APPENDIX G
HUMAN HEALTH AND SAFETY - SUPPLEMENTAL INFORMATION CHARACTERIZING GENERAL PUBLIC AND FACILITY WORKER GROUPS

Introduction

This Appendix describes the affected General Public and Non-Licensed Facility Worker groups and the radiological impact assessment methodology used for the collective dose assessment for the No Action, Unrestricted Release, EPA/State-Regulated Disposal, and Limited Disposition Alternatives. This includes a description of the characteristics of each affected group and the assumed dispositions of each solid material under each Alternative upon which the collective dose assessment for each Alternative and solid material is based.

1. No Action, Unrestricted Release, and Limited Dispositions Alternatives

General Public

<u>Concrete</u>

The only end use of recycled concrete that is analyzed in this Draft GEIS is its use for road construction. The affected General Public groups for the No Action, Unrestricted Release, and Limited Dispositions Alternatives were identified for this end use and potential collective dose was estimated based on driving on roads containing recycled material. Road bed construction was selected as the single end use based on research conducted into the disposition of recycled concrete in commerce. Approximately 85 percent of recycled concrete rubble is used in road construction. The use of concrete rubble is limited because reclaimed concrete is not pure Portland concrete, but rather a mixture of concrete, soil, some amounts of bituminous concrete, and other small debris generated during demolition. The use of concrete with more than 15 percent reclaimed concrete has lead to problems in meeting quality specifications, resulting in its difficult use and workability. Besides road construction, reclaimed concrete is being used in bulk fill applications on land and water, as riprap for shoreline protection, as trench backfill, as a mix in asphaltic concrete, and in revetments for fieldwork and mining. It is expected that such uses would result in much lower exposures and collective doses as compared to the construction and use of road bed made with reclaimed concrete. No general usage of this recycled material as an aggregate for concrete used in building construction was identified in the course of the research conducted for the Draft GEIS.

The selection of road bed construction as the single end use for recycled concrete analyzed in the Draft GEIS is based on research conducted into the disposition of recycled concrete in commerce. USGS reported that in 1997 68 percent of concrete rubble that is recycled was used directly for road base construction, and reported that recycled concrete rubble is also used in new concrete mixes (6 percent), general fill and related “low value” applications (7 percent), asphalt hot mixes (9 percent), “high value” rip rap aggregate (3 percent) and other unclassified applications (7 percent) [USGS 2000a; USGS 1998a]. USGS allocated these applications into three general categories for the purposes of developing a material flow analysis: road base and other related applications; bituminous concrete; and cement concrete.

While recycled concrete is used to a limited extent as an aggregate in portland cement concrete for highway construction, no general usage of this recycled material as an aggregate for concrete used in building construction was identified. A representative of Southern Crushed Concrete Inc.—a company that recycles concrete—knew of no use of recycled concrete as aggregate in new concrete mixes for buildings. He believed that recycled aggregate was not used in buildings because of structural concerns as compared to concrete with virgin aggregate. The company had been involved in a highway project in Texas, where 30 percent of the virgin aggregate was replaced with aggregate from recycled concrete (Miller 2001). The view that reclaimed concrete was not used as an aggregate in concrete used to construct buildings was confirmed by an official of the Construction Materials Recycling Association (Turley 2002). Therefore analysis of recycling of concrete to make building material is not included in the Draft GEIS.

General Public exposure pathways for use of the concrete rubble for road construction include direct radiation exposure to drivers on roads built using recycled concrete and exposure to surface water/drinking water affected by leachate from landfill disposal of concrete dust generated by concrete recycling activities. Drivers on roads built using recycled concrete would be exposed to direct radiation from the radionuclide content of the material, but would not be exposed through inhalation or ingestion. Persons in the vicinity of landfills where concrete dust generated by concrete recycling activities was disposed of would be exposed through ingestion of surface water or drinking water affected by leachate from landfill concrete dust disposal, however, these exposure pathways are not included in the collective dose assessment because it is assumed that 100 percent of