Park, an extension of the Missouri University-Columbia, Missouri and is licensed to the Board of Curators of the Missouri University. A detailed description of the facilities can be found in the Facility Operating License No. R-103 (NRC Docket 50-186), which will expire on October 2026 (MU, 2006b).

MURR is located in Columbia, Missouri, approximately 201 km (125 mi) east of Kansas City and 201 km (125 mi) west of St Louis. The site is 2.4 km (1.5 mi) south of U.S. Interstate 70, just west of Research Park Drive. The Missouri River lies 13.6 km (8.5 mi) west of the site. The site is located 6.4 km (4 mi) northwest of the Discovery Ridge site. Specifically, MURR is located is 1.6 km (1 mi) southwest of the main MU campus. The site's latitude and longitude is 38° 55' 53" north and 92° 20' 31" west. MURR is situated on a 3.0 ha (7.4-acre) lot in the central portion of the University Research Park, a 34.0 ha (84-acre) tract of land approximately 1.6 km (1 mi) southwest of the MU main campus. The campus is situated in the southern portion of Columbia. The University Research Park consists of low-occupancy research buildings. Personnel are currently working in facilities located within 457.2 m (1,500 ft) of the alternative site. A detailed MURR site evaluation is provided in Section 19.5.2.3.

19.3.9.2 Oregon State University Radiation Center Complex

The OSU Radiation Center complex is an approximately 47,000 ft^2 facility and is comprised of three buildings including OSTR, Advanced Thermal Hydraulics Research Laboratory (ATHRL), and Radiation Center Building.

- OSTR or Reactor Building is located in a four-story building located on the north side of the Radiation Center. The Reactor Building contains primarily the main Reactor Bay, the Reactor Control Room, space for reactor mechanical equipment, two research laboratories, office space for the Reactor Operations Staff, and a small conference room.
- ATHRL is a high-bay facility attached to the east side of the Reactor Building and houses experimental test loops. There is no access between the ATHRL and Radiation Center
- Radiation Center Building houses classrooms, offices, a wide variety of radioisotope laboratories, a cobalt-60 irradiation facility, a large inventory of nuclear instrumentation useful for research applications as well as for radiation protection, and a number of supporting facilities. Access to the Reactor Building from the Radiation Center can be made through two secure locations.

The OSTR is a light-water-cooled, graphite-reflected reactor using uranium-zirconium hydride fuel elements. These fuel elements are placed in a circular grid with 16 feet of water over the top of the core. The reactor has an authorized maximum steady-state thermal power of 1.1 MW and may be pulsed to a peak power of over 2,000 MW. A detailed description of the reactor facility can be found in their Facility Operating License No. R-106 (NRC Docket 50-243), which will expire on August 2028 (NRC, 2008b).

The Radiation Center Complex is located on the east side of 35th Street and the north side of South Jefferson Way both two lane roads. 35th street provides access to the Complex and intersects to the south approximately 0.75 miles with combined U.S. Highway 20 and Oregon State Highway 34. Highway 20 and Highway 34 separate approximately 1.25 miles to the east with Highway 20 continuing approximately 11 miles where proceed to Albany Oregon and intersects with U.S. Interstate 5. Highway 34 intersects U. S. Interstate 5 approximately 8.25 miles to the east. To the west Highway 20 and Highway 34 separate approximately 5 miles with Highway 20 continuing approximately 46 miles to the coast were it terminates at Newport, Oregon. Highway 34 continues approximates 57 miles to the southwest where it terminates in Waldport, Oregon.

19.3.9.3 Third Reactor

The third reactor will be similar to the OSTR and will located on a University campus.

19.4 IMPACTS OF PROPOSED CONSTRUCTION OPERATIONS, AND DECOMMISSIONING

This section provides an analysis of the impacts of the RPF construction, operation, and decommissioning. Overall impact rankings are given to each environmental resource evaluated. Unless otherwise defined, criteria followed the guidance given in NRC Impact Rankings at 10 CFR 51, Subpart A, Appendix B, Table B-1, Footnote 3, as follows:

- **Small** – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource
- **Moderate** – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource
- **Large** – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource

19.4.1 Land Use and Visual Resources

19.4.1.1 Land Use

This section presents the evaluation of impacts of the proposed action to land use in the 8 km (5-mi) ROI, as described in Section 19.3.

Impacts on land use were assessed based on the consistency of the proposed action with State and local plans and on compatibility with land uses in and near to the proposed RPF site. Impacts include effects from (1) activities associated with construction, including excavation, grading, placement of fill material, temporary staging and construction laydown, and construction of permanent features; (2) activities associated with operations, including potential operational disturbances; and (3) activities associated with decommissioning a nuclear medical isotope production facility, which are similar to construction except for the final handling and disposition of radioactive materials and wastes.

Factors considered for determining impacts involving changes to the affected environment are discussed in Section 19.3. The proposed RPF is considered to have an impact on land use if its presence:

- Results in land use change on a short- and/or long-term basis
- Curtails the range of beneficial uses of the environment
- Involves substantial secondary land use impacts (e.g., population changes, effects on public facilities/infrastructure)
- Conflicts with existing or planned land uses within Discover Ridge or the ROI
- Conflicts or is incompatible with the objectives, policies, or guidance of State and local land use plans (e.g., *Discovery Ridge Master Plan and Protective Covenants* [MU, 2009], "Columbia Imagined, The Plan for How We Live & Grow" [City of Columbia, 2013c], *Boone County Master Plan* [Boone County, 1996])
- Conflicts or is incompatible with administrative designations or special land uses
- Conflicts or is incompatible with agricultural resources or facilities and mineral resources

Impacts to land use are related to the amount of land disturbed and the type of construction on the land. The proposed RPF would be approximately 106.7 x 56.4 m (350 x 185 ft) and stands 19.8 m (65 ft) tall above grade (maximum). The actual RPF building would occupy a rectangular area approximately 213 x 91 m (700 x 300 ft) at the outer perimeter and cover approximately 1.95 ha (4.8 acres) on Lot 15 of Discovery Ridge.

The land on which Discovery Ridge is sited is zoned for commercial agriculture; however, Missouri, via the MU, has acquired and set aside this area to achieve the research park mission. Therefore, construction of the proposed RPF would be consistent with land use at the park. Discovery Ridge is not mined or used for any mineral resources. Construction of the proposed RPF was found to be consistent with the objectives, policies, and guidance of the Discover Ridge, Columbia, and Boone County land use plans.

19.4.1.1.1 Impacts of Construction

The entire 3 ha (7.4 acres) of Lot 15 would be directly and permanently disturbed to construct and support the RPF. Construction staging activities could also occur along Discovery Drive bordering the lot and the adjacent Discovery Ridge Lot 14. Staging activities would be temporary and would cease after construction of the facility. After the facility is built, landscaping would mitigate disturbances caused during construction on the lot, both exterior of the perimeter fence and from the perimeter fence to the perimeter of the building. The facility would retain the amount of undeveloped open space and developed landscaped areas in accordance with the Discovery Ridge covenants (MU, 2009). This includes maintaining a minimum of 30 percent of the site (preferably 35 percent) as open for landscaping and not covered by buildings or paving for access, circulation, loading, or parking.

Direct impacts from construction activities would occur as ground disturbance. Indirect impacts associated with construction activities could affect Discovery Drive. These impacts (e.g., broken curbing and pot holes) would be temporary since they could be mitigated through road repairs. Overall, because direct and indirect impacts are constrained to those typically associated with construction activities necessary to build any facility, they would be small.

19.4.1.1.2 Impacts of Operation

After the RPF is constructed, no additional land would be disturbed during operational activities. Operational activities would not interfere with any surrounding land uses or change land uses near the facility. Operations activities would not interfere with any mineral resource uses. The addition of 98 employees to Discovery Ridge for facility operation would not result in a population change that would impact current facilities or infrastructure, or result in any subsequent changes to land use to accommodate the increase. Thus, both direct and indirect impacts to land use from operations would be small.

19.4.1.1.3 Impacts of Decommissioning

From a land use perspective, decommissioning activities (except for the final handling and disposition of radioactive materials and wastes) are assumed to be similar to construction activities. The facility would be demolished, and resultant land would return to commercial agriculture/open space. Facility modification and demolition activities both require (de)construction and staging activities. Thus, facility demolition activities would result in impacts similar to construction. No additional ground disturbance would occur if the nuclear components of the building were decommissioned and removed, and if facility modification was confined to the interior of the building.

Under decommissioning, an additional indirect impact would be an increase in landfilled materials from demolition activities for any materials that could not be recycled. This impact would not be significant from the proposed RPF in comparison to similar remodeling or demolition activities in the ROI. Impacts from final handling and disposition of radioactive materials and wastes under the decommissioning scenario are discussed in Section 19.4.10.

With the land at Discovery Ridge designated as a research park, it is reasonable to assume that the land would not be returned to commercial agriculture use and the park would remain a dedicated industrial/research area for the foreseeable future. The RPF would be used for some time (20 to 40 years) and then demolished at the end of its useful life. As such, direct and indirect impacts to land use that can be reasonably assumed from decommissioning activities are anticipated to be similar to the impacts associated with construction, which would be small.

19.4.1.2 Visual and Aesthetics Resources

This section describes the visual and aesthetic impacts of the proposed RPF during the phases of construction, operations, and decommissioning. Potential impacts to viewers over the facility lifespan are addressed. Satellite imagery was used to identify populations that would have views of the RPF. Those with views on a routine basis would be Discovery Park employees (currently RADIL and ABC Laboratories), MU personnel associated with South Farm, residents at nearby homes or businesses, U.S. Highway 63 commuters, and regular travelers on the roads surrounding Discovery Ridge. Those with intermittent or a limited-basis view would be Discovery Ridge visitors, Nifong Park and Perry Phillips Lake users, and travelers passing through the area.

Eight viewpoints were identified and used to conduct a GIS visual analysis to determine facility impacts to potential viewers and viewsheds. Viewsheds are areas of land or water visible from a fixed vantage point (see Section 19.3.1.2). Using vantage points, viewsheds are calculated using the Spatial Analyst Viewshed tool in ESRI ArcMap 10.

A calculated viewshed shows all that an observer can see from that point. The tool does not take into consideration vegetation, buildings, fences, or other obstructions, but assumes the view is completely unobstructed, with the exception of intervening topography (e.g., a mountain). Thus, all calculated RPF viewsheds conservatively represent maximum viewsheds because vegetation and structures are found throughout the ROI. The calculated observer is 183 cm (6 ft) tall and standing at ground level, a conservative height for analysis purposes. Using the combination of an unobstructed view and a tall person as model parameters, the calculated viewsheds are exceptionally conservative regarding the views that would be seen by a typical viewer. The viewsheds from the eight viewpoints were calculated and mapped, and the maps analyzed.

Factors considered in determining if the proposed RPF would have a significant impact to visual and aesthetic resources include the extent or degree to which the facility would:

- Introduce physical features that are substantially out of character with adjacent developed areas
- Alter a site so that a sensitive viewing point or vista is obstructed or adversely affected, or if the scale or degree of change appears as a substantial, obvious, or disharmonious modification of the overall view
- Partially or completely obstruct views of the existing landscape
- Create visual intrusions (e.g., radar towers, cooling towers, effluent stacks) to the existing landscape character
- Require the removal of natural or built barriers, screens, or buffers, thus enabling lower quality viewscapes to be seen
- Alter historical, archaeological, or cultural properties, other areas of a special land-use category, or the character of the property's setting when that character contributes to the property's significance
- Create visual, audible, or atmospheric elements that are out of character with the site or alter its setting
- Be inconsistent with the visual resource policies of the *Discovery Ridge Master Plan and Covenants* (MU, 2009)

19.4.1.2.1 Visual Impacts

Figure 19-42 shows an artist's rendition of the proposed RPF to demonstrate what the completed facility would look like on Lot 15 of Discovery Ridge.

Figure 19-42. Radioisotope Production Facility Visualization

Photographs of RADIL and ABC Laboratories are provided in Figure 19-43 and Figure 19-44, respectively. The RPF in design and character, as shown in the artist rendition, and as approved by the design review committee operating under the Master Plan and Covenants, would be similar in aesthetics to these buildings. Because the facility is being sited on an open space, there are no natural or built barriers, screens, or buffers that would require removal; therefore, no lower quality viewscapes would become visible. As discussed in the Section 19.3.6, there are no historical, archaeological, or cultural properties or other areas of a special land-use category in, near, or associated with Lot 15 in Discovery Ridge, or in the immediate area, with which the proposed RPF would be considered visually incompatible.

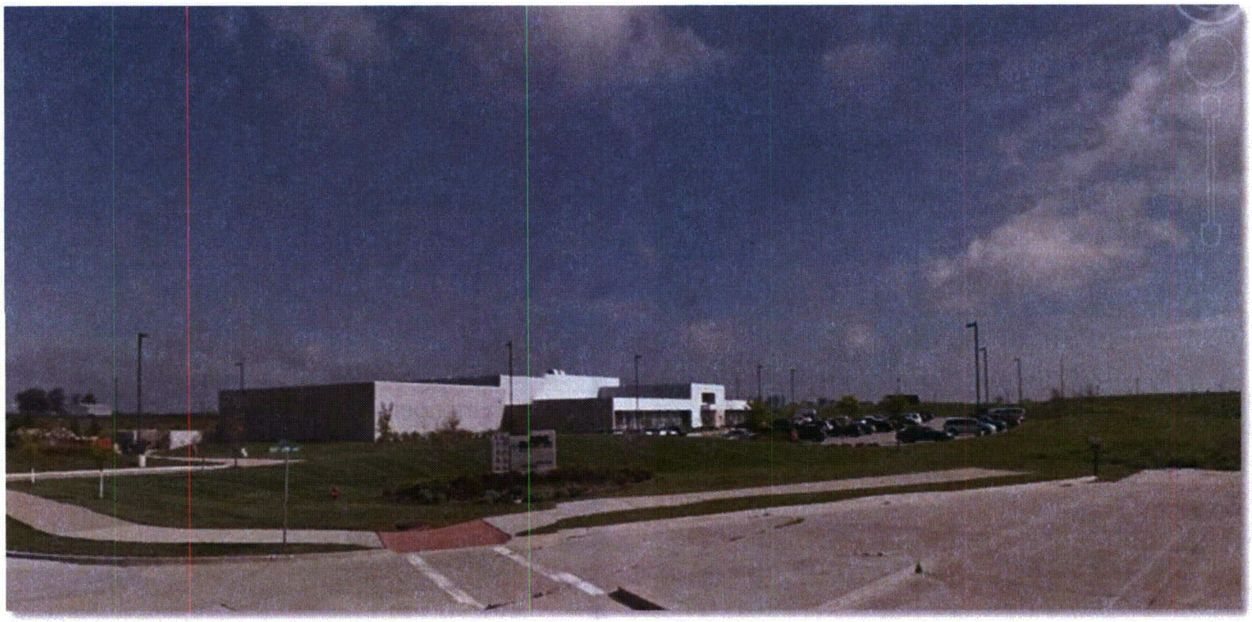

Figure 19-43. Research and Diagnostic Laboratory Facility Located at Discovery Ridge

Figure 19-44. ABC Laboratories Facility Located at Discovery Ridge

The visual study, review of photos from the eight observer viewpoints, and the artist rendition of the facility (Figure 19-42) provide significant data to determine the visual impacts with regard to partially or completely obstructing views of the existing landscape or creating intrusions in the existing landscape character, as follows:

- At its tallest point, the RPF's exhaust stacks, at 22.9 m (75 ft) total height and 3 m (10 ft) above roof level, would be the facility's tallest fixed feature viewable from a distance. While steam, under certain meteorological conditions might be seen coming from the stacks, it would dissipate quickly and is not discussed further in this section. As a viewer observes the RPF from a vantage point and then continues to move closer to the facility, more of the facility would come into view, until the entire facility is viewable. Figure 19-18 through Figure 19-25 show various viewpoints toward Lot 15 in Discovery Ridge from distances between 0.4 and 4.4 km (0.25 and 2.72 mi).
- When the RPF is completed, if the viewer is located on Lot 15, close to the facility, and expecting to look through or around the facility to the other side, the facility would partially or completely obstruct views of the surrounding landscape. In this circumstance, having a blocked or obstructed view would be an expected impact of placing a facility in an open space where no facility existed before. Because the land was designated for use as a research park, it is reasonable to expect that at some point buildings supporting research would be constructed. As such, observers who are located at close range to the facility would have views of the facility, and their views toward landscapes on the other side of the facility would be partially or completely obstructed by the facility.

To determine the visual impacts associated with fully or partially obstructed views from further distances, views toward the facility from the eight viewpoints were analyzed with Spatial Analyst Viewshed tool in ESRI ArcMap 10. The resultant viewshed is shown in Figure 19-45. The figure shows the areas from which an observer can see the stacks on the RPF. Again, this analysis does not account for screening effects from structures and vegetation, and provides the maximum potential viewsheds from the observer points.

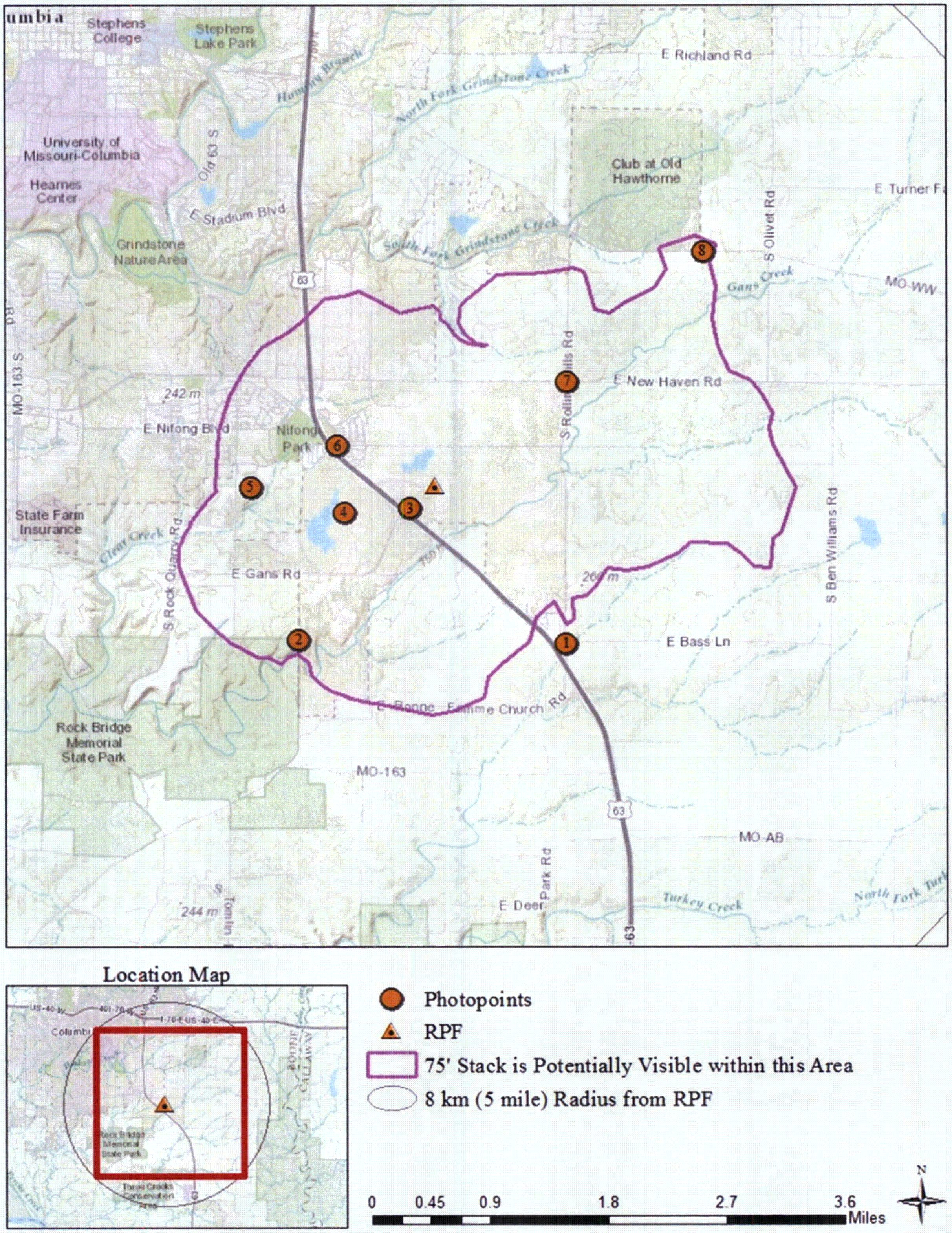

Figure 19-45. Stack Potentially Visible Areas

19.4.1.2.2 Impacts of Construction

The most noticeable impact to viewers would be during the construction phase. Lot 15 of Discovery Ridge would transition from an area of open space to a fully constructed facility with surrounding landscaping. During this initial phase, changes at the lot would be significant and noticeable. The changes would not be out of character with the research park, but the changes would seem sudden and dramatic, particularly to viewers familiar with Discovery Ridge. Specific activities at the lot would be varied on a daily basis, but would be similar to general facility construction project activities, including:

- Heavy equipment would be brought onsite
- Materials would be staged on the lot and in the immediate area around the lot
- Workers would use equipment for excavation, grading, and building activities
- Cranes may be onsite to lift and place materials and components in the facility and on the lot

As the facility progresses toward completion, there would be less large equipment and construction personnel on the exterior of the building as work proceeds to interior construction-related activities (e.g., electrical installation, sheetrocking, and painting). The final exterior work would require equipment and personnel for grading, paving, and landscaping. When the building is complete, the view from the street and from the other facilities in the park is anticipated to be similar to the views one can see of the RADIL and ABC Laboratories buildings shown conceptually in Figure 19-42, and in Figure 19-43 and Figure 19-44.

As discussed in Section 19.3.1.2, the *Discovery Ridge Master Plan and Covenants* (MU, 2009) addresses visual resources and scenic considerations throughout the plan's building and design requirements. At a minimum, compliance with the following covenants and review by the Discovery Ridge Design Committee would ensure that the RPF visual impact is compatible with the character of the property setting (MU, 2009):

- 5.4, Minimum Open Space and Landscaped Area
- 5.5, Building Height
- 5.6, Exterior Appearance of Buildings
- 5.8, Parking and Loading Areas
- 5.12, Landscape Design
- 5.13, Site Lighting
- 5.14, Storage Areas and Fences

While the visual impacts are most notable during the construction phase, over time, as viewers become more aware of the activities Discovery Ridge, view the activities more frequently, and the building progresses to completion, the building's presence becomes less noticeable. Because the proposed RPF would be in context with Discover Ridge and its setting, it is unlikely that the average viewer would see the facility as an isolated structure or a distraction on the overall landscape. In context, impacts of construction on visual resources are considered small.

19.4.1.2.3 Impacts of Operations

The RPF would not generate electricity and thus does not maintain any power transmission lines. While steam might be seen coming from the stacks under certain meteorological conditions, it would dissipate quickly and is not discussed further in this section. Operation of the RPF has no visual impact on anything external to the building, including the aesthetics of the surrounding area. The facility would look the same on a daily basis during the operations phase. The impacts to visual resources would be restricted to the impact the facility has on the landscape, which is small.

19.4.1.2.4 Impacts of Decommissioning

At the end of its lifespan, the RPF would be demolished and returned to commercial agriculture use or open space. Facility demolition would require activities similar to construction activities. For example, heavy equipment would be used, a crane might be needed to remove interior components to transport, and a number of personnel would be onsite. There would be considerable activity occurring daily as the facility is demolished, until the end result is obtained. From a visual and aesthetics resource perspective, facility demolition activities are not uniquely different from construction activities. As such, visual impacts during decommissioning would be similar to those seen in the construction phase, and are considered small.

19.4.2 Air Quality and Noise

19.4.2.1 Air Quality

The proposed RPF site is located in Boone County, Missouri, which is part of the EPA Region 7. The Missouri DEQ is the regulatory agency responsible to protect and enhance the quality of the Missouri environment and its citizens, while the MDNR operates an extensive network of ambient air monitors to comply with the Clean Air Act and its amendments.

The ambient air quality monitoring network for Missouri includes State and local air monitoring stations, special purpose monitoring stations, and National Core (NCore) multi-pollutant monitoring stations consistent with requirements in Federal regulation 40 CFR 58.10. The only DNR air monitor in Boone County is located at Finger Lakes and monitors for O_3 from May to October each year. The MDNR continuous air monitors nearest to the proposed RPF site, which are also in similar urban locales, are in the following locations:

- **Mark Twain State Park** – In Stoutsville, Monroe County, approximately 103 km (64 mi) northeast of the proposed RPF site; monitors for SO_2, O_3, and inhalable particulates PM-10 and PM-2.5
- **El Dorado Springs** – In Cedar County, approximately 261 km (162 mi) southwest of the proposed RPF site; monitors for NO_2, inhalable particulate PM-2.5, and O_3

Both air monitor locations are well outside of the ROI.

The EPA established NAAQS for six common pollutants (also referred to as "criteria" pollutants). Missouri DEQ monitors for CO, NO_2, O_3, total suspended particulate, inhalable particulates (PM-10 and PM-2.5), and Pb. Other pollutants or compounds are measured as part of air toxics or particulate speciation sampling. Legal descriptions of the standards are provided in 10 CSR 10-6, "Air Quality Standards, Definitions, Sampling and Reference Methods and Air Pollution Control Regulation for the Entire State of Missouri." The NAAQS are summarized in Table 19-27.

Gaseous effluents at the proposed RPF would originate from several sources, including construction equipment, isotope production, fuel combustion from heating and generating systems, and decommissioning activities. RPF operations would generate gaseous effluents. The permits required for release and their status are listed in Table 19-4. The anticipated gaseous effluents and their associated air quality parameters for construction, operations, and decommissioning are discussed in the following subsections.

19.4.2.1.1 Air Impacts from Construction

Construction activities result in localized increases in air emissions. Earthmoving, excavation, clearing, pile driving, erection, batch plant operation, and construction-related traffic generate fugitive dust and fine particulate matter that potentially impact both on-site workers and off-site residents of the community. Vehicles and engine-driven equipment (e.g., generators and compressors) generate combustion product emissions such as CO, NO_x, and, to a lesser extent, SO_2. Painting, coating, and similar operations also generate emissions from the use of VOCs.

People living near or working at or near construction sites may be subject to the physical impacts of construction activities. Activities associated with the use of construction equipment may result in varying amounts of dust, air emissions, noise, and vibration. The magnitude and area of extent of the impacts from these emissions depends on atmospheric conditions at the time of the activity. The magnitude of these potential impacts is typically related to specific construction controls and the proximity of the site to populated areas. Contractors, vendors, and subcontractors are required to adhere to appropriate Federal and State occupational health and safety regulations. These regulations set limits to protect workers from adverse conditions, including air emissions.

19.4.2.1.1.1 Fugitive Dust

Earth-moving activities involve operation of heavy construction equipment on exposed soil. Methods for calculating fugitive dust emissions for earth-moving activities outlined in EPA AP 42, *Compilation of Air Pollutant Emission Factors, Volume 1, Stationary Point and Area Sources*, Chapter 13, "Miscellaneous Sources" (EPA, 2010) were used. Activity rates (A) for earth-moving were derived from information on hours of vehicle operation, tons of material moved, or vehicle miles traveled.

$$E = A \times EF \times (1 - ER/100)$$

where:

E	= emissions
A	= activity rate
EF	= emission factor
ER	= overall emission reduction efficiency, percentage

Values for these parameters are expected to evolve over time as design parameters are refined. Therefore, conservative parameter values based on the notional facility designs were established to bound PM-10 and PM-2.5 activity rates. Activity rates for each parameter are provided in Table 19-51.

Table 19-51. Activity Parameters for Earth Moving

Activity/equipment	Activity parameter	Number of units	Number of hours run	Material moved (t)	Material moved (tons)
Bulldozing	hr	1	100	NA	NA
Loading of earth haulers from excavators	hr	1	120	10,886	12,000
Loading of earth haulers from front loaders	hr	1	60	10,886	12,000
Unloading of fill material from earth haulers	hr	1	120	21,772	24,000
Compacting	hr	1	80	NA	NA
Motor grading	hr	1	80	NA	NA

Sources: EDF-3124-0001, 2015, *Estimate of Excavation for the NWMI Radioisotope Production Facility*, Rev. 3, Portage, Inc., Idaho Falls, Idaho, February 2, 2015.

EDF-3124-0004, 2015, *Calculation for the Determination of Fugitive Dust during Construction Activities from Construction Equipment*, Rev. 1, Portage, Inc., Idaho Falls, Idaho, February 3, 2015.

NA = not applicable.

Equations recommended by the EPA (EPA, 2010, Section 13.2, Table 13.2.3-1) for dust-generating operations using heavy equipment on exposed soils were used to calculate emission factors for different sizes of particulate matter. Emission factors for earth moving activities were based on guidance (EPA, 2010) and are provided in Table 19-52 (EDF-3124-0004, *Calculation for the Determination of Fugitive Dust during Construction Activities from Construction Equipment*). The total PM-10 and PM-2.5 emissions from earth moving activities during construction presented in Table 19-52 are summarized in Table 19-53.

Table 19-52. PM-10 and PM-2.5 Emission Factors for Earth-Moving Activities During Construction

Activity/Equipment	Units	PM-10	PM-2.5
Bulldozing	kg/hr	4.05E-01	4.17E-01
	lb/hr	8.92E-01	9.19E-01
Loading of earth haulers from excavators	[a]kg/t	2.96E-02	4.48E-03
	[a]lb/ton	5.92E-02	8.96E-03
Loading of earth haulers from front loaders	[a]kg/t	2.96E-02	4.48E-03
	[a]lb/ton	5.92E-02	8.96E-03
Unloading of fill material from earth haulers	[a]kg/t	2.96E-02	4.48E-03
	[a]lb/ton	5.92E-02	8.96E-03
Compacting	kg/hr	4.05E-01	4.17E-01
	lb/hr	8.92E-01	9.19E-01
Motor grading	kg/VKT	5.39E-02	3.47E-03
	lb/VMT	1.91E-01	1.23E-02

Source: EDF-3124-0004, 2015, *Calculation for the Determination of Fugitive Dust during Construction Activities from Construction Equipment*, Rev. 1, Portage, Inc., Idaho Falls, Idaho, February 3, 2015.

[a] Per ton of material moved.

PM-2.5 = particulate matter, 2.5 μ.
PM-10 = particulate matter, 10 μ.
VMT – vehicle miles traveled
VKM – vehicle kilometer traveled

Table 19-53. Annual PM-10 and PM-2.5 Emissions from Earth-Moving Activities During Construction

Measure	Emissions PM-10	Emissions PM-2.5
kg	1.4E+03	2.7E+02
lb	3.0 E+03	6.0E+02
t	1.4	27
tons	1.5	30

PM-2.5 = particulate matter, 2.5 µ.
PM-10 = particulate matter, 10 µ.

19.4.2.1.1.2 Fugitive Dust Emissions from Wind Erosion of Bare Ground

Areas where wind erosion of bare ground could occur during construction include all disturbed areas whether temporary or permanent, including clear and grub areas, roadways, rail lines, power lines, piping, batch plant footprint, gravel pit, and stockpiles.

Equations and calculation steps for wind erosion of bare ground from EPA (2010), Section 13.2.5, were used. PM-10 and PM-2.5 emissions for wind erosion of bare ground during construction are provided in Table 19-54 (EDF-3124-0006, *Determination of Wind-Blown Dust during Construction Activities*).

Table 19-54. Annual PM-10 and PM-2.5 Emissions from Wind Erosion of Bare Ground

Measure	Emissions PM-10	Emissions PM-2.5
kg	73	11
lb	160	24
t	0.077	0.011
tons	0.082	0.012

Source: EDF-3124-0006, 2014, *Determination of Wind-Blown Dust during Construction Activities*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

PM-2.5 = particulate matter, 2.5 µ.
PM-10 = particulate matter, 10 µ.

19.4.2.1.1.3 Summary of Total Particulate Matter Emission from Construction Activities

The total release of particulate matter (PM-10 and PM-2.5) from construction of the facility presented in Table 19-53 and Table 19-54 is summarized in Table 19-55. Implementation of controls and limits at the source of emissions on the construction site would result in a reduction of impacts offsite.

Table 19-55. Total PM-10 and PM-2.5 Emissions from Construction

Source	Emissions							
	PM-10				PM-2.5			
	kg	lb	t	tons	kg	lb	t	tons
Equipment	1.4E+03	3.0E+03	1.5	1.4	270	6.0E+02	0.27	0.30
Wind-blown dust	73	160	0.077	0.082	11	24	0.011	0.012
Totals	1473	3160	1.6	1.5	281	624	0.28	0.31

PM-2.5 = particulate matter, 2.5 µ.
PM-10 = particulate matter, 10 µ.

Specific mitigation measures to control fugitive dust may include any or all of the following:

- Stabilizing construction roads and spoil piles
- Limiting speeds on and periodically watering unpaved construction roads
- Covering haul trucks when loaded or unloaded
- Minimizing material handling (e.g., drop heights, double-handling)
- Phased grading to minimize the area of disturbed soils
- Revegetating road medians and slopes

19.4.2.1.1.4 Vehicle Emissions – Criteria Pollutants

On-road vehicles – On-road vehicle emissions estimates were generated for construction vehicles used for hauling and delivery of materials and for the construction workforce traveling to and from the construction site. The EMFAC2011 model was used to calculate on-road vehicle emission factors for this period. The model estimates vehicle emission factors based on fuel type, vehicle type, vehicle speed, and the climatological normal for temperature and humidity.

EMFAC2011 is the latest installment of the EMFAC series of models, which is the California Air Resources Board tool for estimating emissions from on-road vehicles. EMFAC2011 was used to calculate on-road and non-road vehicle emission factors for the construction period. The model produces an estimation of vehicle emission factors based on fuel type, vehicle type, vehicle speed, and climatological normal for temperature and humidity.

On-road vehicle emissions were calculated using emission rate in grams (g)/(vehicle miles traveled) + g/day(idle) + g/day(starting). On-road vehicles considered for the construction period were dump trucks, concrete trucks, asphalt trucks, and general delivery trucks. For workforce travel during construction, light-duty gas vehicles, light-duty gas trucks, and light-duty diesel trucks were considered. A round trip value of 64.4 km (40 mi) and a vehicle split of 60 percent light-duty gas vehicles, 30 percent light-duty gas trucks, and 10 percent light-duty diesel trucks were assumed for workforce travel.

Total mileage estimates for on-road vehicles during the construction period are shown in Table 19-56 (EDF-3124-0005, *On-Road Emissions for Vehicles during Construction*). Estimates of the on-road vehicle emissions for criteria pollutants and carbon dioxide (CO_2) are provided in Table 19-57 (EDF-3124-0005); emissions are presented for an estimated construction period spanning 17 months.

Table 19-56. Total Mileage Estimates for On-Road Vehicles

Equipment (quantity)	Construction activity	Total	
		km	mi
Earth haulers (dump trucks) (4)	Material hauling (3 months)	4,258	2,646
Concrete trucks (4)	Concrete mixing/hauling (14 months)	32,596	20,254
Asphalt trucks (2)	Asphalt hauling (14 months)	811	504
Delivery trucks (varies)	Delivery of construction materials (17 months)	46,670	29,000
Workforce travel (60)	Commute – light duty gas vehicles (17 months)	1,421,373	883,200
Workforce travel (30)	Commute – light duty gas trucks (17 months)	710,686	441,600
Workforce travel (10)	Commute – light duty diesel trucks (17 months)	236,895	147,200

Source: EDF-3124-0005, 2014, *On-Road Emissions for Vehicles during Construction*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

Table 19-57. On-Road Vehicle Emissions (During Construction)

Vehicle Type	Fuel	CO		NO_x		CO_2		PM-10		PM-2.5		SO_x	
		kg	lb	Kg	lb	kg	lb	Kg	Lb	kg	lb	Kg	lb
Light duty autos	Gas	1,500	3,400	140	300	320,000	700,000	2.1	4.6	1.9	4.2	3.2	7.1
Light duty trucks	Gas	1,900	4,100	170	380	180,000	400,000	2.3	5.1	2.1	4.7	1.9	4.1
Light duty trucks	Diesel	49	110	99	220	52,000	120,000	9.0	20	8.3	18	0.50	1.1
Light heavy duty delivery trucks	Diesel	32	70	130	280	15,000	34,000	1.4	3.0	1.2	2.7	0.15	0.32
Earth haulers	Diesel	1.8	3.9	21	47	3,3000	7,200	0.22	0.49	0.21	0.45	0.031	0.069
Concrete trucks	Diesel	12	27	160	340	24,000	54,000	1.7	3.7	1.6	3.4	0.23	0.51
Asphalt trucks	Diesel	1.1	2.5	9.3	21	1,000	2,200	0.056	0.12	0.050	0.11	0.010	0.022
Total		3,495.9	7,713.4	729.3	1,588	625,000	1,317,400	16.8	37.0	15.4	33.6	6.0	13.2
Totals (t) (tons)		3.50	3.86	0.72	0.79	597.44	658.70	1.68 E-02	1.85 E-02	1.52 E-02	1.68 E-02	6.0 E-03	6.61 E-03

Source: EDF-3124-0005, 2014, *On-Road Emissions for Vehicles during Construction*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

PM-2.5 = particulate matter, 2.5 μ.
PM-10 = particulate matter, 10 μ.

Off-road vehicles – Off-road vehicle emissions were estimated for diesel-fueled construction equipment used for moving, grading, and compacting earthen materials using emission factors for off-road construction based on values from the EPA NONROAD model. Model emission factors were based on g/hr. These values were combined with the number of pieces of equipment and hours of operation to estimate the total pounds released for each activity. The results are shown in Table 19-58 (EDF-3124-0009, *Off-Road Emissions During Construction*).

While emissions from construction activities and equipment are unavoidable, the implementation of mitigation measures minimizes the impacts to local ambient air quality and the nuisance impacts to the public in proximity to the project. Mitigation measures may include any or all of the following:

- Implementing controls to minimize daily emissions such as reducing engine idle time, using cleaner fuels (e.g., ultra-low sulfur diesel fuel or biodiesel), installing pollution control equipment on construction equipment (e.g., diesel oxidation catalysts and particulate matter filters), and curtailing or controlling the time of day construction activities are performed
- Performing proper maintenance of construction vehicles to maximize efficiency and minimize emissions

Table 19-58. Air Pollutant Emissions Factors for Off-Road Construction Equipment

			CO		NOx		CO_2		PM-10		PM-2.5		SOx	
Equipment	Qty	Hours	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb
Bulldozer	1	100	140	310	19	41	6.3	14	4.7	10	13,000	29,000	23	51
Compactor	1	120	160	340	21	46	7	15	5.3	12	15,000	32,000	26	57
Excavators	1	60	49	110	7.5	17	2.4	5.4	1.8	4	4,500	10,000	8.1	18
Front loaders	1	120	68	150	10	23	3.4	7.4	2.5	5.6	6,200	14,000	11	25
Graders	1	80	66	150	10	22	3.2	7.2	2.4	5.4	6,000	13,000	11	24
Paver	1	80	64	140	10	22	3.2	7	2.4	5.3	5,900	13,000	11	23
Asphalt roller	1	80	100	230	14	31	4.7	10	3.5	7.7	9,700	21,000	17	38
Totals			647	1430	91.5	202	30.2	66.0	22.6	50.0	60300	132000	107.1	236

Source: EDF-3124-0009, 2014, *Off-Road Emissions during Construction*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

PM-2.5 = particulate matter, 2.5 μ.
PM-10 = particulate matter, 10 μ.

19.4.2.1.1.5 Emissions Modeling

Emissions from construction activities were evaluated using AERSCREEN, Version 11126. This screening model uses standard defaults for meteorology and terrain values. Modeled emissions included PM-10, PM-2.5, CO, NO_x, and sulfur oxides (SO_x). The model estimated ambient air concentrations at 112 m (368 ft) (nearest road) and 375 m (1,230 ft) (near residence). These values were then compared to relevant Missouri and EPA air quality standards. This comparison is summarized in Table 19-59. In summary, unmitigated air emissions during construction are below Federal and State emissions standards for all parameters except PM-10 at 375 m (1,230ft) (closest residential receptor). The standard mitigation methods described previously would be used to ensure that the PM-10 levels at 112 m (368 ft) remain below the air quality parameters (6 CSR Division 10) (EDF-3124-0014, *Emission Modeling for Construction Activities using AERSCREEN*).

Table 19-59. Anticipated Gaseous Effluents and Their Associated Air Quality Parameters for Construction

		Amount		Concentration		Regional air quality parameter
Effluent	[a]Origin	kg	lb	at 112 m	at 375 m	
PM-10	W, C, OR	1,483	3,270	2.95 μg/m^3	1.21 μg/m^3	[b]150 μg/m^3
PM-2.5	W, C, OR	305	672	6.1 μg/m^3	2.5 μg/m^3	[c]35 μg/m^3
NO_x	C, OR	646	1,422	68 ppb	28 ppb	[d]100 ppb
CO	C, OR	91	201	0.018 ppm	0.007 ppm	[e]35 ppm
SO_x	C, OR	107	236	0.008 ppm	0.009 ppm	[f]0.075 ppm

Source: EDF-3124-0014, 2014, *Emission Modeling for Construction Activities using AERSCREEN*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

[a] W = wind-blown dust, C = construction activities, OR = emissions from off-road construction activities.
[b] 24-hr, not to be exceeded more than once per year on average over three years.
[c] 24-hr, 98th percentile, averaged over three years.
[d] 1-hr, 98th percentile, averaged over three years.
[e] 8-hr, not to be exceeded more than once per year.
[f] 1-hr, 99th percentile of 1-hr daily maximum concentrations, averaged over three years.

PM-2.5 = particulate matter, 2.5 μ.
PM-10 = particulate matter, 10 μ.

19.4.2.1.2 Air Quality Impacts from Operations

Operation activities may result in a slight increase in vehicle traffic in the immediate area of the proposed RPF, which could cause a slight increase in internal combustion emissions such as CO, NO_x and, to a lesser extent, SO_2. Operation of the emergency standby generator would also result in a slight increase in emission products, but due to intermittent use, these emissions would be low. The majority of effluent would be from radioisotope production and the release of a small amount of gaseous fission products. The offgas system is designed to filter and/or retain these isotopes in the facility until they are less than the established allowable concentrations for residential receptors. Each of these emissions is discussed in the following subsections.

19.4.2.1.2.1 Stack Characteristics

The RPF is designed to have five emission points that would each vent different areas of the process. The Zone I, Zones II/III, and the laboratory stacks would be located in the northwest corner of the facility (Figure 19-9) and extend 22.9 m (75 ft) high, which is 3 m (10 ft) above the building roof. The locations of the process steam and HVAC boilers are not shown on Figure 19-9. A summary of the five emission sources is provided below.

Zone I

Exhaust air flow rate:	534 m^3/min (18,850 ft^3)/min)
Diameter:	86 cm (34 in.)
Exhaust velocity:	911 m/min (2,990 ft/min)
Release frequency:	Continuous
Effluent temperature:	Ambient

Zone II/III

Exhaust air flow rate:	999.5 m^3/min (35,300 ft^3/min)
Diameter:	117 cm (46 in.)
Exhaust velocity:	933 m/min (3,060 ft/min)
Release frequency:	Continuous
Effluent temperature:	Ambient

Laboratory Exhaust

Exhaust air flow rate:	467 m^3/min (16,500 ft^3/min)
Diameter:	81 cm (32 in.)
Exhaust velocity:	900 m/min (2,955 ft/min)
Release frequency:	Continuous
Effluent temperature:	Ambient

Process Steam Boiler

Exhaust air flow rate:	39 m^3/min (1,386 ft^3/min)
Diameter:	30.4 cm (12 in.)
Exhaust velocity:	538 m/min (1,765 ft/min)
Release frequency:	Continuous
Effluent temperature:	29°C (85°F)

HVAC Boiler

Exhaust air flow rate:	40.6 m^3/min (1,435 ft^3/min)
Diameter:	30.4 cm (12 in.)
Exhaust velocity:	557 m/min (1,827 ft/min)
Release frequency:	Continuous
Effluent temperature:	29°C (85°F)

19.4.2.1.2.2 Gaseous Control System Description

Process exhaust offgases would be treated in two subsystems for the process offgas components and for the primary exhaust system for the hot cell(s). Each process offgas subsystem would treat the process offgas components separately to prevent mixing of waste constituents. A detailed description of the gaseous control system is provided in Section 19.2.3.2.12.

19.4.2.1.2.3 Releases from Isotope Production

Gaseous effluents from the RPF production process would originate from three main sources:

- Processing of irradiated targets for recovery and purification of ^{99}Mo product
- Recovery of LEU from the target processing activities
- Recycling the recovered uranium for fabrication into new targets.

Process offgases are treated in two subsystems that serve the process offgas components and the primary exhaust system for the hot cell(s).

Each process offgas subsystem would treat the process offgas components separately to prevent mixing of waste constituents. (Addition information is provided in Section 19.2.3.2.12.) Gaseous effluents resulting from the production process are based on a 50-week/year operating schedule. There are no emissions of CO, Pb, O_3, or particulate matter from the process exhaust system. All iodine fission products would be removed using absorption methods. Fission product gases such as xenon (Xe) and krypton (Kr) would be removed using gas trapping to allow decay. The resulting release would be maintained until levels are less than those defined in Table 2 of 10 CFR 20, Appendix B, "Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure; Effluent Concentration; Concentrations for Release to Sewerage."

19.4.2.1.2.4 Releases for Fuel Combustion

Emergency generator – A diesel generator is used for temporary operation and safe shutdown of the system if required. The emergency generator would emit CO, NO_x, PM, SO_2, VOCs, and CO_2, as summarized in Table 19-60, assuming less than 24 hr of operation a year, as required for routine maintenance (EDF-3124-0008, *Emissions from Natural Gas Boiler and Emergency Diesel Generator Operation*).

Table 19-60. Emissions for Standby Emergency Diesel Generator

		[a]CO		[a]NO_x		[b]CO_2		PM		[b,c]SO_x	
Emission factor		g/kW-hr	oz/kW-hr	g/kW-hr	oz/kW-hr	g/kW-hr	oz/kW-hr	g/kW-hr	oz/kW-hr	g/kW-hr	oz/kW-hr
		3.3	0.12	7.9	0.28	710	25	0.43	0.015	2.5	0.087
Emission factor		kg/hr	lb/hr	kg/hr	lb/hr	kg/hr	lb/hr	kg/hr	lb/hr	kg/hr	lb/hr
Standby diesel generator	2,600 kW	8.7	19	21	45	1,800	4,000	1.1	2.4	6.4	14
	[d]per year	210	460	490	1,000	44,000	97,000	27	59	150	340

Source: EDF-3124-0008, 2014, *Emissions from Natural Gas Boiler Operation*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

[a] Values from U.S. Environmental Protection Agency Tier 4 standards for non-road diesel generators (Table 7 of 40 CFR 1039.102, "What exhaust emission standards and phase-in allowances apply for my engines in model year 2014 and earlier.").

[b] Values from EPA, 2010, *Compilation of Air Pollutant Emission Factors, Volume 1, Stationary Point and Area Sources*, AP 42, Fifth Edition, U.S. Environmental Protection Agency, Office of Air and Radiation, Washington, D.C., 2010.

[c] Assumes 0.5% sulfur content.

[d] Assumes 24 hr/year operation for maintenance.

PM = particulate matter.

Natural gas-fired boilers – Several combustion sources at the proposed RPF would contribute to the gaseous effluents. These combustion sources would be two natural gas-fired boilers using steam production and two natural gas-fired boilers using heating. In addition to these natural gas-fired heaters, a diesel-fired standby diesel generator is proposed at the facility.

The two steam boilers and the two boilers used for heating would be released through two separate stacks. The boiler and generator all emit CO, NO_x, PM, VOCs, and CO_2, as summarized in Table 19-61 and Table 19-62 (EDF-3124-0012, *Emission Modeling for Process and HVAC Boilers Using AERSCREEN*). The total annual emissions for natural gas-fired boilers are summarized Table 19-61 (EDF-3124-0008).

Table 19-61. Natural Gas-Fired Boiler Total Annual Emissions

Pollutant	Annual emissions		Average hourly emissions	
	t/yr	(ton/yr)	kg/hr	(lb/hr)
CO	16	18	1.07	4.2
NO_x	1.0E+01	11	0.59	2.5
PM (total)	0.36	0.40	0.03	0.39
NHC (VOC)	1.1	1.2	0.086	0.28
SO_2	0.12	0.13	0.009	0.030
CO_2	24,000	26,000	1,380.17	6.0E+03

Source: EDF-3124-0008, 2014, *Emissions from Natural Gas Boiler Operation*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

PM = particulate matter.
VOC = volatile organic compound.

The AERSCREEN modeling system was used to assess the impacts of pollutants expected to be generated by the RPF from the production unit's four natural gas-fired heaters and the standby emergency diesel generator.

Table 19-62. AERSCREEN Model Total Annual Emissions

Pollutant	[a,b]Emissions (ton/yr)	Hourly emissions (lb/hr)	Maximum concentration (123 m) (μg/m³)	Modeled concentration to closest residential receptor (375 m) (μg/m³)	NAAQS (μg/m³)
CO	4.3E+00	18	7.2E+01	4.6E+01	4.0E+04
NO_x	2.5E+00	11	4.3E+01	2.7E+01	1.9E+02
[c]PM-10 (total)	3.9E-01	1.6	6.5E+00	4.2E+00	[g]150
[d]PM-10 (filterable)	9.6E-02	0.40	1.6E+00	1.0E+00	[g]35
[e]VOC	2.8E-01	1.2			
SO_2	3.1E-02	0.13	4.7E+00	3.0E+00	1.97E+02
[f]CO_2	6.1E+03	26,000	5.1E-01	3.3E-01	NA

Source: EDF-3124-0012, 2015, *Emission Modeling for Process and HVAC Boilers Using AERSCREEN*, Rev. 1, Portage, Inc., Idaho Falls, Idaho, February 4, 2015.

[a] It was determined that the stack effluent maximum concentration was found at 136 m (446 ft).
[b] Based on 50 weeks/year.
[c] Used as PM-10 values.
[d] Assumed to represent PM-2.5.
[e] No NAAQS for volatile organic compounds.
[f] No NAAQS for carbon dioxide.
[g] 24-hr standard for PM-10 and PM-2.5

NA = not applicable.
NAAQS = National Ambient Air Quality Standards.
PM-2.5 = particulate matter, 2.5 μ.
PM-10 = particulate matter, 10 μ.
VOC = volatile organic compound.

Release point characteristics – Emissions and stack characteristics for each emission source are based on the design parameters, assumptions, and emission factors. Exhaust characteristics for the boilers are estimated based on heat input to the source, fuel consumption, and combustion calculations assuming 30 percent excess combustion air and 75 percent efficiency.

Exhaust gas temperatures for the natural gas-fired boiler are based on temperature data provided by boiler vendors for other similar projects. Exhaust from the natural gas-fired boiler is vented to the atmosphere through different 22.9 m (75 ft) stacks that are separate from the other three process stacks. Each stack is 4.9 m (10 ft) taller than the tallest point of the building.

The results of the AERSCREEN model, as it relates to the NAAQS, are shown in Table 19 62. The results are presented for the point of maximum concentration (136 m [446 ft]) and at 375 m (1,230 ft), which represents the distance to the closest residential receptor. As shown in Table 19 62, no pollutant is estimated to be released during normal RPF operations that exceeds the NAAQS based on AERSCREEN modeling, making the need for more detailed modeling unnecessary (EDF-3124-0012).

19.4.2.1.2.5 Vehicle and Other Emissions

During the operations phase, vehicular air emissions would result from the commuting workforce and from routine deliveries to and from the proposed RPF. EMFAC2011 was used to calculate on-road vehicle emission factors for this period. The model estimates vehicle emission factors based on fuel type, vehicle type, vehicle speed, and climatological normal for temperature and humidity.

The volume of traffic generated during operations would be considerably lower than that expected during construction. In additional, the lands on the RPF site are either developed surfaces (buildings, paved parking/access road) or consist of either agricultural or landscaped areas. Consequently, limiting routine vehicle use to paved areas would reduce the emission of fugitive dust. In summary, impacts from vehicular air emissions and fugitive dust during operations would be far less than during the construction phase.

Emissions data shown in Table 19-63 provide an estimate of vehicle emissions. Calculations used to obtain the estimates are based on an average workforce of 25-50 vehicles/day using a specific vehicle ratio (60 percent light-duty autos, 30 percent light-duty gas trucks, and 10 percent light-duty diesel trucks) and a round trip of 40 mi/day (EDF-3124-0013, *On-Road Emissions for Vehicles During Operations*).

Table 19-63. Vehicle Emissions During Operations

		CO		NO_x		CO_2		PM-10		PM-2.5		SO_x	
Vehicle type	Fuel	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb
Light duty autos	Gas	540	1,200	48	110	110,000	250,000	0.74	1.62	0.67	1.48	1.1	2.5
Light duty trucks	Gas	660	1,500	61	130	65,000	140,000	0.82	1.8	0.75	1.65	0.66	1.5
Light duty trucks	Diesel	17	39	35	77	19,000	41,000	3.2	7.0	2.9	6.5	0.18	0.39
Total		1,200	2,700	140	320	196,000	430,000	4.7	10	4.3	9.6	2.0	4.3

Source: EDF-3124-0013, 2014, *On-Road Emissions for Vehicles During Operation*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

PM-2.5 = particulate matter, 2.5 μ.
PM-10 = particulate matter, 10 μ.

19.4.2.2 Monitoring

Gaseous effluents from the RPF would be released through three separate stacks (Zone I stack, Zones II/III stack, and the laboratory stack) (discussed in Section 19.2.3.2.12). The airborne effluent exhaust from the Zone I stack is expected to contain measurable quantities of noble gas radioactivity (i.e., Xe and Kr). There could also be radioactive iodine, radioactive particulates, and tritium in the airborne effluent exhaust. Due to the expectation of having measurable quantities of radioactivity in the airborne effluent and since malfunction of the exhaust carbon filtration system could result in a change in iodine radioactivity releases, the Zone I exhaust stack would be continuously monitored for gross gamma radioactivity. Grab sampling provisions would also be in place to support routine collection and analysis of gas and particulate samples from the Zone I exhaust stack to identify radionuclides, identify relative concentrations of radionuclides in the airborne effluent, and quantify radionuclide releases. No monitoring would occur for the HVAC and process steam boiler stacks.

19.4.2.2.1 Air Impacts from Decommissioning

Following the cessation of operations, the facility would be decommissioned. Decommissioning activities, however, are assumed to be similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. Effluents resulting from decommissioning are anticipated to be similar to the impacts associated with construction, with the addition of some particulate fission products radionuclides as a result of contamination of the equipment used in the process. The nonradioactive emissions should not exceed those defined in Table 2 of 10 CFR 20, Appendix B. Radioactive releases from contaminated equipment would be mitigated to acceptable levels using standard containment methods and procedures.

19.4.2.2.2 Visibility Impacts

19.4.2.2.2.1 Impacts of Construction

People living near or working at or near construction sites may have some visibility impact due to construction activities. The use of construction equipment may result in varying amounts of dust and air emissions. The magnitude and area of extent of the impacts from these emissions depends on atmospheric conditions at the time of the activity. BMPs, including dust control suppressants, would be used to limit any impacts. Contractors, vendors, and subcontractors would be required to adhere to appropriate Federal and State occupational health and safety regulations. Given the above-mentioned factors, the visibility impacts associated with gaseous effluents during construction are considered small.

19.4.2.2.2.2 Impacts of Operation

Quantities of gaseous effluent released from the facility during operations would be below regulatory limits, and these quantities are not anticipated to result in visibility impacts. As such, the visibility impacts associated with gaseous effluents during operation are considered small.

19.4.2.2.2.3 Impacts of Decommissioning

Following the cessation of operations, the facility would be decommissioned. Decommissioning activities are similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. Visibility impacts from decommissioning are anticipated to be similar to the visibility impacts associated with construction and, as such, are considered small.

19.4.2.2.3 Greenhouse Gas Emissions

GHGs trap heat in the atmosphere, absorbing and emitting radiation in the thermal infrared range. The most important of these gases are CO_2, methane, nitrous oxide, and fluorinated gases. GHGs are reported as CO_2 equivalent (CO_{2e}) and refer to the global warming potential of the GHG or gases being emitted.

Activities associated with the proposed RPF site that are expected to contribute to GHGs (summarized in Table 19-64) include:

- Construction activities at the site principally result in emissions of CO_2; GHG emissions associated with construction activities include those from the commuting construction workforce and operation of construction equipment at the site
- Plant operation activities associated with the operation of plant equipment and the operations workforce

Table 19-64. Expected Green House Gas Emissions from Radioisotope Production Facility Project

Source	CO_2 kg	CO_2 lb
Construction phase onsite	44,000	97,000
Construction phase offsite	610,000	1,330,000
Normal plant operations (per year)	23,000,000	51,000,000
Operations on-road vehicle travel (per year)	200,000	430,000

Source: EDF-3124-0011, 2014, *Greenhouse Gas Emissions*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

The increase in total GHGs in the form of CO_2 from on-road and off-road sources, and the annual CO_2 expected from normal operations are summarized in Table 19-64 (EDF-3124-0011, *Greenhouse Gas Emissions*).

NWMI will develop a comprehensive program to avoid and control GHG emissions associated with the RPF. This program is expected to include elements such as:

- Developing a GHG emission inventory
- Investigating and implementing methods for avoiding or controlling identified GHG emissions
- Encouraging carpooling or other measures to minimize GHG emissions due to vehicle traffic
- Conducting periodic audits of GHG control procedures
- Implementing corrective actions when necessary

19.4.2.2.4 Mitigations

Emission-specific strategies and measures would be developed and implemented to ensure compliance within the applicable regulatory limits defined by the National Primary and Secondary Ambient Air Quality Standards (40 CFR 50) and NESHAP (40 CFR 61). Contractors, vendors, and subcontractors would be required to adhere to appropriate Federal and State occupational health and safety regulations. These regulations set limits to protect workers from adverse conditions, including air emissions. Implementation of controls and limits at the source of emissions on a construction site result in reduced impacts offsite.

19.4.2.2.5 Meteorology

Meteorological measurements would be available for use in responding to accidental radiological releases, other emergencies, and any other routine purposes that require access to meteorological information during the licensing period. That meteorological information would be obtained for local government weather monitoring stations that observe wind and other surface meteorological parameters on an hourly basis.

When needed during an emergency, real-time hourly surface meteorological measurements of wind direction, wind speed, air temperature, and weather type would be accessed by NWMI through Government data sources. Access would be attempted during the emergency in the following sequence, until reliable data is obtained, as follows:

1. Internet access to hourly surface weather observations recorded at station 231791, Columbia Regional Airport (w1.weather.gov/data/obhistory/KCOU.html).
2. Telephone access to an automated voice recording at (573) 499-1400 of the most recent hourly surface observations recorded at the Columbia Regional Airport.
3. If weather observations are not available from the station at the Columbia Regional Airport, weather information from another station with hourly meteorological data in the site climate region would be used. The following Missouri stations would be used as listed in order of increasing distance from Columbia:
   a. Jefferson City Memorial Airport: w1.weather.gov/data/obhistory/KJEF.html
   b. Kansas City International Airport: w1.weather.gov/data/obhistory/KMCI.html
   c. Sedalia Memorial Airport: w1.weather.gov/data/obhistory/KDMO.html
   d. Spirit of St. Louis Airport: w1.weather.gov/data/obhistory/KSUS.html

During normal operations, data would be obtained by internet access to hourly surface weather observations recorded at the Columbia Regional Airport at w1.weather.gov/data/obhistory/KCOU.html.

19.4.2.3 Noise

This section provides an assessment of the noise impacts associated with RPF construction, operation, and decommissioning.

19.4.2.3.1 Impacts of Construction

Site preparation, grading, and facility construction activities would require the use of heavy equipment such as graders, bulldozers, and concrete trucks. Noise generated from these types of equipment ranges from 75 to 89 dBA at approximately 15 m (50 ft) (FHWA, 2006). Most construction activities would occur during weekday, daylight hours (8:00 a.m.–5:00 p.m., Monday–Friday); however, construction may continue during nights and weekends when necessary to maintain the construction schedule. A special permit is required per Section 16-265 of the Columbia Code of Ordinances (City of Columbia, 2013b), if construction activities are conducted outside of the normal weekday, daylight hours.

Onsite noise level exposure would be controlled through appropriate training, PPE, periodic health and safety monitoring, and industry best practices. Practices such as maintenance of noise-limiting devices on vehicles and equipment, controlling access to high-noise areas, controlling duration of emissions, and/or shielding high noise sources near their origin limit the adverse effects of noise on workers. Nonroutine activities with potential adverse impacts on noise levels are limited and use best industry practices that further limit adverse effects.

The closest receptor is located 152 m (500 ft) from the proposed RPF, as shown in Figure 19-41. Increased noise levels resulting from construction activities would be short-term, lasting the duration of construction of the facility, and would not result in long-term impacts to ambient noise levels. In addition, the natural attenuation of the noise over distance would reduce the effect of construction noise. The impact of noise from construction of the new site on nearby residences, churches, and recreational areas is small.

Traffic associated with the construction workforce commuting to and from the facility site also generates noise. As previously discussed, the baseline noise conditions for traffic include airports, railways, and highways. The increase in noise relative to baseline conditions is most noticeable during periods of high-activity onsite and during shift changes in the morning and late afternoon. In addition, potential indirect impacts may be anticipated to off-site areas associated with the roadway network and adjacent lands beyond the site boundary. Noise-related impacts may result from an increased traffic volume and resultant increases in traffic-generated noise. The potential noise impact to nearby receptors due to construction-related traffic is small.

19.4.2.3.2 Impacts of Operation

Long-term noise sources resulting from operation of the proposed RPF would include process equipment, ventilation, heating and cooling systems, and increased traffic. These noise sources are similar to existing noise sources near the proposed facility location. Ambient background noise sources in the area currently include vehicular traffic along highways and commercial building heating, cooling, electrical, and ventilation systems. In addition, intermediate operation of agricultural equipment is present in the area.

Process equipment would be housed inside the facility, such that the noise contribution to the environment would be minimal. The major source of process noise from the facility is anticipated to be the HVAC systems associated with process and routine operations. Many of these systems are already present at other facilities within the immediate area (e.g., ABC Laboratories, RADIL). Impacts from operation of the systems associated with the RPF are not anticipated to increase the baseline noise levels for any process activity at the RPF. Therefore, potential noise impacts to the community from process noise, including HVAC systems, at the RPF are small.

Commercial vehicle traffic would include regular shipments of laboratory supplies, waste, irradiated targets, newly fabricated targets, and ^{99}Mo product. Shipments would occur at regular intervals. Supply shipments would be expected to be weekly or bi-weekly. Transport shipments of irradiated targets are expected to occur two times per week. Transport of the ^{99}Mo product is also expected to occur two times per week. Occupational vehicle traffic would include the daily commute of on-site workers, resident workers, residents, and students. In many cases, this occupational traffic is not expected to significantly impact existing traffic patterns. Noise generated from occupational traffic is expected to occur during normal weekday, daylight operational hours (8:00–5:00, Monday–Friday).

To meet schedule demands, the transport of product, targets, and waste could occur during times other than normal operational hours. Noise from truck transports would include engine noise, air brake noise, backup warning beepers, tire noise, and air horn.

Potential indirect impacts to off-site areas are associated with the roadway network and adjacent lands beyond the site boundary. Noise-related impacts may result from an increased traffic volume and resultant increases in traffic-generated noise as discussed in this section. Noise levels during operations in these off-site areas would not be notable, as these areas are currently located within a roadway network (e.g., highway, agriculture) that is characterized by traffic volumes that exhibit traffic/vehicle noise. The intermittent increase in traffic volume associated with normal work conditions, intermediate deliveries, and the natural noise attenuation over distance results in noise levels to receptors at baseline levels. Therefore, noise impacts resulting from normal operations are small.

19.4.2.3.3 Impacts of Decommissioning

Decommissioning is the removal of a nuclear facility from service and reduction of residual radioactivity to a level that permits release of the property for unrestricted use and termination of the license. During the decommissioning phase activities, equipment usage and the noise associated with their operation are expected to be similar or less than that of the construction phase. As such, noise impacts during the decommissioning phase of the RPF are considered small.

19.4.3 Geologic Environment

This section provides a description of the impacts to geology and soils that can be expected from the proposed RPF construction, operation, and decommissioning. A complete description of the geology and soils at the proposed site is provided in Section 19.3.3. Brief descriptions of the geology and soils provide context for the impacts discussion.

19.4.3.1 Soils and Bedrock

The proposed RPF would be located on flat terrain, requiring some cut and fill to bring the ground surface to the final grade. The excavation of a detention basin would also produce fill material. The maximum depth of excavation is anticipated to be 4.7 m (15.5 ft). About 6,881 m^3 (9,000 cubic yards [yd^3]) is estimated to be excavated for the building footprint (EDF-3124-0001, *Estimate of Excavation for the NWMI Radioisotope Production Facility*). The material excavated would be soil; no blasting is anticipated. The volume of material resulting from excavation of the site would be used as fill for the lower areas of the site, with no additional fill required. No contaminated soils are expected to be encountered during construction.

Minimal excess excavated material is anticipated. Any excess would be stockpiled by Discovery Ridge for any future construction and landscaping activities within the park area. Because of the agricultural history of the site, the resulting terrain change for the site from gently sloping to flat topography as a result of construction of the facility is expected to cause a small environmental impact to the site geology or soils.

Lot 15 is underlain by competent limestone bedrock that would not be expected to subside due to construction of buildings and related infrastructure. The possible exception to this generalization is the potential for the occurrence of sink holes. The subsurface could be subject to collapse due to increased loads resulting from facility construction. However, there was no evidence of subsidence or sinkholes within the Discovery Ridge project area during geotechnical investigation (Terracon, 2011a). Based on these observations, the likelihood of subsurface sinkholes within the facility footprint is expected to be small but should be considered during detailed subsurface investigations associated with facility construction.

19.4.3.1.1 Impacts of Construction

Short-term increases in soil erosion and dust generation in the areas within and adjacent to the proposed RPF footprint and roads may occur during construction due to earth-moving activities, clearing of vegetation, and compaction of soils. However, dust production and erosional impacts due to site clearing and grading would be mitigated by using construction and erosion control BMPs. Disturbed soils would be stabilized as part of construction work. Earthen berms, dikes, and sediment fences would be used as necessary during all phases of construction to limit runoff. These measures would prevent the local surface drainages from being affected substantially by construction activities. Much of the excavated areas would be covered by structures or paved, limiting the creation of new dust sources. At a minimum (when needed), twice-daily watering would be used to control potentially fugitive construction dust in addition to other fugitive dust prevention and control BMPs, as discussed in Section 19.4.2.2.4. Because site preparation and construction result in only short-term effects to the geology and soils, the impacts would be small.

19.4.3.1.2 Impacts of Operation

The proposed RPF operation phase would not involve additional disruption of the local soil or bedrock and, therefore, is expected to have no impact on the site geology beyond that caused by excavation activities during construction. Thus, the impact to geology and soils due to operation would be small.

During operation of the proposed facility, BMPs would also be used to manage stormwater runoff from paved and compacted surfaces to drainage ditches and basins. Process wastewater would be contained within enclosed systems, treated, and evaporated. Process waste water would not be disposed to the subsurface bedrock or local soils. These various measures would minimize impacts to geology and soils from the proposed facility. As such, the impacts associated with RPF operation are small.

19.4.3.1.3 Impacts of Decommissioning

Following the cessation of operations, the facility would be decommissioned. Decommissioning activities, however, are similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. Direct and indirect impacts from decommissioning are anticipated to be similar to the impacts associated with construction and are considered small.

19.4.3.2 Large-Scale Geologic Hazards

Large-scale hazards include earthquakes, volcanic activity, landslides, subsidence, and erosional processes. As noted in Section 19.3.3, the USGS projected hazards for Boone County if an earthquake occurs along the NMSZ in the 50 years after 2002 include (USGS, 2003):

- 25–40 percent chance of a magnitude 6.0 and greater earthquake
- 7–10 percent chance of a magnitude 7.5–8.0 earthquake

According to the USGS, Boone County is one of the 47 counties in Missouri that would be severely impacted by a 7.6 magnitude earthquake with an epicenter on or near the NMSZ (USGS, 2003). According to the *Boone County Hazard Mitigation Plan* for 2010 (MMRPC, 2010), the Missouri State Emergency Management Agency has made projections of the highest earthquake intensities that would be experienced throughout Missouri if various magnitude earthquakes occur along the NMSZ (Figure 19-33), as measured by the MMI scale.

Geologic features that are associated with landslide, subsidence, and errosional processes are discussed in Section 19.3.3. The occurrence of landslides is low because the topography of the site is relatively level. Previous investigations at the site (Terracon, 2011b) did not identify any evidence of shallow bedrock, karst features, and/or extensive previous deposits of water-bearing sand associated with sinkholes. The investigation did not find any evidence of subsidence or sinkholes.

19.4.4 Water Resources

19.4.4.1 Surface Water

Water resources at the proposed RPF site are discussed in Section 19.3.4. The nearest water body is created by the MU R1 Dam, located approximately 152 m (500 ft) northwest of the site. This dam is not on a regulated water body. The second nearest water body is a farm pond approximately 305 m (1,000 ft) to the northeast of the site. Gans Creek, which is located approximately 0.8 km (0.5 mi) south of the site, drains the site and Discovery Ridge. Perry Phillips Lake is located approximately 1.2 km (0.75 mi) west of the RPF site.

19.4.4.1.1 Impacts of Construction

Federal, State, and local regulations and permit procedures provide minimum requirements for stormwater management during construction activities to prohibit adverse impacts on surface water or stormwater. Some dewatering due to groundwater and precipitation may be required during construction at the deepest excavation. Any water would be collected in a detention/retention pond. Disturbed soils would be stabilized as part of construction work. Earthen berms, dikes, and sediment fences would be used as necessary during all phases of construction to limit runoff. These measures would prevent the local surface drainages from being affected substantially by construction activities. Impacts associated with construction of the proposed RPF on the surface water are small.

19.4.4.1.2 Impacts of Operation

As described in Section 19.2.4, all water used at the proposed RPF would be obtained from the Consolidated Public Water Supply District #1 water supply system, and all sanitary wastewater would be discharged directly to the Columbia sanitary sewer system. The facility would be designed to have zero liquid discharge from the radiologically controlled area, and there would be no use or release water from the facility to the adjacent environment that would affect surface water. As such, direct and indirect impacts to surface water from RPF operations are small.

19.4.4.1.3 Impacts of Decommissioning

Following the cessation of operations, the proposed RPF would be decommissioned. Decommissioning activities, however, are similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. Direct and indirect impacts from decommissioning are anticipated to be similar to the impacts associated with construction and, as such, are considered small.

19.4.4.2 Groundwater

The groundwater aquifer beneath the proposed RPF site is the Mississippian aquifer (also referred to as the Kimmswick-Potosi aquifer). The Mississippian aquifer is the principal aquifer supplying groundwater to Boone County. In accordance with drillers' reports generated from 1987 to 2005, the estimated static water level in the area near the proposed site was approximately 198 m (650 ft) below ground surface. During previous investigations at Discovery Ridge, groundwater was observed at depths ranging from approximately 3.7–5.6 m (12–18.5 ft) below ground surface.

19.4.4.2.1 Impacts of Construction

Some dewatering due to groundwater may be required during construction at the deepest excavation. No alterations to groundwater systems are expected during facility construction. Runoff controls would be in place during construction as part of the BMPs to prevent uncontrolled releases of water. The potential for water or other liquids from spills or leaks to cause significant migration of contaminants downward to the groundwater system is considered unlikely. No groundwater withdrawals or returns are required during construction. As such, direct and indirect impacts of construction of the proposed RPF on groundwater are small.

19.4.4.2.2 Impacts of Operation

The RPF would obtain its water supply from the Columbia municipal water system. Operations would not require any groundwater. Consequently, direct and indirect impacts on groundwater during operations are small.

19.4.4.2.3 Impacts of Decommissioning

Following the cessation of operations, the facility would be decommissioned. Decommissioning activities are similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. Direct and indirect impacts from decommissioning are anticipated to be similar to the impacts associated with construction and, as such, are considered small.

19.4.4.3 Monitoring

The proposed RPF is eligible for a Missouri General Operating Permit MO-R10A000. The permit does not include any stormwater monitoring requirements. Because of the absence of direct impacts to surface water and groundwater, the low potential for indirect impacts, and the use of management measures and controls to prevent releases to surface water or groundwater, no surface water or nonradiological groundwater monitoring activities are planned for the site.

19.4.5 Ecological Resources

This section assesses the impacts of construction, operation, and decommissioning on ecological resources, as described in Section 19.3.5, for the proposed RPF site and analysis area. Impacts include effects from activities associated with construction, operation, and decommissioning, including excavation, grading, placement of fill material, temporary staging and construction laydown, construction of permanent features (or deconstruction in decommissioning), and potential operational disturbances.

19.4.5.1 Impacts of Construction

As discussed in Section 19.3.5.3, the proposed site and the ROI are mostly urban development or used for agriculture or pasture. The proposed RPF site is located in an area that has been used historically for cropland and pasture. There are no designated critical habitats for Federal- or State-listed species within the ROI (Section 19.3.5.9). Furthermore, Federal- or State-listed species are not likely to occur near the proposed site because of the lack of available resources. There are no aquatic environments located on the proposed site. Flora within the proposed site consists of common grasses and forbs typically found in cropland and pasture. Potential fauna within the proposed site would mostly consist of transient species because of the lack of available resources.

Direct and indirect impacts from construction of the facility would potentially consist of temporary displacement of fauna species from the area, bird collisions with construction equipment, and stormwater runoff. Construction noise would most likely cause temporary displacement of fauna species and would primarily occur during construction hours. After construction hours, elevated noise levels would cease and displaced fauna species would potentially return to the area.

Bird collisions with the proposed facility are unlikely because of the low profile of the building and the low occurrence of bird strikes with buildings. Based on the findings of NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, bird collisions with buildings occur at very low frequencies. Bird strikes with construction equipment (e.g., cranes) are rare, but are most likely to occur during nighttime construction due to the use of artificial lights. To mitigate any potential strikes, BMPs for artificial lights are used (e.g., artificial lights are directed toward construction activities and shielded). Potential impacts from stormwater runoff are limited because there are no aquatic environments located on the site. Potential impacts to aquatic environments offsite would be mitigated because of the stormwater retention systems already in place and the use of BMPs in accordance with the site-specific construction SWPPP, which prevents runoff and subsequent siltation from reaching any of the surrounding streams.

Potential impacts to ecological resources, either permanent or temporary, from construction of the facility are considered small due to:

- Historical and current use of the proposed site, which limits available resources for fauna species
- Commonality and distribution of the current flora located on the site
- Lack of an aquatic environment on the site

Mitigations for bird collisions and stormwater runoff would limit any potential impact.

19.4.5.2 Impacts of Operation

Direct and indirect impacts from operation of the proposed RPF would potentially consist of the exposure of flora and fauna to herbicides used for vegetation management, bird collisions with the facility, and stormwater runoff. Potential impacts from herbicides used for vegetation management would be mitigated with BMP requirements that would limit their use and contain the broad application throughout the site. Bird collisions with the proposed facility are unlikely because of the low profile of the building, available windows on the building, and the low occurrence of bird strikes with buildings. Based on the findings of NUREG-1437, bird collisions with buildings occur at very low frequencies. Potential impacts from stormwater runoff would be limited because there are no aquatic environments located on the site. Potential impacts to aquatic environments offsite would be mitigated because of stormwater retention systems on the site.

Potential impacts, either permanent or temporary, from operation of the RPF are considered small because of the historical and current use of the proposed site, which limits the available resources for fauna species, the commonality and distribution of the current flora located on the site, the ability for fauna species to habituate to their surroundings, and the lack of an aquatic environment on the site. Mitigations for bird collisions and stormwater runoff would limit any potential impact.

19.4.5.3 Impacts of Decommissioning

Potential direct and indirect impacts to ecological resources from decommissioning of the proposed RPF would be similar to those from construction. As such, potential impacts to ecological resources, either permanent or temporary, from decommissioning of the facility are considered small because of the historical and current use of the proposed site, which limits the available resources for fauna species, the commonality and distribution of the current flora located on the site, and the lack of an aquatic environment on the site. Mitigations for bird collisions and stormwater runoff would limit respective potential impacts.

19.4.5.4 Monitoring

As described in Section 19.3.5, the proposed RPF site has been used for agriculture for the past several decades and is routinely disturbed by the discing, plowing, herbicide application, and harvesting activities associated with row crop production. Ecological resources at the site are limited by the lack of surface water and the historical agricultural practices on the site. Because the baseline conditions consist of agricultural land lacking native terrestrial or aquatic habitat, post-construction ecological monitoring and maintenance plans are not deemed necessary.

19.4.6 Historical and Cultural Resources

As described in Section 19.3.6.3, no on-site historic properties are associated with the proposed RPF project area. No archaeological sites or evidence of cultural resources were identified within the survey area. The Missouri SHPO has reviewed the findings of the Phase I archaeological survey and indicated that no further consultation with the SHPO regarding the proposed RPF is required (DNR, 2013).

As discussed in Section 19.3.6.8, NWMI initiated consultation with six Federally recognized tribes regarding the proposed development. No responses have been received. The nearest listed NRHP property is the Maplewood House located approximately 1.6 km (1 mi) to the northwest of the proposed RPF site. No direct impacts would occur to this property from construction, operational, or decommissioning activities. Therefore, potential impacts to historic and archaeological resources are small. However, if potential cultural or historical resources are identified during construction, the SHPO will be immediately notified.

19.4.7 Socioeconomics

This section assesses the impacts of construction, operation, and decommissioning of the proposed RPF on the socioeconomic environment, including transportation system impacts. The evaluation of potential socioeconomic impacts addresses potential changes in the regional population, economy, housing availability, and public services. The evaluation of transportation system impacts addresses routes and modes that would be involved with transporting materials, workers, and equipment to the proposed RPF site.

Operation of the RPF from 2017 through 2047 would lead to a permanent increase in employment, income, and population in the area. Facility employment during operation would include up to 98 workers. If all 98 operational workers traveled or moved to Boone County from outside the area, this would only represent a 0.11 percent increase in the total employed labor force of 92,742 (USDOL, 2014) in Boone County. A significant number of the operational jobs are likely to be filled by local residents. Some of the in-migrating construction workers would likely stay to become part of the operational workforce of the RPF.

The annual RPF operating payroll is estimated to be approximately $8.122 million for a workforce of 98, or an average of $82,878 per worker per year (in constant 2013 dollars). This average salary is approximately 176 percent more than the 2010 Boone County $47,123 median household income (USCB, 2010b).

19.4.7.1 Population

The Boone County population is 162,642 (USCB, 2010a). Growth projections show that the population is estimated to increase an average of 20.3 percent over the next 20 years (Table 19-46). Analysis of the population changes considers impacts that would result from RPF construction, operation, and decommissioning.

19.4.7.1.1 Impacts of Construction

As shown in Table 19-65, for major labor categories, a large construction trade workforce is available in Boone County. A large number of workers are not anticipated to relocate to Boone County to support construction. The labor force within the ROI for the construction trades is demonstrated to be abundant relative to construction workforce requirements. Approximately 80 percent (66) of the required construction workforce for these trades are estimated to come from within the ROI. The remaining 16 (of total 82 needed) are anticipated to temporarily relocate to the ROI. Using the ROI average of 2.4 persons per household, the total population increase in the various communities within the ROI due to the construction workforce requirements would be 38 people. This estimated population increase constitutes 0.02 percent of the 2013 population of the ROI. Therefore, the impact of construction of the RPF on population is small.

Table 19-65. Workforce Required for Construction

Occupation	[a]Available in Columbia Area	Required for Radioisotope Production Facility	Excess/ (deficient)
Carpenters	750	5	745
Construction laborers	470	17	453
Electricians	170	8	162
Supervisors of construction	220	11	209
Construction equipment operators	370	12	358
Plumbers, pipefitters, and steamfitters	230	17	213
Sheetmetal workers	50	6	44
Structural iron and steel workers	60	6	54

[a] BLS, 2012, "May 2012 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates," www.bls.gov/oes/current/oessrcma.htm, U.S. Bureau of Labor Statistics, Washington, D.C., accessed September 2013.

19.4.7.1.2 Impacts of Operation

Table 19-66 shows that the 89 (non-management) permanent operations workers needed are available in the ROI. About 40 percent (36) of the operations workers and their families are assumed to relocate to reside in the ROI. Using the ROI average of 2.4 persons per household, the total population increase in the various communities within the ROI due to operational workforce requirements is 86 people. This estimated population increase constitutes 0.05 percent of the projected 2015 population of the ROI. Therefore, the impact of operating the RPF on population is small.

Table 19-66. Workforce Required for Operations

Occupation	[a]Available in Columbia Area	Required for Radioisotope Production Facility	Excess/ (deficient)
[b]Technical support	1,140	30	1,110
Production workers	170	43	127
Production worker support	280	16	264

[a] BLS, 2012, "May 2012 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates," www.bls.gov/oes/current/oessrcma.htm, U.S. Bureau of Labor Statistics, Washington, D.C., accessed September 2013.
[b] Includes all architecture and engineering occupations.

19.4.7.1.3 Impacts of Decommissioning

An estimated 81 workers would be required for decommissioning. The workers needed are assumed to be similar to workers employed during construction, with the addition of approximately 15 radiation technologists. About 60 percent (49) of the 81 workers are assumed to come from the ROI, and the remainder of the workers (32) and their families would relocate to Boone County during the decommissioning period. Based on the ROI average of 2.4 persons per household, the ROI population would increase by 77 due to the decommissioning workforce. This estimated population increase constitutes 0.03 percent of the projected population of the various communities within the ROI at the end of the 30-year license period. Therefore, the impact of decommissioning the RPF on population is small.

19.4.7.2 Housing

Section 19.3.7.1.5 provides a summary of the 2010 Census data concerning availability of housing in the ROI. This data is used as a basis for estimating the number of housing units that may be available to accommodate housing demands resulting from construction, operation, and decommissioning of the RPF. In 2010, there were 69,551 housing units, of which 64,077 are occupied and 5,474 are not occupied within the county.

19.4.7.2.1 Impacts of Construction

As discussed in Section 19.4.7.1.1, a total of 16 workers would be anticipated to move into the area during the construction period, requiring an equal number of housing units. The available number of housing units is 5,474. Potential impacts on housing are small due to the large number of available vacant housing units in the ROI and the relatively small requirements for construction.

19.4.7.2.2 Impacts of Operation

As discussed in Section 19.4.7.1.2, a total of 36 workers would be anticipated to move into the area during operation of the NWMI facility and would require an equal number of housing units. The available number of housing units is 5,474. Potential impacts on housing are small due to the large number of available vacant housing units in the ROI and the relatively small requirements for operations.

19.4.7.2.3 Impacts of Decommissioning

As discussed in Section 19.4.7.1.3, a total of 32 workers are anticipated to move into the area during decommissioning of the NWMI facility and would require an equal number of housing units. The available number of housing units is 5,474. The percentage of available housing units is anticipated to remain constant over the life of the RPF license. Potential impacts on housing are small due to the large number of available vacant housing units in the ROI and the relatively small requirements for decommissioning.

19.4.7.3 Public Services

Public services impacts as a result of construction, operation, and decommissioning of the proposed RPF include the requirements for water, sanitary sewer, and power.

Water – Water at the facility site would be used for dust control and compaction, and to support the needs of the construction workforce. During construction and operations, Consolidated Public Water Supply District #1 would provide water to the site. Construction needs are estimated to not exceed an average of 7,571 L/day (2,000 gal/day).

The average per capita water usage in the U.S. is 340.7 L/day (90 gal/day) per person, including personal use, bathing, laundry, and other household uses (USGS, 2013d). Assuming half of that level of usage is onsite, the 92 workers would use 15,672 L/day (4,140 gal/day). Including construction needs, this amounts to a total water usage of 23,242 L/day (6,140 gal/day).

As noted in Section 19.3.7.1.9.2, the Consolidated Public Water Supply District #1 presently supplies 5.49 ML/day (1.45 Mgal/day). Construction requirements of the RPF are small compared to the available water supply, and operations requirements are similarly small. As noted in Section 19.2.4, the RPF would require 4,885 L/day (1,286 gal/day) during operations. This is a small impact compared to the total water available. Decommissioning requirements are anticipated to be similar to construction.

Sanitary Sewer – The facility would be connected to the Columbia sanitary sewer system. Sanitary sewer service is provided to the lot line for each of the Discovery Ridge tenants and has been sized to support the industrial park with tenants similar to the RPF. The sanitary sewer requirements for construction and operation of the facility would not exceed those presently provided for the research park.

Power – The RPF is estimated to require approximately 1,150 kilowatts (kW) of power during operation, or approximately 10 megawatt (MW) hours annually. This is a small impact compared to the total power (1,188,483 MW hours) distributed by Columbia in 2013 (City of Columbia, 2014).

19.4.7.4 Public Education

Schools and student populations are discussed in Section 19.3.7.2. The criteria used to determine impacts to public education as a result of construction, operation, and decommissioning of the RPF are based on projected changes in both student enrollment and the number of teaching staff and classrooms.

19.4.7.4.1 Impacts of Construction

Columbia Public Schools has a student enrollment of 17,722. Construction of the RPF is estimated to result in an increased population of 38. Based on the U.S. Census data (USCB, 2010a), 14.9 percent of the population in Boone County is school age (5 to 18 years). The estimated impact to the school system would be six new students during the construction phase, an increase of 0.03 percent. Columbia Public Schools are presently planning for an annual increase of 2 percent (CPS, 2006). Impacts from the RPF construction on public schools are a small fraction of the presently planned increase and, as such, are small.

19.4.7.4.2 Impacts of Operation

Operation of the proposed RPF is estimated to result in an increased population of 86. Based on the U.S. Census data (USCB, 2010a), 14.9 percent of the population in Boone County is school age (5 to 18 years). The estimated impact to the school system would be 13 new students during the operation phase, an increase of 0.07 percent. Columbia Public Schools are presently planning for an annual increase of 2 percent (CPS, 2006). The impacts from operations on public schools are a small fraction of the presently planned increase and, as such, are small.

19.4.7.4.3 Impacts of Decommissioning

Following the cessation of proposed RPF operations, the facility would be decommissioned. Decommissioning activities are considered similar to those of construction, with an estimated increase of 32 workers into the ROI. Direct and indirect impacts from decommissioning are anticipated to be similar to the impacts associated with construction and, as such, are small.

19.4.7.5 Tax Revenues

Tax revenues associated with proposed RPF construction, operation, and decommissioning would include payroll taxes on wages and salaries of the construction and operations workforces; sales and use taxes on purchases made by NWMI and construction, operations, and decommissioning personnel; and property taxes on owned real property and improvements. Increased tax collections would benefit Missouri, Boone County, city of Columbia, and Columbia Public Schools.

Workforce payroll taxes (Federal and State) would be generated by construction, operations, and decommissioning activities and purchases, and the taxes generated by workforce expenditures. State tax payments would be distributed throughout the ROI and extend beyond the ROI, based on the expectation that some construction, operations, and decommissioning employees would reside outside of Boone County. Table 19-67 provides an estimate of the annual tax payments (EDF-3124-0007, *Tax Revenue from the Construction, Operation, and Decommissioning of the Northwest Medical Isotope Facility*).

Table 19-67. Estimated Annual Tax Payments

Year	Income tax	Property tax	Sales tax	Total
2015	$200,709	$485,574	$217,017	$903,300
2016	$200,709	$1,213,936	$217,017	$1,631,662
2017	$465,296	$1,213,936	$832,053	$2,511,285
2018	$465,296	$1,213,936	$832,053	$2,511,285
2019	$465,296	$1,213,936	$832,053	$2,511,285
2020	$465,296	$1,213,936	$832,053	$2,511,285
2021	$465,296	$1,213,936	$832,053	$2,511,285
2022	$465,296	$1,213,936	$832,053	$2,511,285
2023	$465,296	$1,213,936	$832,053	$2,511,285
2024	$465,296	$1,213,936	$832,053	$2,511,285
2025	$465,296	$1,213,936	$832,053	$2,511,285
2026	$465,296	$1,213,936	$832,053	$2,511,285
2027	$465,296	$1,213,936	$832,053	$2,511,285
2028	$465,296	$1,213,936	$832,053	$2,511,285
2029	$465,296	$1,213,936	$832,053	$2,511,285
2030	$465,296	$1,213,936	$832,053	$2,511,285
2031	$465,296	$1,213,936	$832,053	$2,511,285
2032	$465,296	$1,213,936	$832,053	$2,511,285
2033	$465,296	$1,213,936	$832,053	$2,511,285
2034	$465,296	$1,213,936	$832,053	$2,511,285
2035	$465,296	$1,213,936	$832,053	$2,511,285
2036	$465,296	$1,213,936	$832,053	$2,511,285
2037	$465,296	$1,213,936	$832,053	$2,511,285
2038	$465,296	$1,213,936	$832,053	$2,511,285
2039	$465,296	$1,213,936	$832,053	$2,511,285
2040	$465,296	$1,213,936	$832,053	$2,511,285
2041	$465,296	$1,213,936	$832,053	$2,511,285
2042	$465,296	$1,213,936	$832,053	$2,511,285
2043	$465,296	$1,213,936	$832,053	$2,511,285
2044	$465,296	$1,213,936	$832,053	$2,511,285
2045	$465,296	$1,213,936	$832,053	$2,511,285
2046	$200,709	$404,645	$166,411	$771,765
Total	**$14,095,718**	**$37,308,300**	**$24,729,973**	**$76,133,991**

Source: EDF-3124-0007, 2014, *Tax Revenue From the Construction, Operation, and Decommissioning of the Northwest Medical Isotope Facility*, Rev. 1, Portage, Inc., Idaho Falls, Idaho, November 1, 2014.

19.4.7.6 Transportation

Impacts on the local transportation infrastructure as a result of proposed RPF construction, operations, and decommissioning are measured against the existing traffic conditions and the assumption that no new infrastructure would be developed. Materials for construction, operations, and decommissioning would be transported to and from the facility using the existing roadway networks.

19.4.7.6.1 Impacts of Construction

The majority of traffic related to the construction phase would travel to and from the site on U.S. Highway 63. Peak construction traffic volume is estimated to be 30 heavy vehicles (dump truck and deliveries) and 82 vehicles (pickup trucks and cars) traveling to and from the site daily in 2015. Except during the peak construction period, the worksite traffic volume is expected to be less and represents an estimated 0.5 percent increase over the existing traffic levels. As such, the impact on transportation due to construction is considered small.

19.4.7.6.2 Impacts of Operation

Traffic volume during facility operation is estimated to be one heavy vehicle and 98 vehicles (pickup trucks and cars) traveling to and from the site daily during operations. This estimate does not take into account potential carpooling and alternative transportation that some employees may use. The majority of this traffic would likely travel to the worksite on U.S. Highway 63 and represents an estimated 0.5 percent increase over the existing traffic levels. As such, the impact on transportation due to operations is considered small.

19.4.7.6.3 Impacts of Decommissioning

Following cessation of operations, the facility would be decommissioned. Decommissioning activities are considered similar to those of construction, with an estimated 30 heavy vehicles (waste trucks) and 81 vehicles (pickup trucks and cars) traveling to and from the site daily. This estimate represents a 0.5 percent increase over the existing traffic levels. As such, the impact on transportation due to decommissioning is considered small.

19.4.8 Human Health

This section describes public and occupational health impacts from both nonradiological and radiological sources. Regulations for generating, managing, handling, storing, treating, protecting, and disposing of hazardous materials during construction, operation, and decommissioning are contained in Federal regulations. These regulations include compliance with provisions of the Clean Air Act, CWA, Atomic Energy Act, and RCRA, among others.

19.4.8.1 Nonradiological Impacts

The following sections discuss the potential nonradiological public and occupational hazards and impacts for proposed RPF construction, operation, and decommissioning. Nonradiological hazards/impacts are associated with emissions, discharges, and waste from processes within the facility and with accidental spills/releases. Nonradioactive/hazardous materials encountered during construction, operation, and decommissioning of the facility include chemicals, wastes (solid and liquid), discharges, and air emissions. These materials would be managed in accordance with applicable Federal, State, and local laws and regulations, and applicable permit requirements.

19.4.8.1.1 Nonradiological Impacts During Construction

Construction of the proposed RPF would include potential hazards to workers typical of any construction site. Slips, trips and falls, heavy lifting, moving machinery, excessive noise, sharp objects, environmental hazards, and other safety hazards would be encountered by workers while on the RPF site. Proper procedures, BMPs, and access control would be employed to promote worker safety and reduce the likelihood of worker injury during construction.

Chemicals, hazardous liquids, and gases may also be encountered during construction. Compressed gases, oxidizers, flammable liquids, and gases are expected to be onsite during construction activities. Access controls, proper PPE and other typical construction practices would be used to ensure safe work conditions and reduce the likelihood of an accident or exposure to hazardous materials. In addition, construction equipment and tooling would be used in such a way to ensure compliance with OSHA requirements. In the event of a spill/accident during construction, the impact to human health and the environment would be mitigated by following an emergency response plan. The cumulative impacts to human health during construction are small.

19.4.8.1.2 Nonradiological Impacts During Operation

Potential nonradiological public and occupational hazards pertaining to operation of the proposed RPF are associated with emissions, discharges, and waste associated with processes within the facility, and with accidental spills/releases. Typical occupational hazards associated with work conducted in a process facility would be expected. These hazards include lighting, noise, repetitive motion, awkward posture, sharp objects, and slips, trips, and falls.

19.4.8.1.2.1 Chemical Sources

Chemical processes would be conducted throughout the proposed RPF, including inside the hot cell area, outside the hot cell, and in the laboratory and waste management areas. The anticipated list of chemicals, locations, and estimated quantities is presented in Table 19-68. The Table 19-68 values are intended to be bounding for accident analysis. Laboratory chemicals and janitorial supplies are also listed for completeness. These values may be updated as the process is revised.

19.4.8.1.2.2 Nonradiological Waste Management and Effluent Control Systems

Chemicals would be recycled and reused to minimize waste when applicable. Any wastes created by RPF processes would be handled by waste management processes and procedures, including sorting and segregating, volume reduction, containerization, and shipping to the appropriate off-site disposal or recycle facility. Worker exposure to wastes outside of the hot cell could result from accidents/spills during receiving, movement, routine operations, or disposal. Exposure to chemicals during laboratory processes can also occur. Waste management processes and procedures help to reduce the probability of an exposure. If an accident or spill occurs, emergency response plans would mitigate the effects of the accident or spill. Waste from the accident or spill would be managed according to the facility hazardous waste management plan.

19.4.8.1.2.3 Liquid Waste Management

Liquid wastes produced at the proposed RPF as a result of routine activities or accidents/spills would be sampled and treated as necessary. Wastes that do not meet the local municipal wastewater treatment standards would be containerized and disposed of following proper procedures to ensure worker safety and compliance with applicable disposal requirements. Floor and sink drains would only be used for sanitary purposes. Where applicable, containerized liquid waste, sumps, and traps would be sampled and treated (if possible) before release.

Table 19-68. Chemical Inventory for the Radioisotope Production Facility

Chemical	Quantity		Location	Physical form	Concentration (if applicable)
Nitric acid (HNO_3)	100,000 L/yr	26,420 gal/yr	Chemical make-up room/laboratory	Liquid	10.4 M (50 wt%)
Hydrogen peroxide (H_2O_2)	500 L	132 gal	Chemical make-up room/laboratory	Liquid	10.4 M (30 wt%)
Ammonium hydroxide (NH_4OH)	100 L	26.4 gal	Chemical make-up room	Liquid	15.7 M (62 wt%)
Ammonia	100 kg	220 lb	Chemical make-up room	Gas	
Carbon dioxide	200 kg	441 lb	Chemical make-up room	Gas	
Oxygen	100 kg	220 lb	Chemical make-up room/laboratory	Gas	
Nitrogen	1,800 kg	4,000 lb	Chemical make-up room/laboratory	Gas	
Sulfamic acid (HSO_3NH_2)	20.8 kg/yr	45.8 lb/yr	Chemical make-up room	Solid	
Sodium hydroxide (NaOH)	70,000 L/yr	18,490 gal/yr	Chemical make-up room	Liquid	19 M (50 wt%)
Reductant ($Fe(SO_3NH_2)_2/HSO_3NH_2$	230 L/yr	507 gal/yr	Chemical make-up room/waste management area	Liquid	
Sodium hypochlorite (NaOCl)	1 L	0.26 gal	Chemical make-up room	Liquid	2 M
Amberlite LA-2 (or other secondary amine)	25 kg	55 lb	Chemical make-up room/laboratory	Liquid	
Diethylbenzene	50 kg	110 lb	Chemical make-up room/laboratory	Liquid	
Sorbent	10,000 kg	22,046 lb	Chemical make-up room/laboratory/ waste management area	Solid	
Solvent	200 L	53 gal	Chemical make-up room/laboratory	Liquid	
Hexamethylenetetramine $(CH_2)_6N_4$	200 kg	441 lb	Chemical make-up room	Solid	
Urea ($Co(NH_2)_2$)	100 kg	220 lb	chemical make-up room	Solid	
Silicone oil	100 L	26 gal	Chemical make-up room	Liquid	
General laboratory supplies	Nominal		Laboratory	Solids/ liquids/gas	
General custodial supplies	Nominal		Janitor closet	Liquids/ solids	

19.4.8.1.2.4 Solid Waste Management

Solid wastes are expected to be generated during routine operation of the proposed RPF. This waste is typical for a production facility, including wood, metal, plastics, wires and piping, office supply waste, packaging waste, batteries, solidified oil/used solvents, and liquid waste.

These wastes would be containerized and disposed of following proper waste management procedures, including a recycling and reuse plan and waste reduction practices. All hazardous waste would be handled in accordance with applicable regulations (e.g., RCRA, Missouri Hazardous Waste Management Law).

19.4.8.1.2.5 Gaseous Wastes

The proposed RPF would generate gaseous effluents resulting from process operations and the ventilation of operating areas. Gaseous effluent from ventilation of operating areas would include a cascading pressure zone ventilation control system. This system would draw air from the cleanest areas of the facility to the most contaminated. Standard offgas treatments would be performed using two-stage HEPA filtration and activated carbon prior to the release stack(s). Stack sampling and monitoring would occur to establish compliance with NESHAP requirements and applicable State law. The cascading zones are described in Section 19.2.3.2.12.

19.4.8.1.2.6 Nonradiological Effluent Release

Liquid waste effluents meeting municipal treatment standards would be discharged to the municipal sewer. Liquid wastes that do not meet the municipal treatment standards would be containerized, volume reduced, neutralized, solidified, and shipped to an appropriate disposal facility.

Nonradioactive solid wastes (e.g., office waste, recyclables) would be collected, temporarily stored, and disposed of or recycled locally. Scrap metal, universal wastes (i.e., Federally designated universal waste includes batteries, pesticides, mercury-containing equipment, and bulbs [lamps]), used oil, and antifreeze would be collected, stored, and recycled or recovered at an off-site permitted recycling or recovery facility, as appropriate.

All the gaseous effluents from the RPF would be filtered and vented to the atmosphere through one of the three main stacks. These stacks would be equipped with air monitors/samplers to ensure compliance with applicable regulations (e.g., NESHAP, Missouri Air Conservation Law). Impacts of gaseous effluents are discussed in detail in Section 19.4.2.1.

Effluent monitoring and sampling/control systems would be used to detected and mitigate the possible releases of air emissions outside the facility. Impacts from nonradiological air emissions during normal operations are discussed in Section 19.4.2.1.2.

Most chemicals would be stored in tanks and piping or in controlled access storage. Bulk chemical quantities would be limited to a four-week supply. Table 19-68 lists the estimated chemical inventory at any given time for the RPF. The general public would not be allowed access to the RPF site. As a result, the public would not have direct contact with chemicals at the RPF. Therefore, potential air emissions effects to the public are limited to indirect impacts.

Quantitative analyses for nonradiological impacts as a result of credible accident scenarios are discussed in Chapter 13.

Control systems would be used to mitigate risks and control exposure of the public to nonradiological constituents during accidents. Spill prevention/mitigation procedures, air emission controls, liquid effluent sampling, and treatment and monitoring processes, along with emergency response plans, would be in place as appropriate to ensure that the exposure to the public is in compliance with applicable regulations. Therefore, cumulative impacts from nonradiological sources to human health are small.

19.4.8.1.2.7 Physical Occupational Hazards

Exposure characteristics of the workforce for nonradiological hazards would be defined when the operating strategies are finalized. No indirect impacts (offsite) are identified. General types of occupational physical hazards that may be present at the proposed RPF include lighting, noise, repetitive motion, awkward posture, sharp objects, and slips, trips, and falls.

Occupational physical hazards would be addressed and reduced or eliminated through implementation of administrative controls, safety practices, training, and control measures. In summary, occupational hazards would be managed and minimized by compliance with OSHA regulations, and, therefore, impacts from physical occupational hazards are considered small.

19.4.8.1.2.8 Nonradiological Exposure to the Workforce

The majority of process chemicals used is in liquid form and would be contained in tanks and pipes. Most processes involving chemicals would occur in hot cells, limiting workforce exposure. The proposed RPF would be designed and practices would be applied to keep air contaminants below the limits in 29 CFR 1910.1000, "Air Contaminants." The occupational hazards would be managed and minimized by compliance with OSHA regulations. The impacts from chemical occupational hazards are small.

19.4.8.1.3 Nonradiological Impacts during Decommissioning

Impacts associated with decommissioning activities would be similar to impacts associated with construction (e.g., heavy equipment, noise, slips, trips, and falls). An additional hazard encountered during decommissioning may be exposure to a legacy chemical, caused by an unknown spill or leak. In such instances, these hazards would be addressed using work control practices to minimize impacts. The cumulative impacts to human health during decommissioning are small.

19.4.8.1.4 Nonradiological Environmental Monitoring Program

Applicable regulations and attending administrative codes that prescribe monitoring requirements may include those associated with emergency management, environmental health, drinking water, water and sewage, pollution discharge, air pollution, hazardous waste management, and remedial action. Sampling and monitoring programs would be established to ensure that requirements of the Federal CWA, the Missouri Clean Water Law (i.e., Missouri Revised Statutes, Chapter 640, "Department of Natural Resources," and Chapter 644, "Water Pollution"), and other local requirements are met.

The RPF would generate gaseous effluents resulting from process operations, the ventilation of operating areas, and boiler emissions from facility buildings. Sampling/monitoring procedures would be implemented to ensure that the Federal Clean Air Act and the Missouri Air Conservation Law (Missouri Revised Statutes Chapter 643, "Air Conservation") requirements are met. Specific monitoring requirements in support of required local air permits would be determined through the permitting process.

19.4.8.1.5 Mitigation Measures

Mitigation measures, including workplace and environmental regulations, are used to ensure the protection of human health. NWMI is committed to BMPs during construction, operation, and decommissioning to minimize pollutant releases to on-site and off-site areas, guarantee delivery of all facility wastewater to the local municipal wastewater treatment facility, and impose air emission controls, as appropriate. Required permits would be obtained for effluents and emissions. Waste reduction practices, including recycling and waste minimization, are also employed.

19.4.8.2 Radiological Impacts

The proposed RPF may release small quantities of radionuclides to the environment. Gaseous effluent activity releases and liquid effluent activity releases would be managed to ensure compliance with applicable Federal, State, and local requirements.

19.4.8.2.1 Baseline Radiation Levels

Baseline radiation levels onsite and in the vicinity of the proposed RPF site are discussed in Section 19.4.8. There are no identified abnormal sources of radiation onsite or within the vicinity of the site that would cause radiation levels to be any higher than the expected natural background radiation level.

19.4.8.2.2 Radiological Impacts During Construction

The majority of the proposed RPF construction activities would not include any sources of radiological exposure. The impacts to human health from radiological sources during construction are small. Prior to initiating operation, radiological sources for analysis and LEU would be brought onsite to support initial startup and component testing. During this period, the potential impacts would be similar to those during operation and are discussed in the following sections.

19.4.8.2.3 Radiological Impacts During Operation

19.4.8.2.3.1 Location of and Types of Radiological Sources

Radioactive material would be located in the RPF hot cell area, irradiated target receipt and unloading area, target fabrication area, and waste management areas. The radioactive liquid effluent and radioactive gas would be contained within process waste management systems and the offgas systems.

19.4.8.2.3.2 Dose Rates

Direct dose to a member of the public at the fence line would be due to gamma radiation penetrating the walls of the production facility and the waste staging and shipping area. The facility and facility systems would be designed to ensure that any dose at the fence line would be below applicable limits.

19.4.8.2.3.3 Dose at the Site Boundary

As a result of site shielding design, the direct dose outside of the buildings would be small and decreases with increasing distance. For this analysis, the site boundary is the facility fence line. The fence line is located at an appreciable distance from the sources of radiation (production facility hot cell and the waste staging area). Therefore, the dose would be negligible at the fence line, and the impacts to human health are small.

The proposed RPF would be designed such that the radiological impacts to any individual would be below applicable limits. Accident scenarios presented in Chapter 13 detail the initiating event, accident evolution, and the final consequences. The impacts to human health and the environment as a result of an accident involving radiological materials would be small.

19.4.8.2.3.4 Annual Dose to the Maximally Exposed Worker

Administrative dose limits are occupational radiation exposure limits that radiation workers at the RPF would not exceed without prior management approval. Administrative controls would be used to ensure that workers do not receive dose above the regulatory reference.

19.4.8.2.3.5 Dose Rates from Transportation Activities

The radiation dose to the public due to the transport of radioactive waste (considered an indirect effect) is discussed in Section 19.4.10. All shipments made to and from the proposed RPF would be in compliance with applicable DOT regulations. As such, the dose limit for transport of radioactive material is 200 milliroentgen/hr (mR/hr) on contact, and 10 mR/hr at 1 m. In addition to these requirements, individual cask and container requirements may dictate a smaller allowable dose. Impacts to the public as a result of transporting radioactive material to and from the RPF are small.

The dose to the public and to the workforce resulting from transportation activities is discussed in Section 19.4.10. Under normal operating conditions, the greatest radiological impact to the workforce is anticipated to be during transportation activities. Transportation workers may receive a larger dose. In compliance with DOT and NRC requirements, the transport of radioactive material would be conducted using approved radiation control procedures that are based on ALARA principles. Therefore, the cumulative impacts resulting from transporting nuclear material from the addition of the RPF are small.

19.4.8.2.3.6 Radiation Exposure Mitigation Measures

Occupational and public exposures due to routine operations at the RPF would be ALARA. This exposure minimization goal would be met through both engineered and administrative controls.

Engineered controls – The facility would employ the following engineered controls to minimize radiation exposure to the public and workers:

- Radiation source identification
- Shielding around radiation sources
- Ventilation control
- Access control to radiation areas
- Contamination control
- Remote operation
- Waste minimization
- Administrative controls

Administrative controls – To minimize radiation exposure to the public and workers, the facility would employ administrative controls consisting of written procedures, policies, and employee training in the following subject areas:

- General environmental activities, including hazards associated with the facility
- Waste minimization requirements and goals
- Radiation safety, including workforce protection
- ALARA principles
- Specific environmental issues and responsible environmental stewardship
- Continual improvement
- Regulation compliance

19.4.8.2.4 Characteristics of Radiological Sources and Effluents

19.4.8.2.4.1 Gaseous Sources of Radioactive Material

Radioactive gaseous effluents produced in the proposed RPF during normal operations would consist of offgas from hot cell processes (i.e., processing of irradiated targets, recovery of LEU from processing activities, and recycling of recovered uranium for target fabrication). All gaseous effluents released from the RPF would be combined and released through three vent stacks. As stated in Section 19.4.2.1.2.3, all iodine fission products would be removed using absorption methods. Fission product gases such as Xe and Kr would be removed using gas trapping to allow decay. The resulting release would be maintained until levels are less than those defined in Table 2 in 10 CFR 20.

19.4.8.2.4.2 Liquid Sources of Radioactive Material

Liquid waste generated during process operations would be recycled and reused, if practicable. As discussed in Section 19.2.3.1.5, liquid waste would be treated in the aqueous waste handling system. Liquid waste would be treated and solidified into a solid waste form suitable for off-site disposal. No radioactive liquid sources of radioactive material would be released to the environment as a result of normal operating conditions.

19.4.8.2.4.3 Solidified Sources of Radioactive Material

Solid radioactive waste would be located in either the hot cell/target fabrication area or the waste management area.

19.4.8.3 Radiological Impacts During Decommissioning

The potential impacts from radiological material associated with decommissioning activities are from residual contamination in the hot cell and process areas. Proper radiation protection measures would be followed for all decontamination operations. During shutdown operations, most areas would be decontaminated as part of cell cleanout. Piping and vessels would be decontaminated, rinsed, and sampled to ensure that the removal of radioactive material has been achieved. In the event that a vessel/area cannot be adequately decontaminated, a fixative would be applied to prevent the spread of contamination.

When the remaining contamination has been immobilized, items would be sized and placed into the appropriate containers and disposed of following applicable regulations. In all activities, proper care, including ALARA practices, would be followed to limit exposure to workers or the public. The cumulative impact to human health during decommissioning is small.

19.4.8.4 Radiological Monitoring Program

In addition to the nonradiological monitoring program, the radiological monitoring program would include effluent monitoring and environmental monitoring.

19.4.8.4.1 Radiological Effluent Monitoring

The NWMI Radiological Effluent Monitoring Program identifies and quantifies principal radionuclides in effluents (Regulatory Position C.1 of NRC Regulatory Guide 1.21, *Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste* [NRC, 2009a]). This program would be used to verify that the RPF is performing as expected and within its design parameters so that doses to individual members of the public remain within the limits established in 10 CFR 20.1301 and doses due to airborne emissions meet the ALARA requirement of 10 CFR 20.1101(d) as required by Regulatory Guide 4.20, *Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees other than Power Reactors* (NRC, 2012b). All effluent pathways that could be a significant release pathway for radioactive material from the RPF include radiological effluent monitoring.

19.4.8.4.2 Gaseous Monitoring

19.4.8.4.2.1 Gaseous Effluent Monitoring

All gaseous effluents from the RPF would be released through three vent stacks (Zone I, Zone II/III, and the laboratory). Each exhaust system would have a separate stack, with the exception of the process offgas subsystem, which would merge with the Zone I exhaust stream of the HEPA filter train. Each exhaust filter train would consist of pre-filters, two stages of HEPA filters, carbon absorbers, and isolation dampers. Exhaust ducts upstream of the filter trains would be round to minimize areas where contamination can accumulate and sized to minimize particulate settling in the duct. No monitoring would occur for the HVAC and process steam boiler stacks.

The Zone I exhaust stack would service the hot cell, waste loading area, target fabrication enclosures, and process offgas system. HEPA filters would be included in both the inlet and outlet ducts. The outlet HEPA filters would minimize the spread of contamination from the hot cell into the ductwork leading to the exhaust filter train. The inlet HEPA filters would prevent contamination spread in the event of an upset condition. Zone II/III exhaust would service portions of the target fabrication systems, laboratory, uranium storage, truck bay, mechanical, supply rooms, corridor and airlocks, and general occupational areas of the facility. The laboratory exhaust system would handle exhaust air from fume hoods and gloveboxes located in the laboratory area.

The airborne effluent exhaust from the vent stacks is expected to contain measurable quantities of noble gas radioactivity (i.e., Xe and Kr). Radioactive iodine, radioactive particulates, and tritium could also be present in the airborne effluent exhaust. Due to the expectation of having measurable quantities of radioactivity in the airborne effluent and since malfunction of the exhaust carbon filtration system could result in a change in iodine radioactivity releases, the combined exhaust in the vent stacks would be continuously monitored for gross gamma radioactivity using an off-line gas monitor. Additionally, grab sampling provisions would be available for routine collection and analysis of gas, particulate, iodine, and tritium samples from the combined exhaust in the vent stacks, to (1) identify radionuclides, (2) identify relative concentrations of radionuclides in the airborne effluent, and (3) quantify radionuclide releases.

19.4.8.4.2.2 Liquid Effluent Monitoring

The proposed RPF is designed to have zero liquid discharge from the radiologically controlled area, and there would be no release of water from the facility to the adjacent environment that would affect surface water. As such, there are no defined liquid effluent release pathways from the radiologically controlled area and no requirement for radiation monitoring of liquid effluent pathways.

19.4.8.4.3 Radiological Environmental Monitoring

The requirement to have a radiological environmental monitoring program is documented in 10 CFR 20.1302, "Compliance with Dose Limits for Individual Members of the Public." The radiological environmental monitoring program is used to verify (1) the effectiveness of plant measures that are used to control the release of radioactive material, and (2) that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected based on effluent measurements and modeling of the environmental exposure pathways. Methods for establishing and conducting environmental monitoring are provided in Regulatory Guide 4.1, *Radiological Environmental Monitoring for Nuclear Power Plants* (NRC, 2009b). Regulatory Guide 4.1 refers to NUREG-1301, *Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors*, for detailed guidance on conducting effluent and environmental monitoring. Although Regulatory Guide 4.1 (NRC, 2009b) and NUREG-1301 are written for nuclear power plants, due to the similarities between airborne releases of radioactivity from nuclear power plants and those released from the RPF, guidance provided in Regulatory Guide 4.1 and NUREG-1301 was considered when developing radiological environmental monitoring for the RPF. Specifically, guidance provided in Figure 1 of Regulatory Guide 4.1 and Table 3.12-1 of NUREG-1301 was considered when determining which exposure pathways to sample, sample locations, types of samples, and sample frequencies for the RPF.

The following radiation exposure pathways are considered for monitoring under the NWMI radiological environmental monitoring program:

- Waterborne exposure pathway
- Direct radiation exposure pathway monitoring using TLDs
- Airborne exposure pathway monitored using continuous air samples
- Ingestion exposure pathway

19.4.8.4.3.1 Waterborne Exposure Pathway Monitoring

The proposed RPF is designed to have zero liquid discharge from the radiologically controlled area, and there would be no release of water from the facility to the adjacent environment that would affect surface water (e.g., Gans Creek). As such, surface water sampling is not included in the radiological monitoring plan. Similarly, aquatic life in the rivers is not expected to accumulate detectable levels of radioactivity, and sampling of fish or other aquatic creatures for the ingestion pathway is not included in the radiological environmental monitoring plan.

The groundwater aquifer beneath the proposed RPF site is the Mississippian aquifer (also referred to as the Kimmswick-Potosi aquifer), which is discussed in detail in Section 19.3.4.2. There are no defined liquid effluent release pathways, and the groundwater is not expected to be contaminated due to operation of the RPF. Therefore, groundwater sampling is not included in the radiological environmental monitoring plan.

19.4.8.4.3.2 Direct Exposure Pathway Monitoring

TLDs provide measurements of the direct radiation from radioactive materials located at the RPF and from radioactivity in airborne effluent and deposition of airborne radioactivity onto the ground.

NUREG-1301 recommends 40 TLD locations but can be reduced based on geographical limitations. The TLD locations would consist of an inner ring and outer ring of TLDs, with one TLD located in each ring at each of the 16 meteorological sectors (i.e., a total of 32 TLDs) and the remainder located at special interest areas. NUREG-1301 also provides for at least one TLD to be located a significant distance from the facility as a control station to measure background radiation dose.

At the RPF, six TLDs would be located outside at entry points to the building where personnel may congregate or spend time outside of the RPF building. An additional TLD would be located on the outside wall near the target fabrication area of the building to evaluate direct radiation from the hot cells and waste management area. The location of the on-site TLDs is shown in Figure 19-46.

TLDs would also be located at the site boundary (the perimeter of the lot) to evaluate the direct radiation dose. Sixteen TLDs would be placed on the lot line, with a TLD placed at all four corners of Lot 15 and the remaining TLDs placed at approximately equal distances from each other. The sixteen TLDs would provide adequate coverage to ensure that direct doses to neighboring facilities on adjoining lots can be monitored and evaluated. The location of the perimeter TLDs is shown in Figure 19-46.

An additional TLD would serve as a control and would be located offsite at a significant distance from the facility such that it represents a background dose. One TLD location would be provided with two TLDs so that data quality can be determined.

Figure 19-46. Location of On-site Environmental Thermoluminescent Dosimeters and Continuous Air Monitors

19.4.8.4.3.3 Airborne Exposure Pathway Monitoring

Airborne effluent releases from the RPF contribute to off-site doses. The airborne effluent exhaust from the vent stacks is expected to contain measurable quantities of noble gas radioactivity (e.g., Xe and Kr). Radioactive iodine, radioactive particulates, and tritium could also be present in the airborne effluent exhaust. However, most of the off-site exposure due to airborne effluent releases is associated with noble gas and radioactive iodine releases.

Environmental airborne sampling is performed to identify and quantify particulates and radioactive iodine in airborne effluents. Regulatory Position C.3.b of Regulatory Guide 4.1 (NRC, 2009b) indicates that airborne sampling should always be included in the environmental monitoring programs for nuclear power plants. Since the RPF includes airborne effluent releases, and radioactivity in the airborne effluent can result in measurable off-site doses, the radiological environmental monitoring program includes airborne sampling.

The guidance provided in Table 3.12-1 of NUREG-1301 is used to establish locations for airborne sample acquisition, sampling frequency, and type of sample analysis. Continuous air sample locations are specified in accordance with the guidance provided in Table 3.12-1 of NUREG-1301. The continuous air monitors (CAM) that are used to obtain continuous air samples include a radioiodine canister for weekly ^{131}I analysis, and a particulate sampler that is analyzed for gross beta activity and for quarterly isotopic analysis.

Four CAM locations would be located near the facility fence line, with one CAM being located in the direction of the prevailing wind (e.g., north-northwest) and the other three CAMs being located in the remaining cardinal directions (e.g., 90 degrees) from the first CAM location (i.e., west-southwest, south-southeast, and east-northeast). The CAM locations are shown in Figure 19-46.

An additional CAM would be located a sufficient distance from the RPF, in the least prevalent wind direction, to provide background information for airborne activity.

19.4.8.4.3.4 Ingestion Exposure Pathway Monitoring

NUREG-1301 suggests sampling of various biological media (biota monitoring) to indirectly assess doses due to particulate and iodine ingestion. This type of monitoring may include sampling of soils, broad-leafed plants, fish, meat, or milk. Considering that particulates and iodine radionuclides are not expected to be present in measurable quantities within the RPF airborne effluent releases, biota monitoring would not be performed. In the event that environmental airborne sample results indicate the presence of iodine or particulates in measurable quantities, or if the effluent monitor sample results indicate the presence of iodine or particulates in quantities large enough to result in a calculated dose at the property line that exceeds 10 percent of the dose constraint (i.e., 1 mrem/yr), a sampling campaign would be undertaken.

Milk is an important food product that contributes to the radiation dose to people, most notably from radioactive iodine. If biota sampling is determined to be required as a result of radioactive iodine and particulate activity measured during effluent monitoring or air sampling, milk sampling would be performed following the guidance provided in Table 3.12-1 of NUREG-1301 (e.g., sampling frequency and type of sample analysis). Cow and/or goat milk samples would be obtained from dairy production sites on a semi-monthly basis (when animals are on pasture) and on a monthly basis (at other times). A gamma isotopic analysis and ^{131}I analysis would be performed on the samples. Since milk samples are considered a better indicator of radioactive iodine in the environment than vegetation, as long as milk samples are obtained, vegetation sampling (e.g., broad leaf vegetation) is not expected to be included in the exposure pathway sampling, in accordance with guidance provided in Table 3.12-1 of NUREG-1301.

19.4.9 Waste Management

A detailed description of the sources, types, and approximate quantities of waste within the proposed RPF is provided in Section 19.2.7. This section also discusses the proposed waste management systems, including on-site treatment and waste minimization approaches and the anticipated disposal locations. The facility waste types would be managed in accordance with applicable Federal, State, and local regulations. The direct and indirect impacts associated with the treatment and disposal of RPF-generated wastes are small.

19.4.10 Transportation

Materials to be transported to the proposed RPF include LEU, irradiated targets, commercial supplies/chemicals, and other industrial supplies to support the day-to-day operation of the facility. Materials transported from the facility would include ^{99}Mo product, unirradiated targets, and waste. Section 19.2.7 provides a description of the treatment of radioactive and nonradioactive waste prior to shipment. Section 19.2.8.2.1 provides a description of the waste packaging required for LEU, irradiated and unirradiated targets, and ^{99}Mo product.

19.4.10.1 Transportation Mode and Projected Distances

Descriptions of the modes of transportation and distances are provided in Section 19.2.8.2.2, along with the estimated distance to projected destinations. The following subsections provide specific information regarding the transport of LEU, irradiated and unirradiated targets, ^{99}Mo product commercial supplies/chemicals, and RPF-generated waste.

19.4.10.1.1 Fresh Low-Enriched Uranium

The fresh LEU would be transported by commercial carrier to the proposed RPF from the DOE Y-12 Program Office in Oak Ridge, Tennessee, approximately 953 km (592 mi) from the proposed RPF site. The transportation route includes one stop for fuel or other provisions.

19.4.10.1.2 Irradiated and Unirradiated Targets

Both unirradiated and irradiated targets would be sent from the three reactor facilities to the proposed RPF by commercial carrier using a commercial cask, certified by the NRC, on public roads. The routes are:

- RPF to MURR in Columbia, Missouri – Approximately 9 km (6 mi) with no stops
- RPF to OSTR in Corvallis, Oregon – Approximately 3,320 km (2,063 mi) with two stops each way
- RPF to third reactor – Approximately [Proprietary Information]

19.4.10.1.3 Molybdenum-99 Product

The ^{99}Mo product produced at the proposed RPF is assumed to be distributed to two vendors. One vendor, located in Hazelwood, Missouri, would require transport by commercial ground carrier from the RPF to the vendor facility, which is 181 km (112.5 mi) away. The ^{99}Mo product sent to the other vendor would be transported by commercial ground carrier to the Columbia Regional Airport, which is approximately 13 km (8 mi) from the RPF site. From the airport, the ^{99}Mo product would be transported by air carrier to Boston Logan International Airport. Exposure from ^{99}Mo to the general public during the flight is assumed to be negligible and was not calculated. The ^{99}Mo product is assumed to be transported by commercial ground carrier for a distance of 50 km (31 mi) from Boston Logan International Airport to the vendor in Billerica, Massachusetts. Approximately 50 percent of the ^{99}Mo product is assumed to be shipped to Hazelwood and 50 percent shipped to Billerica.

19.4.10.1.4 Spent Low-Enriched Uranium

The spent LEU would be transported approximately 1,345 km (836 mi) to the Savannah River Site in Aiken, South Carolina using an ES-3100 cask, or equivalent. The transportation route includes one stop for fuel or other provisions.

19.4.10.1.5 Commercial Supplies/Chemicals

Commercial supplies and chemicals would be transported by commercial carrier on public roadways in compliance with vendor requirements. There is no anticipated dose resulting from the transport of commercial supplies and chemicals.

19.4.10.1.6 Waste Transportation

Waste generated at the proposed RPF would be disposed in licensed facilities. Radioactive waste would be transported by truck to Waste Control Specialists (WCS) in Andrews, Texas. WCS is approximately 1,470 km (913 mi) from the RPF site. The transportation route includes one stop each way.

NWMI also incorporates a recycling program into general operations at the facility. This program includes arranging for recycle drop-off and pick-up of recyclable wastes. The recycling drop-off point is located approximately 6 km (4 mi) from the RPF site. Municipal waste would be disposed of at the local sanitary landfill, approximately 17.5 km (11 mi) from the facility.

19.4.10.1.7 Radioactive Waste Packaging

Radioactive waste generated at the proposed RPF would be treated and packaged as discussed in Section 19.2.7. Solid waste would include used components, equipment, and solidified liquid wastes. This material would be collected, stored at the facility to allow for radioactive decay, and then size-reduced and consolidated for shipment. Prior to shipment, all radioactive material would be packaged to meet DOT and NRC requirements for transporting radioactive materials.

19.4.10.2 Incident-Free Radiological Dose

Incident-free radiological doses are determined for members of the public and the transportation and handling workers involved in transporting the fresh LEU, irradiated and unirradiated targets, ^{99}Mo product, spent LEU, and radioactive wastes.

Calculation of the incident-free radiological doses is performed using the RADCAT/RADTRAN modeling code. The RADCAT/RADTRAN code calculates doses to workers and members of the public. For shipments by air, transport of the ^{99}Mo product from the proposed RPF to Columbia Regional Airport is modeled; ground transport from the RPF to Hazelwood, Missouri, is also modeled. As described below, transportation scenarios based on land routes are used to conservatively estimate the radiological doses resulting from radioactive material transport.

The highway route and distance traveled for a shipment from the proposed RPF to a destination facility were determined from route data from MapQuest[2] and applicable GIS data available from ArcGIS[3] software. Census data files were used to derive the population density along the route (USCB, 2010a), which is required for calculating the dose to members of the public. National Highway Planning Network data files were used to derive the vehicle density data required for the model (FHWA, 2013).

Regions containing segments of each transportation route are classified as rural, suburban, or urban, based on population. Population zones are based on the following specific population concentration ranges:

- Rural – Less than 54 persons/km^2 (139 persons/mi^2)
- Urban – Between 54 and 1,284 persons/km^2 (139 and 3,326 persons/mi^2)
- Suburban – Greater than 1,284 persons/km^2 (3,326 persons/mi^2)

Once data are gathered, the route segment categories, transportation information for each route, package shielding information, and radioactive characteristics for the constituents of each package would be loaded into the RADCAT interface and run with the RADTRAN computer model. The route information is listed in Table 19-69. The route segment information is summarized in Table 19-70 (EDF-3124-0010, *Radiological Dose Consequences Associated with Transportation of Materials for the Radioisotope Production Facility for Northwest Medical Isotopes*).

[2] MapQuest is a registered trademark of MapQuest, Inc., Denver, Colorado.
[3] ArcGIS is a trademark of Esri, Redlands, California.

Table 19-69. General Route Information

Destination	Length (km)	Length (mi)	Number of stops	Number trips annually
RPF to MURR	9.6	6	0	26
MURR to RPF	9.6	6	0	104
RPF to OSTR	3,320	2,063	2	8
OSTR to RPF	3,320	2,063	2	16
RPF to third reactor	[Proprietary Information]	[Proprietary Information]	[Proprietary Information]	8
Third reactor to RPF	[Proprietary Information]	[Proprietary Information]	[Proprietary Information]	16
DOE Y-12 Program Office (Oak Ridge, Tennessee to RPF)	953	592	1	2
RPF to WCS (Andrews, Texas)	1,469	913	1	200
RPF to distributor (Hazelwood, Missouri)	181	113	0	52
RPF to distributor via the Columbia Regional Airport	12.8	8	0	52
Boston Logan Airport to distributor (Billerica, Massachusetts)	50	31	0	52
RPF to DOE SRS (Aiken, South Carolina)	1,345	836	1	2

Source: EDF-3124-0010, 2015, *Radiological Dose Consequences Associated with Transportation of Materials for the Radioisotope Production Facility for Northwest Medical Isotopes*, Rev. 2, Portage, Inc., Idaho Falls, Idaho, January 4, 2015.

DOE = U.S. Department of Energy.
MURR = University of Missouri Research Reactor.
OSTR = Oregon State University TRIGA Reactor.
RPF = Radioisotope Production Facility.
SRS = Savannah River Site.
WCS = Waste Control Specialists.

Table 19-70. Route Segment Information

Destination	Segment	Length		Population density (persons/km^2)	Vehicle density (vehicles/hour)	[a]Percentage of total for each destination
		km	mi			
MURR	Urban	**0**	0	NA	NA	0
	Suburban	**9**	6	476	1,193	100
	Rural	0	0	NA	NA	0
OSTR	Urban	64	40	1,871	3,853	16
	Suburban	410	255	505	1,932	45
	Rural	2,847	1,769	13	830	39
Third Reactor	Urban	73	45	1,958	4,103	21
	Suburban	[Proprietary Information]	[Proprietary Information]	473	2,311	43
	Rural	[Proprietary Information]	[Proprietary Information]	10	938	36
DOE Y-12 Program Office (Oak Ridge Tennessee)	Urban	12	8	2,161	1,768	7
	Suburban	393	244	404	2,138	62
	Rural	548	341	24	1,216	31
WCS (Andrews, Texas)	Urban	27	17	1,716	1,716	13.5
	Suburban	269	167	1,464	417	43.5
	Rural	1,173	729	859	77	43
Hazelwood, Missouri	Urban	7	4	1,816	3,276	13
	Suburban	74	46	511	3,396	63
	Rural	100	62	16	2,348	24
Columbia Missouri Regional Airport	Urban	0	0	NA	NA	0
	Suburban	13	8	476	1,193	100
	Rural	0	0	NA	NA	0
Boston Logan International Airport to Billerica, Massachusetts	Urban	11	7	5,635	5,992	50
	Suburban	36	22	788	4,128	44
	Rural	3	2	57	449	6
Savannah River Site (Aiken, South Carolina)	Urban	47	29	2,126	6,416	22
	Suburban	592	368	513	3,561	65
	Rural	706	439	24	1,319	13

Source: EDF-3124-0010, 2015, *Radiological Dose Consequences Associated with Transportation of Materials for the Radioisotope Production Facility for Northwest Medical Isotopes*, Rev. 2, Portage, Inc., Idaho Falls, Idaho, January 4, 2015.

[a] Percentage of Geographical Information System census tracts for each destination.

DOE = U.S. Department of Energy.
MURR = University of Missouri Research Reactor.
NA = not applicable.
OSTR = Oregon State University TRIGA Reactor.
WCS = Waste Control Specialists.

19.4.10.2.1 Radiological Source Term

Radiological characteristics are derived from estimated source term data, and then evaluated from material balance calculations, product specification, and estimated waste calculations.

The radioactive characterization for each of the materials is presented in Table 19-71 through Table 19-76 (EDF-3124-0010). These numbers are preliminary and subject to change based on future data. Radionuclides less than 0.1 Ci were not listed for the irradiated target.

Table 19-71. Unirradiated Target Shipment Source Term

Radionuclide	MURR (Ci)	OSTR and Third Reactor (Ci)
^{232}U	[Proprietary Information]	[Proprietary Information]
^{234}U	[Proprietary Information]	[Proprietary Information]
^{235}U	[Proprietary Information]	[Proprietary Information]
^{236}U	[Proprietary Information]	[Proprietary Information]
^{238}U	[Proprietary Information]	[Proprietary Information]
^{60}Co	[Proprietary Information]	[Proprietary Information]
^{137}Cs	[Proprietary Information]	[Proprietary Information]
^{90}Sr	[Proprietary Information]	[Proprietary Information]
^{237}Np	[Proprietary Information]	[Proprietary Information]
Total	[Proprietary Information]	[Proprietary Information]

MURR = University of Missouri Research Reactor.
OSTR = Oregon State University TRIGA Reactor.

Table 19-72. Irradiated Targets for Oregon State University and Third Reactor Radiological Characteristics

Radionuclide	[a]Amount (Ci)	Radionuclide	[a]Amount (Ci)
^{85}Kr	[Proprietary Information]	^{129m}Te	[Proprietary Information]
^{89}Sr	[Proprietary Information]	^{131}I	[Proprietary Information]
^{90}Sr	[Proprietary Information]	^{132}Te	[Proprietary Information]
^{90}Y	[Proprietary Information]	^{133}Xe	[Proprietary Information]
^{91}Y	[Proprietary Information]	^{133m}Xe	[Proprietary Information]
^{95}Nb	[Proprietary Information]	^{137}Cs	[Proprietary Information]
^{95m}Nb	[Proprietary Information]	^{140}Ba	[Proprietary Information]
^{99}Mo	[Proprietary Information]	^{141}Ce	[Proprietary Information]
^{103}Ru	[Proprietary Information]	^{143}Pr	[Proprietary Information]
[b] ^{106}Rh	[Proprietary Information]	^{144}Ce	[Proprietary Information]
^{111}Ag	[Proprietary Information]	^{147}Nd	[Proprietary Information]
^{115m}Cd	[Proprietary Information]	^{147}Pm	[Proprietary Information]
^{123}Sn	[Proprietary Information]	^{151}Sm	[Proprietary Information]
^{125}Sn	[Proprietary Information]	^{155}Eu	[Proprietary Information]
^{125}Sb	[Proprietary Information]	^{156}Eu	[Proprietary Information]
^{126}Sb	[Proprietary Information]	^{234}U	[Proprietary Information]
^{127}Sb	[Proprietary Information]	^{237}U	[Proprietary Information]
^{127}Te	[Proprietary Information]	^{239}Np	[Proprietary Information]
^{127m}Te	[Proprietary Information]		

Source: EDF-3124-0010, 2015, *Radiological Dose Consequences Associated with Transportation of Materials for the Radioisotope Production Facility for Northwest Medical Isotopes*, Rev. 2, Portage, Inc., Idaho Falls, Idaho, January 4, 2015.

[a] Based on 30 targets per shipment at 8-hr end of bombardment.
[b] ^{106}Rh is not included in the nuclide library of RADTRAN. ^{106}Ru in secular equilibrium was used as a substitute.

Table 19-73. Irradiated Targets for University of Missouri Research Reactor Radiological Characteristics

Radionuclide	[a]Amount (Ci)	Radionuclide	[a]Amount (Ci)
^{239}Np	[Proprietary Information]	^{137}Cs	[Proprietary Information]
^{99}Mo	[Proprietary Information]	^{90}Sr	[Proprietary Information]
^{133}Xe	[Proprietary Information]	^{95m}Nb	[Proprietary Information]
^{132}Te	[Proprietary Information]	^{147}Pm	[Proprietary Information]
^{140}Ba	[Proprietary Information]	^{90}Y	[Proprietary Information]
^{143}Pr	[Proprietary Information]	^{127m}Te	[Proprietary Information]
^{131}I	[Proprietary Information]	^{85}Kr	[Proprietary Information]
^{141}Ce	[Proprietary Information]	^{126}Sb	[Proprietary Information]
^{147}Nd	[Proprietary Information]	^{125}Sb	[Proprietary Information]
^{91}Y	[Proprietary Information]	^{155}Eu	[Proprietary Information]
^{89}Sr	[Proprietary Information]	^{115m}Cd	[Proprietary Information]
^{103}Ru	[Proprietary Information]	^{151}Sm	[Proprietary Information]
^{133m}Xe	[Proprietary Information]	^{123}Sn	[Proprietary Information]
^{127}Sb	[Proprietary Information]	^{234}U	[Proprietary Information]
^{237}U	[Proprietary Information]	^{235}U	[Proprietary Information]
^{144}Ce	[Proprietary Information]	^{236}U	[Proprietary Information]
^{127}Te	[Proprietary Information]	^{237}Np	[Proprietary Information]
^{95}Nb	[Proprietary Information]	^{238}Np	[Proprietary Information]
^{129m}Te	[Proprietary Information]	^{238}Pu	[Proprietary Information]
^{111}Ag	[Proprietary Information]	^{238}U	[Proprietary Information]
^{106}Ru	[Proprietary Information]	^{239}Pu	[Proprietary Information]
^{156}Eu	[Proprietary Information]	^{240}Pu	[Proprietary Information]
^{125}Sn	[Proprietary Information]	^{241}Pu	[Proprietary Information]

Source: EDF-3124-0010, 2015, *Radiological Dose Consequences Associated with Transportation of Materials for the Radioisotope Production Facility for Northwest Medical Isotopes*, Rev. 2, Portage, Inc., Idaho Falls, Idaho, January 4, 2015.

[a] Based on twelve (12) targets per shipment at 8-hr end of bombardment.

Table 19-74. Low-Enriched Uranium Radiological Characteristics

Radionuclide	[a,b]Amount (Ci)	Radionuclide	[a,b]Amount (Ci)
^{237}U	[Proprietary Information]	^{60}Co	[Proprietary Information]
^{234}U	[Proprietary Information]	^{137}Cs	[Proprietary Information]
^{235}U	[Proprietary Information]	^{90}Sr	[Proprietary Information]
^{236}U	[Proprietary Information]	^{237}Np	[Proprietary Information]
^{238}U	[Proprietary Information]	**Total**	[Proprietary Information]

Source: EDF-3124-0010, 2015, *Radiological Dose Consequences Associated with Transportation of Materials for the Radioisotope Production Facility for Northwest Medical Isotopes*, Rev. 2, Portage, Inc., Idaho Falls, Idaho, January 4, 2015.

[a] Spent LEU is assumed to have the same source term as fresh LEU.

[b] Based on 186.6 kg (411 lb) total uranium.

LEU = low-enriched uranium.

Table 19-75. Estimated Waste Radiological Characteristics

Radionuclide	[a]Amount (Ci)	Radionuclide	[a]Amount (Ci)
^{89}Sr	0.65	^{132}Te	1.8
^{90}Sr	0.0043	^{140}Ba	2.5
^{91}Y	0.56	^{141}Ce	0.93
^{95}Nb	0.078	^{143}Pr	1.9
^{95}Zr	0.56	^{144}Ce	0.11
^{103}Ru	0.41	^{147}Nd	0.78
^{127}Sb	0.071	^{239}Np	2.3
^{127}Te	0.066	^{239}Pu	3.45E-06

Source: EDF-3124-0010, 2015, *Radiological Dose Consequences Associated with Transportation of Materials for the Radioisotope Production Facility for Northwest Medical Isotopes*, Rev. 2, Portage, Inc., Idaho Falls, Idaho, January 4, 2015.

[a] Based on the quantities in Table 19-13.

Table 19-76. Molybdenum-99 Product Radiological Characteristics

Radionuclide	[a]Amount (Ci)	Radionuclide	[a]Amount (Ci)
^{99}Mo	[Proprietary Information]	^{112}Pd	[Proprietary Information]
^{131}I	[Proprietary Information]	^{89}Sr	[Proprietary Information]
^{103}Ru	[Proprietary Information]	^{90}Sr	[Proprietary Information]
^{132}Te	[Proprietary Information]	--	--

Source: EDF-3124-0010, 2015, *Radiological Dose Consequences Associated with Transportation of Materials for the Radioisotope Production Facility for Northwest Medical Isotopes*, Rev. 2, Portage, Inc., Idaho Falls, Idaho, January 4, 2015.

[a] Based on cask limit of 1,500 Ci ^{99}Mo.

The dose associated with the transport of LEU is much smaller than the dose associated with the transport of other radioactive materials. Doses associated with the transport of LEU metal are much smaller because of the infrequent shipments (two per year) and the low activity in each shipment.

Palladium-112 (^{112}Pd) was not in the available nuclide library in RADTRAN. This radionuclide is a minor contributor to the ^{99}Mo product source term. The dose consequence from ^{112}Pd was not calculated for the transportation scenarios presented. The exclusion of ^{112}Pd has a negligible impact to the ^{99}Mo product source term and derived dose consequence.

19.4.10.2.2 Dose Model Results

The annual incident-free radiological doses resulting from transport of radioactive materials from the RPF are summarized in this section. These doses are calculated assuming that the dose rates associated with the shipping containers are equal to typical dose rates, based on the DOT-approved dose limits of 10 mrem/hr at 2 m. The source term used for the contents of the packages was determined based on the numbers in Table 19-71 through Table 19-76. The dose to workers due to the handling and transport of radioactive material to and from the RPF is 0.366 person-sievert (Sv) (36.6 person-rem/yr).

The dose to the general public resulting from exposure during transportation, including stops/inspections, is 0.473 person-Sv (47.3 person-rem/yr). The total dose to the maximum exposed individual from exposure during transit is 3.93E-06 Sv (3.933E-04 rem) (EDF-3124-0010).

As indicated in Section 19.3.8.2.1, background radiation for the RPF site is approximately 228 mrem/yr. The population within a 5-mi radius of the facility is 33,966; therefore, the population dose in the vicinity of the RPF due to background radiation is approximately 77.44 person-Sv/yr (7,744 person-rem/yr). Compared to the background dose in the vicinity of the RPF, the effect of incident-free transportation is small.

Materials to be transported to the RPF include LEU, irradiated targets, process chemicals, and other industrial supplies to support the day-to-day operation of the facility. Materials transported from the RPF include ^{99}Mo product, targets, spent LEU, and waste. Section 19.2.7 provides a description of the treatment of radioactive and nonradioactive waste prior to shipment. Section 19.2.8.2.1 provides a description of the packaging associated LEU, targets, and ^{99}Mo product. Descriptions of the modes of transport and distances are provided in Section 19.2.8.2.2, along with the estimated distance to anticipated destinations.

19.4.11 Postulated Accidents

This section identifies the hazards associated with the facility, postulated accidents associated with the major systems of the RPF, the initiating events, the postulated accidents/hazards, and the impacts from postulated accidents that drive the design of the facility and systems. These accidents are referred to as design basis accidents (DBA). Detailed analyses of the radiological and nonradiological consequences from the maximum hypothetical accident (MHA) and subsequent accident categories are discussed in Chapter 13.

The hazards associated with the RPF include the following:

- Criticality
- Release of radioactive offgas or radioactive products
- Radioactive waste
- Hydrogen production by radiolytic decomposition of irradiated fissile solution
- Tank and equipment failure leading to a release of radiological or chemical materials
- Release during receiving of hazardous chemicals outside the facility

19.4.11.1 Accident Categories

According to NRC (2012a), the following accident categories are to be addressed for the RPF:

- MHA
- Criticality
- Loss of normal electrical power
- External events
- Mishandling or malfunction of equipment
- Operator error
- Facility fire
- Hazardous chemical release

All initiating events and scenarios applicable to the RPF are discussed in Chapter 13. Representative accident scenarios with bounding consequences for each of the initiating events/scenario categories are evaluated quantitatively in Chapter 13. The most bounding accident scenarios with respect to consequences for the facility are evaluated in the following subsections.

19.4.11.1.1 Maximum Hypothetical Accident

The RPF is being designed to withstand credible external events. Therefore, an internal accident releasing the largest possible quantity of radioactive material is considered to be the initiating event that would result in the maximum bounding radiological consequence. The MHA:

- Defines an event that results in radiological consequences that exceed those of any accident considered to be credible
- Bounds the radiological consequences of postulated DBA scenarios; does not need be a credible scenario but a failure assumed to establish an outer limit consequence
- Is based on events unique to the facility that hypothetically could result in a release of radioactive materials

The accident scenario identified as the MHA is initiated after the dissolver system has been running beyond its nominal target processing rate (12 MURR targets per week) for 12 weeks. This allows the iodine retention units (IRU) to accumulate an amount of iodine greater than during normal operation. Accident events might degrade the IRU, making it less efficient to capturing the fresh iodine during dissolution or generate a partial release of accumulated iodine. However, an accident that could release all of the accumulated iodine has not been identified.

As a conservative analysis, a combustion accident that releases all of the accumulated iodine as a gas was assumed to take place. As a result of the combustion, the entire inventory of iodine would also be released over a two-hour period directly to the 22.9 m (75-ft) stack and into the environment. The source term for the MHA scenario came from NWMI-2013-CALC-011, *Source Term Calculations*. No reduction from secondary filter systems was assumed. In addition, no plating or entrapment of any iodine was assumed.

Controls that mitigate the consequences of the MHA include:

- Hot cell containment area/shielding
- Radiation monitors
- Ventilation system cascading design and secondary iodine retention unit
- Design of the entire dissolution offgas system (e.g., chain of filters and retention systems running in parallel through a large network of piping)

- Sizing of the target dissolution system and batching of target dissolution process for eight targets

The evaluation of the inventory for the considered MHA is based on a set of limiting initial conditions that were designed to maximize the potential source term and bound the credible scenarios. These assumptions include:

- Estimating 12 MURR targets for the process batch upstream of the IRU system, which is beyond the process design capacity of eight MURR targets
- Maximum accumulation of iodine in the IRU based on the 12 targets
- Greater than expected release of material (e.g., entire inventory of iodine is assumed to be deposited on a single IRU, no plating out of iodine, or subsequent capture downstream of IRU).

The Radiological Safety Analysis Code (RSAC) system, RSAC Version 6.2, was used to model the dispersion resulting from the MHA. The following common parameters were used for all model runs:

- Mixing depth: 400 m (1,312 ft) (default)
- Air density: 1,250 g/m^3 (1.25 oz/ft^3) (sea level)
- Pasquill-Gifford σ (NRC Regulatory Guide 1.145, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants* [NRC, 1983])
- No plume rise (i.e., buoyancy or stack momentum effects)
- No plume depletion (wet or dry deposition)
- 2-hr release (constant release of all activity)
- 2-hr exposure
- ICRP-30 inhalation model (ICRP-30, 1979)
- Finite cloud immersion model
- Breathing rate: 3.42E-4 m^3/second (sec) (1.2E-2 ft^3/sec)(ICRP-30 heavy activity)
- Respiratory fraction: 1.0

The results of the modeling show that for a 22.9 m (75-ft) stack with the release detailed above, the maximum dose received during a two-hour exposure by an individual would be 17.1 rem at a distance of 1,100 m. The dose results for the 12-target inventory are provided in Table 19-83.

The 8-hr and 16-hr decay inventories were used. Radionuclides not available in the RSAC library or noted as having an activity less than one atom were removed from the inventory in the RSAC model runs. The wind speed (m/s) and stability category were varied. The model was also run varying the inventory from 100 to 25 percent (EDF-3124-0003, *Preliminary Maximum Hypothetical Accident to Support the Northwest Medical Isotope Facility Environmental Report*). Table 19-83 provides the results.

Table 19-83. MHA Dose Analysis Results

Distance		F Class (2 m/sec [6.56 ft/s])	
(m)	(ft)	Sv	rem
100	328	4.52E-03	4.52E-01
200	656	4.36E-03	4.36E-01
300	984	4.99E-03	4.99E-01
400	1312	1.59E-02	1.59E+00
500	1640	4.46E-02	4.46E+00
600	1968	8.15E-02	8.15E+00
700	2296	1.16E-01	1.16E+01
800	2625	1.40E-01	1.40E+01
1000	3280	1.67E-01	1.67E+01
1100	3609	1.71E-01	1.71E+01
1200	3937	1.70E-01	1.70E+01
1300	4265	1.67E-01	1.67E+01
1400	4593	1.62E-01	1.62E+01
1500	4921	1.56E-01	1.56E+01
1600	5249	1.49E-01	1.49E+01
1700	5577	1.43E-01	1.43E+01

Source: EDF-3124-0003, 2015, *Preliminary Maximum Hypothetical Accident to Support the Northwest Medical Isotope Facility Environmental Report*, Rev. 1, Portage, Inc., Idaho Falls, Idaho, February 5, 2015.

19.4.11.1.2 Criticality

Inadvertent criticality is prevented and/or mitigated by the design of criticality safe geometry tanks, piping, drains, and sumps in the hot cell areas. Administrative controls (e.g., batch sizing [mass] and time requirements) on system operations are implemented to prevent the occurrence of a criticality. Tanks or components containing significant quantities of fissile material are seismically qualified to survive seismic events.

Any potential releases of radioactive material from a criticality are mitigated by the offgas system, the ventilation system, and the passive confinement provided by the hot cell and the facility structure. The criticality event would result in a singular pulse or series of short duration pulses, followed by a dispersion of the fissile material. A criticality would generate source terms and doses that are equivalent to or less than the MHA discussed in Section 19.4.11.1.1.

19.4.11.1.3 Loss of Electrical Power

A loss of power could lead to initiating events that result in various accident conditions, including the loss of ventilation and offgas system. Loss of ventilation and offgas systems could lead to deflagration from the accumulation of hydrogen gas in the offgas system, in the hot cell area, or in smaller vessels/piping. Hydrogen accumulation in the offgas system and the hot cell area is not expected to exceed the lower explosive limit or lower flammability limit. In the event that accumulation occurs in a smaller vessel to a point above the lower explosive or lower flammability limits, and an ignition source is present, the deflagration event may occur. During this accident scenario, radioactive material is confined in the hot cell and ventilation system. The consequences of this scenario are bounded by the release of the entire contents of the dissolver during the MHA.

19.4.11.1.4 External Events

The following potential external events have been identified as possible accident scenarios:

- Seismic event
- Tornado, high wind, or other natural phenomenon hazard
- External crash into the RPF

The facility structure, including the hot cell containment areas and critical process equipment, would be designed, as required by the results of the safety analysis, to provide appropriate levels of mitigation during these accident scenarios.

19.4.11.1.5 Mishandling or Malfunction of Equipment

Potential DBAs that could be initiated by mishandling or malfunction of equipment include:

- Failure of the offgas system
- Vessel or piping failure

The proposed RPF would be designed with multiple engineering features and controls to prevent or mitigate the potential consequences from mishandling or malfunctioning equipment. Critical equipment would be designed robustly with significant redundancy or fail-safe features to prevent or mitigate the consequences from these events. Consequences from these accident scenarios are bounded by the release of the entire contents of the dissolver, as discussed in the MHA.

19.4.11.1.6 Operator Error

In any process, operator error is considered probable. The proposed RPF and systems would be designed to minimize the need for operator inputs. Human factors would be considered when determining process steps, controls, and procedures used to define operations at the facility. Work controls would include independent checks and verifications when transitioning between steps, a mass balance tracking system, and batch-wise process flow controls to help eliminate the need for human judgment and interference with a system. When possible, engineered controls would be used to define process steps. This includes geometrically favorable configurations, small capacity tanks, bird-cages, or zone barriers. When necessary, administrative controls would be used to supplement engineered controls. Batch-wise process, zones, active inventory management for all fissile or hazardous material, and storage accountability controls would be used as administrative controls. The MHA could be initiated by operator error; however, all other postulated accidents that could happen within the hot cell or around the facility proper result in consequences that are bounded by the MHA.

19.4.11.1.7 Facility Fire

A fire in the proposed RPF is identified as a possible DBA. Events that could lead to a fire may be precipitated by failure of electrical or mechanical equipment or human error involving a loss of control of combustible materials or ignition sources. Facility fires are not expected to directly release significant amounts of radioactive material; however, fires can lead to the release of radioactive material where fire damage to process equipment results in a loss of confinement through damage to system integrity, spurious equipment operation, or loss of equipment control. Fire damage to equipment typically results from direct exposure of equipment to a fire or exposure of equipment to elevated temperatures caused by a fire. Widespread fire damage to process equipment that can lead to a radiological release most likely occurs inside a confined enclosure such as the hot cell or vessel. Small spaces also provide confinement of the products of combustion, which can develop into a damaging fire environment.

A damaging fire environment in the general area of the RPF is unlikely due to the large size of the area. Direct fire damage to key process equipment that could lead to a significant radiological release is not likely because redundant control or power circuits are separated by distance to prevent such damage from a single fire. Thus, the DBA is considered to be a fire in an enclosure that may develop into a damaging fire environment.

The design basis fire accident is postulated to occur in the hot cell where it would contribute to the release of the contents of the dissolver. Fire damage to the dissolver, associated valves, or process piping could lead to a release of contents of the dissolver into the hot cell area. Release of this material into the hot cell could lead to an airborne release of radiological material into the cell and ultimately migrate into the ventilation system. The potential release would be mitigated by design of the fire suppression system and the ventilation system. Mitigation would occur due to the activation of the fire suppression system and the isolation of affected parts of the ventilation system in response to a smoke alarm signal or detection of radioactive material by the radiation monitoring system. Activation of the fire suppression system would reduce or stop the spread of combustion. Isolation of the ventilation system would prevent significant release to the environment.

Radiological release of this DBA is bounded by the MHA and contained by the facility (i.e., hot cell) and ventilation system. The hot cell structure and ventilation systems are designed to withstand or contain fire strengths that are postulated for this event.

19.4.11.1.8 Hazardous Chemical Release

Consistent with NUREG/CR-6410, hazardous chemical releases considered for this ER are limited to those that can be released from the processing of licensed nuclear material or that have the potential for adversely affecting radiological safety. Other Federal and State agencies such as EPA and OSHA also regulate hazardous chemical management to protect facility workers and the general public from releases. The controls, programs, licenses, threshold quantities, and other aspects of Federal and State programs other than NRC would be considered during the consequence analysis. Where necessary to ensure that radiological safety is not adversely affected, engineering or administrative controls would be developed to eliminate or mitigate the chemical release and the postulated accident(s) and resultant controls, as discussed in Chapter 13. The effects of chemical releases will also be considered in the facility emergency response plan and operating procedures.

The consequences of chemical releases are evaluated using dispersion models and/or computer codes that conform to NUREG/CR-6410 methodologies. The ALOHA computer code was used to estimate the consequences from releases of certain chemicals currently anticipated to be present at the RPF. ALOHA is an atmospheric dispersion model used for evaluating releases of hazardous chemical vapors. The model does not monitor combinations or chemical reactions. Chemical reactions will be addressed in the safety analysis discussed in Chapter 13. The inventory values used in the ALOHA analysis are considered to be bounding conditions and may be refined during the development of the Final Safety Analysis (FSAR), as the process matures. Within the context of the preliminary safety analysis (PSAR), calculation of the exposure of the maximally exposed off-site individual (MOI) and nearest resident, and comparison to Protective Action Criteria (PAC) limits serve as a baseline to identify where additional controls should be considered (e.g., where the worker is subject to effects that hinder their ability to respond or where off-site response to a radiological emergency may be hindered by chemical effects).

In running the simulation model, no credit is taken for depletion or plate-out of chemicals within the RPF or during transport to the fence line or nearest population location. All dispersion calculations are performed assuming moderate wind conditions (i.e., Stability Class C) based on the average meteorological conditions presented in Section 19.3.2.1. The following environmental parameters were used:

- Wind speed is 14.25 km/hr (8.86 mi/hr)
- Wind direction is from due south (180°)
- Temperature is 23.9°C (75°F)
- Humidity is 70 percent

The location of the MOI is based on the general layout of the RPF, as shown in [Proprietary Information]

Figure 19-10. The distance from the facility to the boundary fence is estimated at 24 m (80 ft). The location of the nearest resident is based on Table 19-77. The nearest resident is 0.43 km (0.27 mi [285 ft]) to the south. The model is run such that the MOI and the resident are both in line with the direction of the wind. This provides a conservative bound for the exposure calculation.

Chemical concentrations were determined for a select list of chemicals from Table 19-68. Chemicals were selected based on availability in the ALOHA library and quantity. Chemical inventory and release concentrations for the MOI and nearest resident are presented in Table 19-77. In each case, the material at risk (MAR) represents the estimated maximum inventory of the chemical listed. Two different scenarios were used for the release, based on the physical form of the chemical. For liquid chemicals, the scenario is a breach in the tank resulting in an unconfined spill and subsequent evaporation. For gases, the scenario is an immediate release to the atmosphere from a ruptured tank. All scenarios were conducted for a 1-hr interval.

Table 19-77. Chemical Dose Analysis Results

Chemical name	MAR quantity		Physical form	PAC-2 limit	MOI result (80 ft)	Nearest resident (1,425 ft)
Nitric acid (HNO_3)	5,000 (L)	1,321 (gal)	liquid	24 (ppm)	1,200 (ppm)	19.1 (ppm)
Hydrogen peroxide (H_2O_2)	500 (L)	132 (gal)	liquid	50 (ppm)	1.74 (ppm)	0.963 (ppm)
Ammonia	100 (kg)	220 (lb)	gas	160 (ppm)	36,800 (ppm)	123 (ppm)
Carbon dioxide (CO_2)	200 (kg)	440 (lb)	gas	30,000 (ppm)	28,500 (ppm)	95.1 (ppm)
[a]Sodium hydroxide (NaOH)	1,900 (L)	502 (gal)	liquid	5 (ppm)	NA	NA

Source: EDF-3124-0002, 2014, *Chemical Hazard Analysis for Accidents Associated with the Radioisotope Production Facility for Northwest Medical Isotopes*, Rev. 0, Portage, Inc., Idaho Falls, Idaho, June 26, 2014.

[a] Sodium hydroxide was not analyzed, but based on the quantity, and the low PAC-2 limit, it is assumed to exceed the PAC-2 limit.

MAR = material at risk.
MOI = maximally exposed off-site individual.
NA = not applicable.
PAC = Protective Action Criteria.

The results for each chemical are compared to the values listed in the PAC for chemicals, including Acute Exposure Guideline Levels (AEGL), Emergency Response Planning Guidelines (ERPG), and Temporary Emergency Exposure Limits (TEEL) (DOE, 2012). The analysis indicates that some of the chemical exposures exceed PAC-2 limits. The PAC-2/EPRG-2 limit is the threshold below which it is believed that nearly all individuals exposed for up to 1 hr would not experience irreversible or other serious health effects or symptoms that could impair their ability to take protective actions. Accordingly, releases above the PAC-2/EPRG-2 limit will be evaluated, and additional controls will be developed. These requirements and controls will be are specifically identified in in the PSAR and subsequent FSAR.

19.4.11.2 Postulated Accident Impacts

The proposed RPF would be designed, constructed, and operated to ensure that the consequences of postulated accidents would comply with applicable regulations and standards, as discussed in other sections (e.g., Chapters 11 and 13 of the Construction Permit Application). Therefore, the postulated accident impacts associated with construction, operation, or decommissioning of the RPF would be small.

19.4.12 Environmental Justice

On February 11, 1994, President Clinton signed Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Executive Order 12898 directs Federal executive agencies to consider environmental justice under NEPA (42 U.S.C. § 4321 et seq.). This Executive Order ensures that minority and/or low-income populations do not bear a disproportionate share of adverse health or environmental consequences associated with the construction, operation, and decommissioning of the RPF.

19.4.12.1 Methodology

This section describes the minority population and household income distribution within the ROI, the 8 km (5.0-mi) area from the center point of the proposed safety-related area at the proposed RPF. The information includes estimates of the minority population and household income for the most recent (2010) census year, and projects that population for the following future years:

- Year submitting Construction Permit application (2015)
- Year submitting Operating License application (2016)
- Five years after submitting Construction Permit application (2020)
- Five years after submitting Operating License application (2021)
- Approximate expected end of Operating License period (2047)
- Five years after approximate expected end of Operating License period (2052)

Estimates and projections of minority and household income distribution around the proposed project site were divided into five distance bands —concentric circles at 0-1 km (0-0.6 mi), 1-2 km (0.6-1.2 mi), 2-4 km (1.2-2.5 mi), 4-6 km (2.5-3.7 mi), and 6-8 km (3.7-5.0 mi) from the center point of the RPF—and 16 directional sectors (with each direction sector centered on one of the 16 compass points) for a total of 80 population segments. For each segment formed by the distance bands and directional sectors, the minority and income distribution was estimated using 2010 Census data. The future minority and household income growth in each distance/direction segment was projected using specific growth rates that depend on whether the segment is located in Columbia or in Boone County.

The City of Columbia comprehensive land use plan, dated October 7, 2013 (City of Columbia, 2013c), presents projections on the future city population calculated using several possible population growth rates. The plan states that the Columbia Area Transportation Study Organization (CATSO) model projects a greater rate of population growth and is considered the most reasonable and conservative basis for estimating the city's future population. According to the plan, the CATSO model growth rate was calculated by obtaining historic population data and determining land use trends, which are then projected forward to estimate future growth. Based on these projections, the CATSO model estimated that the rate of population growth (growth rate) is 1.5 percent annually. This growth rate was used to project future populations for areas within the analysis area that are also within the Columbia city limits. The 2010 Census estimate of resident and transient populations in each distance/direction segment that is located partially or entirely within the city boundaries was increased by 1.5 percent each year from 2011 to 2050.

The Missouri Department of Administration (DOA) provides State and county population projections that were developed using the cohort-component method (DOA, 2008). The cohort-component method involves the review of recent historical patterns to determine age- and sex-specific rates of fertility, mortality, and migration. The DOA used the 2000 Census as a base for population counts. The base count is then advanced at five-year intervals to the year 2030 by using projected survival rates and net migration rates by age and sex. The DOA projections show that the population of Boone County is expected to increase by 7.9 percent for the five-year period from 2010–2015, by 7.2 percent from 2015–2020, by 6.2 percent from 2020–2025, and by 5.0 percent from 2025–2030. For each five-year period, the percent of growth was divided by five to give the estimated annual growth rate within that period. The annual growth rates were used to project future populations for the areas around the project site that are entirely outside the boundaries of City of Columbia. The estimated 2010 resident and transient population in each distance/direction segment that is located entirely outside of the city boundaries was increased by 1.58 percent each year from 2011–2015, by 1.44 percent from 2016–2020, by 1.24 percent from 2021–2025, and by 1.0 percent from 2026–2030. The growth rate, or 1.0 percent, was used for 2031–2050.

19.4.12.2 Minority Population

The 2010 Census race and ethnic minority data associated with the census block and tract areas were used to estimate the minority population within the 1 km (0.6-mi), 2 km (1.2-mi), 4 km (2.5-mi), 6 km (3.7-mi), and 8 km (5.0-mi) distance bands. As defined by the U.S. Census Bureau, ethnic minority populations are Asian Americans, Black or African Americans, Hispanic or Latino, Native Hawaiian or other Pacific Islanders, and Native Indian or Alaska Native. Total minority populations were estimated in each segment for each of the minority populations. For each segment formed by the distance bands and directional sectors, the percentage of each census tract land area that falls, either partially or entirely, within that segment was calculated using ESRI ArcMap 10. The equivalent proportion of each census tract's minority population was then assigned to that segment. If portions of two or more census tracts fall within the same segment, the proportional population estimates for the census tracts were summed to obtain the minority distribution estimate for that segment. This methodology and associated maps are presented in Section 19.2. The minority distribution estimate was then used to calculate the percentage of the resident population by race for each of the designated years. The percent of the resident population by race is based on the resident population estimate discussed in Section 19.3.7.1.2.

19.4.12.3 Household Income

The U.S. Census Bureau 2006–2010 American Community Survey estimate data and associated census tract and block data were used to determine the 2010 household income within the 1 km (0.6-mi), 2 km (1.2-mi), 4 km (2.5-mi), 6 km (3.7-mi), and 8 km (5.0-mi) distance bands (USCB, 2010d). The survey data estimates household income into 16 income levels, starting with those that earn less than $10,000/yr. The method for estimating household income within the distance bands is the same method used for determining the minority population.

19.4.12.4 Assessment of Disproportionate Impacts

Under current NRC staff guidance, a minority or low-income community is identified by comparing the percentage of the minority or low-income population in the impacted area to the percentage of the minority or low-income population in the county and the state. Significance is defined as when the percentage of either the minority or low-income population in the impacted area exceeds 20 percentage points of the state or the county. Significance is also considered if either the minority or low-income population percentage in the impacted area exceeds 50 percent of the total population (NRC, 2012c).

19.4.12.4.1 Minority Population

Table 19-78 provides the results of the analysis for minority populations. The minority population distribution is anticipated to increase at the same rate of the general population (1.5 percent annually) over the license period. The percentages of each minority category within the county and state are also provided as the basis for determining if any of the population groups meet the NRC criteria of significant. For the most part, the population within each segment block within the 8 km (5-mi) radius is within two percentage points of the state and county minority populations. In addition, none of the segment block minority populations exceed 50 percent.

Table 19-78. Percent Population Distribution by Race

Distance band	[a]Resident population	White	Hispanic or Latino	Black or African American	America n Indian and Alaska Native	Asian	Native Hawaiian/ Other Pacific Islander	Other races	Two or more races
0–1 km (0–0.6 mi)	221	81%	4%	9%	0%	3%	0%	0%	3%
1–2 km (0.6–1.2 mi)	2,004	81%	4%	9%	0%	3%	0%	0%	3%
2–4 km (1.2–2.5 mi)	7,608	81%	3%	8%	0%	5%	0%	0%	2%
4–6 km (2.5–3.7 mi)	18,205	83%	3%	7%	0%	5%	0%	0%	2%
6–8 km (3.7–5 mi)	23,143	79%	3%	10%	0%	6%	0%	0%	2%
Boone County	175,018	81%	3%	9%	0%	4%	0%	0%	3%
Missouri	6,444,660	81%	4%	11%	0%	2%	0%	0%	2%

Source: USCB, 2010c, "U.S. Census 2010," factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml#none, U.S. Census Bureau, Washington, D.C., accessed March 12, 2013.

[a] Population extrapolated to 2015.

19.4.12.4.2 Low Income Populations

Table 19-79 provides the results of the analysis for low income populations. The population distribution is anticipated to increase 1.5 percent annually over the license period.

Table 19-79. Estimated Household Income Within Various Distance Bands and Within State and County (2 pages)

	0–1 km (0–0.6 mi)	1–2 km (0.60–1.2 mi)	2 to 4 km (1.2–2.5 mi)	4 to 6 km (2.5–3.7 mi)	6 to 8 km (3.7–5.0 mi)	Boone County	Missouri
Total households	361	954	3,264	5,031	11,245	63,420	2,538,656
Less than $10,000	6.4%	8.0%	10.8%	16.1%	17.8%	9.6%	7.9%
$10,000 to $14,999	7.5%	8.2%	8.3%	7.3%	8.7%	6.0%	6.2%
$15,000 to $19,999	5.3%	5.3%	5.1%	5.6%	6.5%	4.9%	5.9%
$20,000 to $24,999	11.1%	11.8%	11.4%	9.9%	8.0%	7.1%	6.2%
$25,000 to $29,999	4.4%	4.9%	5.9%	7.2%	4.9%	5.4%	6.0%
$30,000 to $34,999	3.9%	4.8%	6.4%	6.1%	5.2%	5.7%	5.8%
$35,000 to $39,999	8.0%	7.5%	6.6%	5.5%	5.2%	5.4%	5.4%
$40,000 to $44,999	5.5%	5.3%	5.4%	5.2%	4.5%	5.3%	5.3%
$45,000 to $49,999	6.4%	5.2%	3.9%	2.9%	3.2%	4.1%	4.7%
$50,000 to $59,999	8.9%	9.1%	9.3%	8.0%	6.9%	8.4%	8.8%
$60,000 to $74,999	9.1%	8.6%	8.0%	7.6%	7.4%	10.7%	10.5%
$75,000 to $99,999	11.6%	10.5%	9.0%	8.3%	8.0%	11.5%	11.7%
$100,000 to $124,999	4.4%	3.8%	3.4%	3.8%	5.4%	6.8%	6.7%
$125,000 to $149,999	3.3%	2.7%	2.6%	2.7%	3.6%	3.7%	3.5%

Table 19-79. Estimated Household Income Within Various Distance Bands and Within State and County (2 pages)

	0–1 km (0–0.6 mi)	1–2 km (0.60–1.2 mi)	2 to 4 km (1.2–2.5 mi)	4 to 6 km (2.5–3.7 mi)	6 to 8 km (3.7–5.0 mi)	Boone County	Missouri
$150,000 to $199,999	2.5%	2.0%	1.9%	2.2%	2.9%	2.9%	3.0%
$200,000 or more	1.4%	2.1%	2.0%	1.5%	1.9%	2.6%	2.5%

USCB, 2010d, *2006-2010 American Community Survey. Household Income in the Past 12 Months (In 2010 Inflation-Adjusted Dollars)*, www.census.gov/acs/www/data_documentation/data_main, Table B1900, U.S. Census Bureau, Washington, D.C., accessed September 2013.

The percentages applicable to each income category within the county and state are also provided as the basis for determining if any of the population groups meet the NRC criteria of significant. For the most part, the low-income population within each segment block within the 8 km (5-mi) radius is within two percentage points of the state and county low-income populations. The "less than $10,000" income level in the segments from 4–8 km (2.5–5 mi) is higher than the state and county (8 to 9.9 percentage points), but below the significance criteria of 20 percentage points. In addition, none of the segment block low-income populations exceed 50 percent.

19.4.13 Connected Actions – University Reactor Network

Irradiation of LEU targets at the university research reactors is key component of the NWMI process. For a specific university reactor to irradiate LEU targets for NWMI, an amendment to the university's 10 CFR 50 NRC license and an analysis of site-specific environmental impacts related to such an amendment would be required. For the purposes of complying with NEPA's requirements to analyze connected actions, the following sections analyze the operations at each of the proposed university reactors.

19.4.13.1 Irradiation Services

Irradiation of LEU targets at the university research reactors is a key component of the NWMI process. For a university research reactor to irradiate LEU targets for NWMI, an amendment to the university's 10 CFR 50 NRC license and an analysis of site-specific environmental impacts related to such an amendment would be required. For the purposes of complying with NEPA requirements to analyze connected actions, the following sections analyze the operations at each of the proposed university reactors.

19.4.13.1.1 University of Missouri Research Reactor

Facility Modification

A number of facility modifications are anticipated to be required to support handling and irradiating LEU targets at MURR. The most significant modifications that will be performed, either via license amendment or by performing a screen or evaluation per 10 CFR 50.59, "Changes, Tests, and Experiments," include:

- **Fabrication and installation of three graphite reflector elements** to provide irradiation locations for the targets near the reactor core – The fabrication and installation of new graphite reflector elements are routine operations and the facility has years of experience in both areas, with personnel doses well documented during installation. Graphite reflector elements are designed based on the programming needs of the facility to support the type of material irradiations needed for research and development and for service work.

- **Fabrication of an intermediate irradiated target transfer cask** – Design and build an intermediate irradiated target transfer cask to transfer irradiated targets from the reactor pool to a Type B transport cask. This cask will be similar, both physically and functionally, to the current TRIGA single element transfer cask that is routinely used for fuel movements at other TRIGA-fueled facilities worldwide.
- **Addition of an airlock on the beamport floor** – Design and construct an airlock on the beamport floor of the reactor to enable the intermediate irradiated target transfer cask to be moved into and out of the containment structure while the reactor is operating.
- **Addition of storage locations for both unirradiated and irradiated NWMI targets** – Design and build storage areas for unirradiated targets in an area yet to be determined and for irradiated targets in the reactor pool awaiting shipment. These storage locations will be similar to what is currently used to store fresh and irradiated reactor fuel in geometrically safe criticality configurations.

Other minor tasks will include refurbishment of the 15-ton capacity overhead rectilinear crane and freight elevator for increased reliability and fabrication of some target handling tools. These tasks may or may not fall under the 10 CFR 50.59 screen and evaluation process depending on whether modifications need to be made.

19.4.13.1.1.1 Fresh Low-Enriched Uranium Target Handling

MURR receives 24 fresh HEU fuel elements per year as part of the normal operating cycle fuel consumption. These elements undergo a receipt inspection that includes a contamination and radiation survey. These elements typically read 2 to 3 mrem/hr on contact. Based on information obtained from TRIGA-fueled reactors that have gone through HEU-to-LEU fuel conversion in the past eight years, the receipt of fresh LEU TRIGA fuel may be indicative of what should be expected for unirradiated LEU targets.

The fuel received for conversions was 20 percent enriched and 30 wt% standard TRIGA fuel containing a nominal uranium mass of 820 g within a stainless-steel clad cylinder with outer dimensions very similar to the proposed LEU targets. Typical dose equivalent rate readings on contact and at 0.3 m (1 ft) were 0.1 to 0.3 and 0 mrem/hr, respectively. No measureable dose equivalent rate at 0.3 m (1 ft) from a fully loaded storage container was observed. Because of this, no appreciable increase in the occupational dose equivalent is expected from the handling of the proposed unirradiated LEU targets at MURR. Additionally, no appreciable increase in dose to the general public is expected from handling the unirradiated LEU targets due primarily to the very low dose equivalent rates observed with the LEU TRIGA fuel handling and a lack of proximity of the general public to the targets themselves.

19.4.13.1.1.2 Irradiated Low-Enriched Uranium Target Handling

MURR has extensive experience in handling fresh and irradiated reactor fuel, fueled experiments, and irradiated samples of varying materials, masses, and fluences within the reactor pool. To support its operating cycle, MURR performs a complete reactor core refueling each week that consists of, at a minimum, 16 fuel-handling evolutions. All of these fuel-handling evolutions and material sample handling have well-documented historical dose rate measurements. The handling of irradiated NWMI targets, using established ALARA principles, is anticipated to have a minimal impact on the occupational dose to MURR staff. Table 19-80, Table 19-81, and Table 19-82 provide a summary of the past five years of occupational dose to the MURR reactor operations, reactor health physics, and shipping groups, respectively, that are responsible for handling, packaging, and shipping the irradiated LEU targets.

Table 19-80. Annual Occupational Dose Summary for MURR Reactor Operations Group (typically 28 people badged within the group)

Year	Highest extremity dose equivalent (mrem)	Highest whole body dose equivalent (mrem)	Monthly average (person) whole body dose equivalent (mrem)	Annual average (person) whole body dose equivalent (mrem)	Total person (group) whole body dose equivalent (mrem)
2013	1,556	1,236	67	696	19,489
2012	3,122	1,275	61	661	15,866
2011	2,895	1,010	68	698	16,055
2010	1,110	794	47	538	14,523
2009	2,930	870	41	574	14,928

Table 19-81. Annual Occupational Dose Summary for MURR Reactor Health Physics Group (typically 8 people badged within the group)

Year	Highest extremity dose equivalent (mrem)	Highest whole body dose equivalent (mrem)	Monthly average (person) whole body dose equivalent (mrem)	Annual average (person)whole body dose equivalent (mrem)	Annual total (group) whole body dose equivalent (mrem)
2013	866	425	22	202	1,621
2012	834	468	16	220	1,981
2011	1,609	1,248	22	461	3,225
[a]2010	1,270	973	14	180	2,340
[a]2009	810	772	11	172	2,411

[a] In 2009 and 2010, Reactor Health Physics Group was part of the Regulatory Assurance Group, which typically badged up to 14 people within the group.

Table 19-82. Annual Occupational Dose Summary for the Shipping Group (typically 8 people badged within the group)

Year	Highest extremity dose equivalent (mrem)	Highest whole body dose equivalent (mrem)	Monthly average (person) whole body dose equivalent (mrem)	Annual average (person) whole body dose equivalent (mrem)	Total person (group) whole body dose equivalent (mrem)
2013	3,397	1,565	51	578	4,623
2012	2,525	981	40	515	4,120
2011	3,209	1,253	33	629	4,403
2010	4,300	1,373	43	557	3,897
2009	3,290	887	36	427	3,842

The MURR environmental monitoring program includes monitoring the annual dose equivalent at various locations and distances from the facility ventilation exhaust stack. There are 40 environmental monitoring stations deployed within the fenced, licensed area and also beyond the fenced area up to a distance of 907 m (2,976 ft). Each station includes a three-chip environmental TLD. Table 19-83 summarizes the annual dose equivalent of the 40 environmental dosimeters. Two stations (Station No. 9 and 15), located immediately adjacent to two separate loading docks that are a part of the laboratory building and well within the fenced area, account for approximately 60 percent of the total annual accumulative dose.

Packages containing radioactive material are staged for transport and loaded at these locations. Most other environmental TLDS receive little or no dose. Given the similarity in activities (i.e., fuel handling evolutions and movements of irradiated NWMI targets), a measureable increase in the projected dose to the general public is unlikely to occur.

Table 19-83. Summation of the Annual Dose Equivalent for the MURR Environmental Thermoluminescent Dosimeters

Year	Measured annual dose equivalent of all environmental dosimeters (mrem)
2013	257
2012	201
2011	214
[a]2010	371
2009[2]	323

[a] After 2010, some of the radioactive material packing was relocated further within the facility, away from the two environmental dosimeters located at Stations 9 and 15.

19.4.13.1.2 Oregon State University TRIGA Reactor

19.4.13.1.2.1 Facility Modifications

Three modifications are anticipated to be needed for the OSTR to handle both unirradiated and irradiated NWMI targets, and include the following:

- Refurbish the existing 5-ton overhead crane (e.g., replacement of contactors, motor brushes, etc.) or replace the crane to increase reliability and weight margin. Either modification will need to follow the process described in 10 CFR 50.59 for making changes to a facility.
- Design and build an intermediate target transfer cask to transfer irradiated targets from the primary tank to a Type B transport cask. This cask will be similar, both physically and functionally, to the current TRIGA single-element transfer cask that is routinely used for fuel movements at OSTR and other TRIGA-fueled facilities worldwide.
- Design and build a storage container for storage of unirradiated LEU targets. This storage container is anticipated to be similar to the one designed and built to hold fresh TRIGA fuel elements during the OSTR fuel conversation in 2008. Approved by the NRC during the order to convert, this container is a metal box with two holding plates containing holes in a grid pattern necessary to maintain a geometrically safe criticality configuration.

19.4.13.1.2.2 Fresh Low-Enriched Uranium Target Handling

Experience with the receipt of fresh LEU TRIGA fuel used for the HEU-to-LEU fuel conversion at the OSTR in 2008 is indicative of what would be expected for the fresh NWMI targets. The fuel received was 20 percent enriched and 30 wt% standard TRIGA fuel containing a nominal uranium mass of 820 g within a stainless-steel clad cylinder with outer dimensions similar to the NWMI LEU targets. After the fresh LEU TRIGA fuel was received, each element was visually inspected, dimensions recorded, and the dose equivalent rates measured at contact and at 0.3 m (1 ft) away along the perpendicular bisect. Typical dose equivalent rate readings at contact and at 0.3 m (1 ft) were 0.1 to 0.3 and 0 mrem/hr, respectively.

Once the inspections were complete, no measureable dose equivalent rate at 0.3 m (1 ft) from the fully loaded storage container was observed.

The receipt of LEU targets is expected to be similar, with no appreciable increase in the occupational dose equivalent expected from their handling. Additionally, no appreciable increase in dose to the general public is expected from handling the LEU targets due primarily to the very low dose equivalent rates observed with the LEU TRIGA fuel handling and a lack of proximity of the general public to the targets themselves.

19.4.13.1.2.3 Irradiated Low-Enriched Uranium Target Handling

The handling of irradiated HEU TRIGA fuel during the HEU-to-LEU fuel conversion at the OSTR is similar to what would be expected for the irradiated NWMI targets. Additionally, the OSTR has collected underwater exposure rate measurements on irradiated HEU TRIGA fuel over several decades. The HEU TRIGA fuel is nearly identical in terms of both outer dimensions and uranium mass as the LEU targets.

In late 2008, the existing HEU core was unloaded to a neighboring storage pool using the single-element TRIGA fuel transfer cask. In early 2009, the fuel from the HEU core was moved from the storage pool to the Type B transport cask. Although the short-lived radioisotopes had decayed away prior to the move, the burn-up on the fuel (1260 megawatt days [MWD]) was considerably higher that what is anticipated for the LEU targets (6.5 MWD). Initial estimates of the exposure rates of the irradiated LEU targets during the transfer at the OSTR from the primary tank to the cask are approximately a factor of 3 larger than experienced during the fuel movements just described. This difference would be accommodated by shield optimization of the intermediate transfer cask that will need to be designed and built. This transfer cask would be similar, both physically and functionally, to the current TRIGA single-element transfer cask that is routinely used for fuel movements at OSTR and other TRIGA-fueled facilities worldwide.

In 2013, the OSTR was completely unloaded and reloaded again, involving well over 200 fuel movements. Table 19-84 summarizes the occupational dose equivalent information for the last seven years. Years 2008, 2009, and 2014, when large number of fuel movements occurred, would be similar in procedure and application to what is anticipated for the irradiated LEU targets. (Note: The higher values in 2014 are largely due to a significant and high-exposure rate maintenance evolution that occurred after unloading the core.) Given that the occupational dose did not otherwise significantly change during these years, were within ALARA guidelines, and all less than the applicable dose limit during these time periods, the routine handling of irradiate LEU targets should not significantly increase the occupational dose rates.

Table 19-84. Annual Summary of Occupational Doses Received at the Oregon State University TRIGA Reactor

Reporting annum	Average whole body dose equivalent (mrem)	Average extremity dose equivalent (mrem)	Highest whole body dose equivalent (mrem)	Highest extremity dose equivalent (mrem)	Total person-mrem whole body dose equivalent (mrem)	Total person-mrem extremity dose equivalent (mrem)
2014	382	502	639	914	2,229	3,518
2013	124	277	203	778	867	1,938
2012	102	340	187	1269	717	2,377
2011	102	258	166	663	711	1,807
2010	39	212	64	478	446	1,489
2009	130	374	225	1,188	911	2,615
2008	106	312	227	566	850	2,495

The OSTR environmental monitoring program includes monitoring the annual dose equivalent at the fence that surrounds the reactor. There are nine environmental monitoring stations located on the fence. Each station includes a three-chip environmental TLD. The average measured annual dose equivalent measured by these stations is provided in Table 19-85.

As noted previously, a number of fuel element transfers similar to what is anticipated with the irradiated LEU targets, occurred in 2008, 2009, and 2014. Given the similarity in activities (i.e., fuel movements and movements of irradiated LEU targets), a measureable increase in the projected dose to the general public is unlikely to occur.

Table 19-85. Total Annual Dose Equivalent Measured at the Oregon State University TRIGA Reactor Fence Line

Reporting annum	Measured annual dose equivalent (mrem)
2014	15 ± 20
2013	12 ± 6
2012	8 ± 4
2011	10 ± 4
2010	7 ± 3
2009	18 ± 7
2008	11 ± 4

19.4.13.1.3 Third University Network Reactor

The third university reactor, once selected, would also require an amendment to the university's 10 CFR 50 license and analysis of site-specific environmental impacts related to such an amendment. Information is not currently available to conduct additional analysis for the third reactor. However, the impacts associated with irradiating LEU targets at both MURR and OSTR are considered to be similar to what would be expected at a third reactor.

19.4.13.2 Transportation

A detailed description of the transportation of unirradiated and irradiated LEU targets to the university reactor network is provided in Section 19.4.10.

19.4.13.3 Waste Management

19.4.13.3.1 University of Missouri Research Reactor

The amount of radioactive waste that would be generated at MURR as a result of handling and irradiating NWMI targets is not anticipated to be significant, as the targets will be minimally handled with little potential for contamination. The majority of the waste generated will be solid dry wastes (e.g., paper, gloves, and absorbent materials) from moving casks into and out of the reactor pool. Estimates of the added amount of dry-solid-compactable radioactive wastes are 0.11 to 0.17 m^3 (4 to 6 ft^3) annually. In comparison, MURR generated an average of 19.4 m^3 (685 ft^3) of dry solid radioactive waste annually over the past five years. No liquid radioactive waste is expected to be generated as a result of these activities.

19.4.13.3.2 Oregon State University TRIGA Reactor

The amount of radioactive waste that would be generated at OSTR as a result of handling and irradiating LEU targets is not anticipated to be signification, as the targets will be minimally handled with little potential for contamination. The majority of the waste generated would be solid dry wastes (e.g., paper, gloves, and absorbent materials) from

The targets will be moved from the reactor core to the intermediate transfer cask underwater in the primary tank. Estimates of the added amount of dry-solid-compactable radioactive wastes at OSTR is 0.11 to 0.17 m^3 (4 to 6 ft^3) annually. In comparison, OSTR typically generates 0.85 to 1.13 m^3 (30 to 40 ft^3) of dry solid radioactive wastes annually. No liquid radioactive waste is expected to be generated as a result of these activities.

19.4.13.3.3 Third University Reactor

The third university research reactor will generate waste similar to OSTR.

19.4.14 Cumulative Impacts

The Council on Environmental Quality regulations implementing NEPA require that the cumulative impacts of a proposed action be assessed (40 CFR 1500-1508, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act"). A cumulative impact is defined by the Council as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or nonfederal) or person undertakes such other actions" (40 CFR 1508.7, "Cumulative Impact"). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7). The Council on Environmental Quality guidance for considering cumulative effects states that NEPA documents "should compare the cumulative effects of multiple actions with appropriate national, regional, State, or community goals to determine whether the total effect is significant" (CEQ, 1997).

This section addresses cumulative effects of the construction, operation, and decommissioning of the RPF in the context of other actions within the ROI and during the reasonably foreseeable future.

Section 19.4.14.1 presents the methodology used to evaluate cumulative impacts. Section 19.4.14.2 presents other projects within the ROI that may have cumulative effects when combined with the impacts from the RPF. Section 19.4.14.3 identifies and describes the cumulative impacts for each of the resource areas discussed in Sections 19.3 and 19.4.

19.4.14.1 Methodology

Cumulative impacts were evaluated by other identified projects and actions (Federal, State, and private) that have occurred or may occur in the present, or in the reasonably foreseeable future. Projects were identified through several sources. The initial lists of local projects were identified using the *City of Columbia FY 2013 CIP Planning Document* (City of Columbia, 2013f). In addition, State and county planning documents were reviewed, and potential projects were discussed with Regional Economic Development, Inc., to identify potential private projects. After identifying projects, the likelihood that a project would be reasonably expected to occur was determined.

An integral part of the cumulative impacts analysis involved determining if impacts from the proposed projects would contribute to ongoing or foreseeable resource trends. A list of projects was evaluated to identify those with the potential to contribute incremental impact resources during RPF construction, operation, and decommissioning. Many of the identified projects are anticipated to have short-term, temporary, direct impacts or are outside of the ROI and not expected to have cumulative impacts with the RPF. These projects include many of the street and sidewalk, maintenance, replacement, and public safety projects.

The cumulative impacts analyses do not assess all expected environmental impacts from regional projects within the ROI. Only those impacts resulting from the RPF and other past, present, and reasonably foreseeable future actions that influence the identified resource area are assessed.

The cumulative impacts were then assessed by resource area (e.g., water resources, air quality, and socioeconomic impacts). Impacts may arise from single or multiple actions, or they may result in additive or interactive effects. Interactive effects may, in some cases, be countervailing, where the adverse cumulative effect is less than the sum of the individual effects; or they may be synergistic, where the net adverse cumulative effect is greater than the sum of the individual effects (CEQ, 1997).

For individual resources, the ROI for cumulative impacts is often larger than the ROI for direct and indirect impacts (identified in Section 19.3, within each resource area discussion). The factors considered in determining the significance of cumulative impacts are often the same as those presented in Section 19.4.

19.4.14.2 Past, Present, and Reasonably Foreseeable Future Projects

Table 19-86 lists 239 projects, which, when considered with the proposed RPF, could result in incremental impacts to a number of resource areas. These activities largely involve State and local construction occurring near the proposed RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Transit						
Oil Water Sep 7th & Walnut	10/1/2003	12/31/2008	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
5th & Walnut Parking Garage	10/1/2006	10/1/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Short St. Parking Garage	10/1/2008	10/1/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Columbia Regional Airport Runway Expansion	-	-	Greater than 8 km	Greater than 5	Y	Construction includes newly disturbed lands and the potential cumulative effects from air emissions and effects on land use.
Columbia Regional Airport Terminal Expansion	Not yet defined	-	Greater than 8 km	Greater than 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Power Plant Rail Spur	10/1/2010	9/30/2011	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
College Avenue Crossing	10/1/2010	9/30/2011	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Buildings/Facilities						
Construct Warehouse & Enclosed Parking	10/1/2013	12/31/2015	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Municipal Office Space Expansion	7/17/2000	4/30/2011	6 to 8 km	3.7 to 5	N	Existing facility with new construction.
Global PET Imaging	Not yet defined	-	0 to 1 km	0 to 0.6	N	Project is conceptual with no identified date to initiate.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Blind Boone Home	12/1/2000	12/1/2000	6 to 8 km	3.7 to 5	N	Existing facility with new construction.
University of Mo Memorial Stadium Expansion	2012	2015	6 to 8 km	3.7 to 5	N	Existing facility with new construction.
University of Mo Campus Chilled Water Plant Phase 2	-	-	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
MURR Industrial Building Expansion	2014	2014	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Odles' Discovery Park Residential/Commercial Development	Not yet defined	-	0 to 1 km	0–0.6 mi	Y	Development is mostly on undisturbed land located near the RPF site. Could potentially have cumulative effects on land use, air, noise, traffic, and utilities.
Aspen Heights Housing Development	2012	2013	2 to 4 km	1.3 to 2.5	Y	Development is mostly on undisturbed land located near the RPF site. Could potentially have cumulative effects on land use, air, noise, traffic, and utilities.
The Grove Student Housing	2011	2011	2 to 4 km	1.3 to 2.5	Y	Development is mostly on undisturbed land located near the RPF site. Could potentially have cumulative effects on land use, air, noise, traffic, and utilities.
The Den Student Hosing	2013	2014	2 to 4 km	1.3 to 2.5	Y	Development is mostly on undisturbed land located near the RPF site. Could potentially have cumulative effects on land use, air, noise, traffic, and utilities.
Fire Station #1	10/11/2005	10/1/2006	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Replace Existing Fire Station # 7	3/6/2006	1/19/2009	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Police Headquarters Building	3/17/2012	3/17/2013	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Power						
Distr. Center/Yard – Consolidation & Expansion	10/1/2005	10/1/2012	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Distributed Generator at Southeast Location	10/1/2007	9/30/2008	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Broadway Undergrounding	10/2/2008	9/30/2011	6 to more than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
New South Side 161/13.8 kV Substation	10/1/2009	9/1/2013	2 to more than 8 km	1.3 to more than 5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
Rebel Hill 212 - Substation Feeder	10/1/2009	10/1/2010	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Perche Substation Transformer Interconnect	10/1/2009	5/1/2015	4 to more than 8 km	2.5 to more than 5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
William Street Undergrounding	10/1/2009	9/30/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Underground Rangeline - Rogers to Wilkes	12/23/2009	3/1/2011	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Relocation of 69 kV Line - Hinkson to Perche	4/1/2010		6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
Primary Control Center	4/1/2010	4/1/2013	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Green Meadows-Providence to Gray Oak-SLA	5/1/2010	11/1/2010	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
E. Broadway-Hinkson Creek-Brickton Dr.	10/1/2010	12/1/2012	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Clark Ln-Rte PP to St. Charles Rd-SLA	10/1/2010	5/1/2012	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Eastpointe Electric Loop Closure	3/24/2011	10/1/2013	2 to 6 km	1.3 to 3.7	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
Grindstone 223 - Substation Feeder	10/1/2011	12/31/2012	2 to 4 km	1.3 to 2.5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
South 161 Tie Line (Grindstone-Perche)	10/1/2012	12/31/2014	2 to more than 8 km	1.3 to more than 5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
5th St. Undergrounding - Rollins to Turner	1/18/2013	-	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
College Undergrounding -Univ to Bouchelle	1/18/2013	11/1/2014	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Extend Rebel Hill Feeder 212	10/1/2013	10/1/2014	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
New Water Reservoir at Power Plant	10/1/2014	10/1/2015	6 to more than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
161 Trans-Perche Sub to New South Sub	10/1/2014	10/1/2015	2 to 8 km	1.3 to 5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
Mill Creek Substation Trans Interconnect	10/1/2015	10/1/2016	0 to 8 km	0 to 5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
161 Transmission - Power Plant Line	10/1/2017	10/1/2018	4 to greater than 8 km	2.5 to greater than 5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
161 kV Power Plant Substation	10/1/2018	10/1/2019	6 to 8 km	3.7 to 5	N	Existing facility with new construction.
Business Loop 70 – Phase 5 Undergrounding	10/1/2019	10/1/2021	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Business Loop 70 – Phase 6 Undergrounding	10/1/2020	10/1/2022	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Water						
16 in. Main-Hwy 63 - West Crossing to Stadium	4/1/2013	9/1/2013	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
8 in. Main - Lake-of-the-Woods	2/25/2009	12/1/2010	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
8 in. Main-Rangeline-Smith to Bus Loop 70	10/1/2012	10/1/2013	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Deep Well Abandonment	10/1/2016	10/1/2017	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
EC: Cliff Dr.: Hawthorne Dr. - Univ Close Loop	10/1/2008	5/31/2012	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
EC: Lawrence Place Main Relocation	10/1/2008	9/30/2009	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
EC: Univ Av: Ann St-Rock Hill Close Loop	10/1/2010	5/30/2012	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Hillsdale PS - 1.5 Mgal Ground Storage Tank	3/17/2008	12/30/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Hinkson Main - Williams to Old Hwy 63	10/1/2013	10/1/2014	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Hominy Branch: Main Relocation	10/1/2009	12/4/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Loop Closure of 12 in. Mains S of Nifong Blvd	10/1/2008	10/1/2012	1 to greater than 8 km	0.6 to greater than 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, the impacts are anticipated to be limited and short-term.
Maguire - 12 in. Main	11/1/2008	10/30/2010	2 to 4 km	1.3 to 2.5	N	Construction activity on previously disturbed land and some undisturbed lands. However, the impacts are anticipated to be limited and short-term.
Main Adjustment-Forum Blvd Improvements	10/1/2018	10/1/2019	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Main Adjustment-Nifong Blvd Improvements	10/1/2018	10/1/2019	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
N Section of 24 in. East Transmission Main	10/1/2008	9/25/2012	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
NC: Rangeline St & Smith St Main Relocation	10/1/2008	9/30/2009	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Old Hwy 63 N & McAlester Loop Closure	10/1/2016	10/1/2017	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Providence Rd at Stewart Rd Close Loop	10/1/2009	6/30/2012	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Quail Drive - Main Relocation	10/1/2011	12/30/2013	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands.
S Section of 24 in. East Transmission Main	10/1/2009	12/1/2013	1 to 6 km	0.6 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, the impacts are anticipated to be limited and short-term.
Stadium Crossing at Audubon	10/1/2017	10/1/2018	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Thilly & Westmount 6 in. Main - 2,800 ft	10/1/2013	10/1/2014	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Bingham Road - Phase II - WT0254	10/1/2019	10/1/2020	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Streets and Sidewalks						
Discovery Parkway	2014	2015	0 to 1 km	0–0.6 mi	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
Audubon Dr S Sidewalk -Shepard Blvd-N Azalea	10/1/2020	12/31/2021	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Ballenger over I-70: Clark to 740 Ext/ Richland	10/1/2009	12/31/2018	4 to 8 km	2.5 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Bearfield Rd; Clear Creek-Gans Road	10/1/2013	12/29/2019	2 to 4 km	1.3 to 2.5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Bearfield Rd; Nifong-Clear Creek	10/1/2013	12/31/2018	2 to 4 km	1.3 to 2.5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Broadway - Garth Ave to West Blvd	4/10/2012	12/1/2015	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Broadway Sdwlk - McBaine-W Blvd, N Side	10/1/1999	5/31/2010	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Bus Loop 70 Sidewalk-Rangeline to Rt B	10/1/2020	12/31/2021	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Carter Lane Sidewalk	6/6/2013	6/6/2013	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Clark Ln - Ballenger to St. Charles Rd	10/3/2005	12/31/2011	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Clark Ln - Woodland Springs Ct to Ballenger	10/1/2013	10/1/2019	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Creekwood Prkwy-Gldn Bear Dr-Vandvr Dr	10/1/2020	12/29/2023	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Discovery Parkway: Gans to New Haven	12/29/2008		0 to 4 km	0 to 2.5	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
East Blvd - Bus Loop 70 to Conley (TDD)	10/1/2020	12/29/2023	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
East Side Sidewalk Phase 1 Stimulus	11/3/2009	11/3/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
East Side Sidewalks – Phase 2 (CDBG)	10/1/2009	10/1/2012	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
East side sidewalks Phase 3 (CDBG)	10/1/2010	10/1/2011	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Elm Street Extension	10/3/2008	12/31/2014	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Forum Blvd Sidewalk - Nifong to Mill Creek	10/1/2019	12/31/2021	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Forum Blvd: Chapel Hill to Woodrail (4-lane)	4/16/2010	4/16/2010	6 to greater than 8 km	3.7 to greater than 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Forum Left turn lanes at MKT/Victoria	7/8/2011	7/8/2011	6 to greater than 8 km	3.7 to greater than 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Gans Rd: Interchange at 63	10/3/2005	12/31/2008	0 to 2 km	0 to 1.3	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
Gans Rd: Providence-Bearfld Rd	10/1/2020	12/29/2023	2 to 6 km	1.3 to 3.7	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
Gans Rd:Providnc-Bearfild Rd (4-Lane Upgrade)	10/1/2020	12/29/2023	2 to 6 km	1.3 to 3.7	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
Gans Rd: U.S. 63 Interchange-Bearfield	10/1/2019	10/1/2020	1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
Gans Rd: U.S. 63 Interchange-Bearfield (4-Lane Upgrade)	10/1/2020	12/29/2023	1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
Grace Ln. - Richland to Stadium Extension	2/21/2018	2/21/2018	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Hanover Blvd - Olympic Blvd to Rice Rd	10/1/2020	12/29/2023	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Heriford Drive - Parker St to Route B	10/1/2020	12/29/2023	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Hominy Trail Connection	7/9/2013	7/9/2013	4 to 6 km	2.5 to 3.7	Y	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Jefferson Commons Pedestrian Crossing	10/1/2002	3/31/2009	2 to 4 km	1.3 to 2.5	N	Construction activity limited to previously disturbed lands.
Keene Street: Broadway to I-70 Drive	3/18/2010	3/18/2010	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Lake of the Woods Rd. and St Charles Rd. Intersect	10/1/2020	12/29/2023	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Lake Ridgeway Dr - Clark Ln-Vandiver Dr	10/1/2020	12/29/2023	6 to 8 km	3.7 to 5	Y	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Landscaping Route AC	10/1/2003	12/31/2009	2 to 6 km	1.3 to 3.7	N	Construction activity limited to previously disturbed lands.
Lenoir Woods Sidewalk	10/18/2013	10/18/2013	0 to 2 km	0 to 1.3 mi	N	Construction activity limited to previously disturbed lands.
Maguire - N to Stadium Blvd & Exit	10/1/2001	12/31/2010	2 to 4 km	1.3 to 2.5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Maguire/Warren to New Haven	7/16/2008		1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
Missouri Theatre Sidewalk	10/20/2009		6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
MM Maguire Blvd: Lemone to Emily	3/18/2010	3/18/2010	1 to 2 km	0.6 to 1.3	N	Construction activity limited to previously disturbed lands.
MM-Green Meadows Rd: Skylark Lane to Oaklawn Drive	3/18/2010	3/18/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
MM-Royal Lytham Drive:Glen Eagle Dr to Chadwick Dr	3/18/2010	3/18/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
MM-Santiago Drive: Granada Blvd to Nifong Blvd	3/18/2010	3/18/2010	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
New Haven: Lemone to Warren	6/2/2009		1 to 2 km	0.6 to 1.3	N	Construction activity limited to previously disturbed lands.
Nifong – Providence to Forum 4 Lane	10/1/2010	12/29/2019	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Nifong: Forum to Old Mill Creek Rd. (4-Lane Upgrade)	2/21/2026	2/21/2026	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Nifong-Bethel Sidewalk	2/21/2012		4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Old Plank Road - S. Providence to Forum Blvd.	10/1/2020	12/29/2023	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Old Route K Bridge over Hinkson Creek	10/1/2007	9/8/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Peachtree Connector and Nifong Signal	10/20/2009		4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Phillips Farm Rd - Southampton to Ponderosa	10/1/2020	12/29/2023	2 to 6 km	1.3 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Ponderosa TDD: Gans to Blue Acres	10/1/2017	10/1/2017	0 to 2 km	0 to 1.3	Y	Construction activity on previously disturbed and undisturbed lands. Could potentially have cumulative effects on land use, traffic, and water resources.
Providence and Nifong Bike Lanes	7/9/2013	7/9/2013	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Providence Corridor - Burnham Inter PH1	10/2/2006	12/31/2012	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Providence Corridor - Burnham Inter PH2	1/1/2020	12/31/2020	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Rangeline -Wilkes to Business Loop	7/16/2008		6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Rice Road - Hanover to Ballenger Lane	2/17/2020	2/17/2023	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands.
Richland - St. Charles to Grace	10/1/2012	12/29/2018	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Rock Quarry Nifong to Gans Road	6/30/1998	12/30/2023	2 to 4 km	1.3 to 2.5	N	Construction activity limited to previously disturbed lands.
Rock Quarry Rd Sidewalk: Stadium Blvd-Hinkson	10/1/2020	12/31/2021	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands.
Rock Quarry Rd - Grindstone Prkwy to Stadium 9,400 ft	10/1/2009	12/29/2015	2 to 6 km	1.3 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Rock Quarry Rd - Nifong to Grindstone Prkwy	10/1/1999	12/29/2023	2 to 4 km	1.3 to 2.5	N	Construction activity limited to previously disturbed lands.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Rolling Hills - County Project: New Haven to WW	3/6/2009		2 to 4 km	1.3 to 2.5	N	Construction activity limited to previously disturbed lands.
Rolling Hills Road (4-Lane)	10/1/2020	12/29/2023	2 to 4 km	1.3 to 2.5	N	Construction activity limited to previously disturbed lands.
Rolling Hills Road- Old Hawthorn to Richland	10/2/2006	12/31/2012	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Rustic Road	3/19/2010	3/19/2010	2 to 4 km	1.3 to 2.5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Shepard Blvd Sidewalk - Old 63 to Danforth	10/1/2020	12/31/2021	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Short Street Garage Traffic Mitigation	9/26/2011		6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Southampton Dr - Sinclair to 1000 ft Eastward	10/1/2020	12/29/2023	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
South Hampton Dr - U.S. Hwy 163-Route	10/1/2004	3/31/2008	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
St Charles Road - Keene to Richland Rd	10/1/2011	12/29/2017	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Stadium at Old 63 Intersection	10/1/2004	11/28/2012	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Stadium Extension East to I-70	10/1/2007	12/31/2010	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Traffic Islands - Old 63 and Broadway	10/1/2004	11/30/2009	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
West Broadway Corridor	3/1/2007	2/8/2010	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Williams Street with Williams - Broadway Intersection Imprv	7/16/2008	12/15/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Woodridge Dr – St Charles Rd to Terminus	10/1/2020	10/31/2023	4 to 8 km	2.5 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Non-Motorized						
Hinkson Cr Tr Stadium - Rockhill Ph III	1/9/2008	3/31/2010	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Hominy Branch Trail: Stephens - Woodridge Phase I	8/16/2011	6/8/2012	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Sewer						
B-8 Relief Sewer - Rangeline & Vandiver	10/1/2019	10/1/2021	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
C-5 Trunk Relief Swr - Rock Quarry: Nifong-Zoe	10/1/2019	10/1/2021	2 to 4 km	1.3 to 2.5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Calvert Drive Sewer Relocation	2/11/2013	2/11/2013	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Douglass High School Sewer Relocation	2/17/2012	2/17/2012	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Flat Branch Watershed Relief Sewers	10/1/2016	11/15/2018	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Hinkson Creek Outfall Replacement	11/18/2010	1/27/2012	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Hominy Branch Outfall Ext: LOW Rd-Mxco Grvl	10/1/2020	1/1/2023	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Hominy Branch Outfall Relief Sewer	10/1/2008	12/1/2010	4 to 8 km	2.5 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
North Grindstone Creek Bank Stabilization	2/20/2012	2/20/2012	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
North Grindstone Outfall Extension Phase I	4/23/2008		6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
North Grindstone Outfall Extension Phase II	10/1/2008	1/1/2011	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
PCCE # 6: S Country Club Dr Area	8/1/2008	1/15/2011	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
PCCE # 8: Thilly Lathrop	2/9/2010	11/1/2012	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
PCCE #11: Wilson Street / High Street	5/7/2010		4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
PCCE #14: Cliff Drive	1/27/2011	1/27/2011	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
PCCE #16: Bingham Rd & West Ridgeley Rd	1/27/2011	1/27/2011	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
PCCE #17: Wilson Street/Ross Street	5/7/2010		6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
PCCE #24: St. James and St. Joseph	10/1/2018	9/30/2019	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
PCCE #25: Glenwood and Redbud	10/1/2018	9/30/2019	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Sewer District – Hillcreek Road	1/27/2020	1/27/2022	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Sewer District #170 - S. Bethel Church Road	1/1/2011	12/31/2012	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Sexton Road Relief Sewer	8/1/2018	8/1/2020	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Stephens Park Sewer Relocation	10/1/2014	12/15/2016	4 to 8 km	2.5 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Westwood Avenue Sewer Relocation	2/17/2012	2/17/2012	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Woodstock MHP WWTP Interceptor	2/20/2012	2/20/2012	2 to 4 km	1.3 to 2.5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Stormwater						
2302 Business 70 East	1/28/2025	1/28/2026	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Alan Lane	10/1/2019	10/1/2021	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Ash & Hubble	10/1/2012	9/30/2013	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Calvert Drive	1/30/2013	1/30/2013	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
East Downtown	1/30/2013	1/30/2013	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Eighth Street Drainage C49084	4/18/2007	4/18/2007	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Grasslands-Brandon Drainage	10/1/2020	10/1/2023	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Greenwood South	1/30/2013	1/30/2013	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Hickman and 6th and 7th	1/30/2013	1/30/2013	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Hinkson Avenue	10/1/2020	10/1/2023	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Hinkson Cr Trail: Grindstone-Stephens Phase I	2/22/2010	12/31/2011	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Hinkson Cr Trail: Grindstone-Stephens Phase II	2/22/2010	12/31/2011	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed land and undisturbed lands.
Hinkson Creek Trail: Stephens to Vandiver Pedway	10/1/2018	12/31/2020	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Hitt and Elm C49099	1/28/2011	1/28/2011	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Kelly Detention Retrofit	4/14/2011	4/14/2011	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Lawrence Place	10/1/2007	5/1/2009	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Mill Creek Phase 3 C49111	1/30/2013	1/30/2013	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
MKT Bridge Improvements Phase II	1/1/2017	1/1/2018	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Nifong and Bethel Drainage Project	10/15/2014	2/1/2015	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Old Plank Storm Drainage - South Side	10/1/2019	6/1/2022	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Peachtree Water Quality Basin	10/1/2028	10/1/2029	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Pear Tree Circle Storm Drainage	10/1/2025	10/1/2026	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Philips Lake Connector: Nifong to GCRA	10/1/2025	10/1/2026	1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed land and undisturbed lands.
Rangeline Street Smith Street	1/9/2025	1/9/2026	6 to greater than 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Rockhill Rd	10/1/2017	11/1/2018	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Royal Lytham - Fallwood	10/1/2007	7/1/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Seventh and Locust	1/28/2016	1/28/2017	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Stewart Park Drainage	10/1/2016	12/31/2018	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Vandiver/Sylvan Storm Drainage	10/1/2014	10/1/2015	6 to greater than 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Wayne Road	10/1/2020	11/1/2023	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Wilson Ross	1/30/2013	1/30/2013	4 to 8 km	2.5 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Parks and Recreation						
American Legion Park: Shelter, Restrooms, Playground	10/1/2016	10/1/2017	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
American Legion Renovation – Phase I	10/1/2009	12/31/2011	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Aquatic Facility	10/1/2017	5/3/2019	1 to 2 km	0.6–1.3	Y	Construction activity on undisturbed lands. Could potentially have cumulative effects on land use and water resources.
COLT Railroad Trail Phase 1: Columbia College to Vandiver	10/1/2018	10/1/2020	4 to greater than 8 km	2.5 to greater than 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Cosmo-Bethel Four Court Tennis Complex	1/7/2008	10/30/2009	4 to 6 km	2.5 to 3.7	N	Construction activity limited to previously disturbed lands.
Douglass Park Improvements: Security	2/24/2012	12/31/1969	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Douglass Park: Amphitheater and Shelter	10/1/2013	12/31/2014	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Douglass Park: Multipurpose Building	10/1/2020	12/31/2023	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Eastport Neighbored Park Develop	10/1/2007	12/31/2010	4 to greater than 8 km	2.5 to greater than 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Flat Branch Park – Phase II	10/1/2001	5/5/2009	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Grasslands Neighborhood Park Development	10/1/2007	12/31/2009	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Grasslands Park Acquisition	9/2/2002	2/28/2003	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Hinkson Creek - Grindstone Trailhead Restroom	10/1/2012	12/31/2014	4 to 6 km	2.5 to 3.7	Y	Construction activity on undisturbed lands. Could potentially have cumulative effects on land use and water resources.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Hominy Creek Trail: Old 63 to Green Valley	2/1/2019	2/1/2021	4 to 6 km	2.5 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Lake of the Woods Golf Course New Restroom	1/19/2006	7/30/2009	6 to 8 km	3.7 to 5	Y	Construction activity on undisturbed lands. Could potentially have cumulative effects on land use and water resources.
MKT Trail: New Restroom at Flat Branch Park	10/1/2016	12/31/2017	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Nifong Park: Covered Tractor and Implement Structure	10/1/2016	12/31/2017	1 to 4 km	0.6 to 2.5	N	Construction activity on previously disturbed land.
Nifong Park: Maplewood Barn/Home & Parking	10/1/2011	12/31/2013	1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed land and undisturbed lands.
Nifong Restroom and Buildings	10/2/2006	1/1/2009	1 to 2 km	0.6–1.3	Y	Construction activity on undisturbed lands.
Paquin Park Improvement-Phase III - Raised Beds	10/1/2009	12/31/2010	6 to 8 km	3.7 to 5	N	Construction activity limited to previously disturbed lands at a distance from the RPF site.
Philips/Gans: Park Development Phase II	10/1/2016		1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed land and undisturbed lands.
Philips/Gans: Ice Skating Facility - Outdoor	10/3/2016	12/31/2018	1 to 2 km	0.6–1.3	Y	Construction activity on undisturbed lands.
Philips/Gans: Indoor Pavilion/Shelter	10/3/2016	10/3/2018	1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed land and undisturbed lands.
Philips/Gans: Indoor Sports Center - Gym	10/1/2016	10/1/2018	1 to 2 km	0.6–1.3	Y	Construction activity on undisturbed lands.
Rock Quarry Park Tennis/Basketball	10/1/2008	4/1/2011	2 to 4 km	1.3 to 2.5	Y	Construction activity on previously disturbed land and undisturbed lands.
South Regional Park - Gans/Philips Phase I	10/1/2012	12/31/2015	1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed land and undisturbed lands.
South Regional Park - Philips Phase I	10/2/2006	6/1/2010	1 to 2 km	0.6–1.3	Y	Construction activity on previously disturbed land and undisturbed lands.
South Regional Park Acquisition	3/19/2007	11/2/2009	1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed land and undisturbed lands.
South Regional Park Development – Phase I	10/1/2009	12/31/2012	1 to 4 km	0.6 to 2.5	Y	Construction activity on previously disturbed land and undisturbed lands.
Stephens Lake Park Development – Phase I	5/18/2000	12/31/2010	4 to 8 km	2.5 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.

Table 19-86. Past, Present, and Reasonably Foreseeable Future Actions (19 pages)

Project name	Project start date	Project end date	Distance from RPF (distance band, km)	Distance from RPF (distance band, mi)	Retained for cumulative analysis	Basis
Stephens Lake Park: E. Walnut Development	10/1/2016	12/31/2017	6 to 8 km	3.7 to 5	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Waters-Moss Develop Phase II: Waters and Jones Buildings	10/1/2015	12/31/2016	2 to 6 km	1.3 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.
Waters-Moss Park: Phase I Development	10/1/2012	10/1/2015	2 to 6 km	1.3 to 3.7	N	Construction activity on previously disturbed lands and undisturbed lands. However, due to the distance from the RPF site, no cumulative effects are anticipated.

CDBG = Community Development Block Grant.
GCRA = Gans Creek Recreation Area.
MHP = mobile home park.
MURR = University of Missouri Research Reactor.
PCCE = private common collector elimination.
RPF = radioisotope production facility.
SLA = street light addition.
TDD = Transportation Development District.
WWTP = wastewater treatment plant.

19.4.14.3 Summary of Cumulative Impacts

19.4.14.3.1 Land Use and Visual Resources

As discussed in Section 19.4.1.1, proposed RPF construction, operation, and decommissioning impacts on land use and visual resources are small. Relevant other projects to be considered for cumulative impacts include the construction of Discovery Parkway and other Discovery Ridge facilities.

19.4.14.3.1.1 Land Use

Discovery Ridge (the proposed site for the RPF) occupies 505 ha (1,250 acres), within which there are presently two existing facilities. The remaining land is either fallow or being used for agricultural purposes. The RPF would change current fallow land to a more industrial use; however, the land-use designations would not be changed with the construction and operation of the facility. The 505 ha (1,250 acres) would be anticipated to be converted to industrial use over time, and there would be a minor loss of agricultural lands.

The Odles' Discovery Park, Aspen Heights, Grove, and Den developments would also impact land use. None of these lands are prime farmland, and the loss of crop production is a minor impact when compared to the amount of agricultural land in the ROI. Therefore, cumulative impacts to land use resources, including agricultural resources, are small.

19.4.14.3.1.2 Visual Resources

The cumulative impacts to the visual or scenic quality of the proposed RPF were assessed by examining the proposed actions associated with construction of the facility and the development of surrounding properties. The RPF would abide by the *Discovery Ridge Master Plan and Covenants* (MU, 2009) to ensure that the visual impact is compatible with the character of the development.

Under ideal conditions with no interferences from vegetation, the exhaust stacks may be visible from up to a distance of approximately 3.2 km (2 mi). However, this visual impact would be small. By considering both proposed on-site and nearby existing developments, modification to the proposed site would result in small visual impacts. Therefore, cumulative impacts would be small on the visual/scenic quality of the proposed RPF site.

19.4.14.3.2 Air Quality and Noise

19.4.14.3.2.1 Air Quality

The cumulative impacts to the air quality resulting from the proposed RPF were assessed by examining the proposed actions associated with construction and operation of the facility and the development of surrounding properties. The road, water, power, and sewer projects in the area may have temporary effects on air quality, but are likely to be short-term. Therefore, the cumulative impacts on the air quality of the proposed site would be small. Other sources in the area, when combined with the RPF, would be unlikely to result in significant cumulative impacts. The cumulative impact to the regional air quality would be small.

19.4.14.3.2.2 Noise

Cumulative noise sources would include the proposed RPF, existing traffic along U.S. Highway 63 and Discovery Parkway, operations at the ABC Laboratories and RADIL facilities, the Odles' Discovery Park development, and farm and ranch operations. Road construction projects in the area (e.g., Discovery Parkway) would also result in a temporary increase in noise, as would RPF construction. Impacts from all noise sources at the RPF during operation would generally remain at or below *Discovery Ridge Master Plan and Protective Covenants* (MU, 2009) and the Columbia Code of Ordinance (City of Columbia, 2013b) requirements. Therefore, cumulative noise impacts from the RPF would be small.

19.4.14.3.3 Geologic Environment

As discussed in Section 19.4.3, RPF construction and operation impacts on the geologic environment would be small. The cumulative impacts to the geologic resources would be similar to the direct and indirect impacts of the facility and those associated with the current land use. RPF construction would result in limited soil erosion, which would be minimized using BMPs. The proposed construction of the Discovery Parkway adjacent to the RPF and the Odles' Discovery Park development would have similar short-term impacts that are anticipated to be mitigated with BMPs. Therefore, cumulative geologic impacts would be small.

19.4.14.3.3.1 Water Resources

The proposed RPF would not extract groundwater, and there would be no liquid discharge from the facility. Stormwater runoff from the facility would be discharged to lined, engineered basins. The proposed construction of the Discovery Parkway adjacent to the RPF and the Odles' Discovery Park development would be required to follow similar requirements for stormwater. As a result, no significant effects on natural water systems are anticipated, and the cumulative impact to water resources would be small.

19.4.14.3.4 Ecological Resources

As discussed in Section 19.4.5, impacts from the construction, operation, and decommissioning of the RPF on terrestrial and aquatic ecosystems, including protected species, is small. The historical and current use of the proposed site limits the available resources for flora and fauna species. The potential for impacts from stormwater runoff are limited because there is no aquatic environment located on the site, and stormwater retention systems would be in place. Therefore, potential cumulative impacts to ecological resources are small.

19.4.14.3.5 Historical and Cultural Resources

As noted in Section 19.4.6, there were no cultural resources located on the proposed RPF site. The nearest listed NRHP property is the Maplewood House located approximately 1.6 km (1 mi) northwest of the site. No direct impacts would occur to this property by either construction or operational activities of the proposed RPF. Other off-site development actions could potentially result in direct or indirect impacts to NRHP-listed or -eligible historic or archaeological resources. Federal- and State-funded projects with such potential impacts on historic resources would require coordination with the SHPO, documentation, and mitigation measures, if warranted. Therefore, potential cumulative impacts to historic and archaeological resources are small.

19.4.14.3.6 Socioeconomics

Labor force and population – A number of other development projects have been proposed in Boone County that could have cumulative effects with the proposed RPF, depending on their scope and schedules for development. These projects would provide additional employment opportunities for construction workers and would increase the economic activity in the region. In addition to the road projects, the MU East Campus Chilled Water Plant, the addition to MU Memorial Stadium, the Odles' Discovery Park development, and the Columbia Regional Airport expansion all have the potential to increase economic activity in the region. The labor pool in the area is considered large enough that potential competition is not likely to lead to increased labor rates or require additional housing needs or public services. Thus, the cumulative socioeconomic impacts of these projects are expected to be small.

Utilities – Discovery Ridge utility service, including power, water, and sewage, has been designed to service the anticipated future tenants. No additional upgrades would be required. The cumulative impacts of these projects on utilities are expected to be small.

Tax base – The development of Discovery Ridge would increase the property values specific to the site and increase the local tax base. The RPF, if built at the Discovery Ridge site, would result in new, well-paying jobs. These jobs would also contribute to the tax base in the area. The overall tax revenues would be positive, but based on the overall tax base, the effects are anticipated to be small.

Transportation – No modifications to the local traffic infrastructure are necessary to support the construction and operation of the proposed RPF. The construction and occupation of the Odles' Discovery Park, Aspen Heights, Grove, and Den developments would likely increase traffic in the general area. However, the construction of Discovery Parkway and the other local road projects is designed to accommodate the increase in traffic associated with these projects. Therefore, cumulative effects to transportation infrastructure and traffic patterns are small.

19.4.14.3.7 Human Health

Nonradiological impacts – Construction of the RPF and the other construction projects considered include potential hazards to workers typical of any construction site. Normal construction safety practices would be employed to promote worker safety and reduce the likelihood of worker injury during construction.

Potential nonradiological public and occupational hazards pertaining to the operation of the RPF, the expansion of the Columbia Regional Airport, and the Odles' Discovery Park, Aspen Heights, Grove, and Den developments include emissions, discharges, and waste associated with the facilities and potential accidental spills/releases. Most of the chemical processes at the RPF would be conducted inside of the facility, limiting the potential effects on the public. Any wastes would be disposed offsite. The RPF would implement spill prevention/controls and air emission controls, as appropriate. The cumulative nonradiological health impacts are anticipated to be small.

Radiological impacts – Operation of the RPF would result in releases of small quantities of radionuclides to the environment. Gaseous effluent activity releases are discussed in Section 19.4.8.2.4. Direct dose to a member of the public at the fence line is due to gamma radiation penetrating the walls of the production facility and the waste staging and shipping facility. With the site shielding design, the direct dose outside of the buildings is small and decreases with increasing distance. The fence line is located at an appreciable distance from the two fixed sources of radiation (production facility building and waste staging and shipping building); therefore, the dose is negligible at the fence line.

19.4.14.3.8 Environmental Justice

No present or ongoing environmental justice actions were identified that are relevant to this analysis. Disproportionate impacts on low-income or minority populations from other actions are not expected. It is not anticipated that there would be any cumulative impacts on low-income or minority groups from construction and operation of the RPF. The cumulative impacts associated with environmental justice are considered small.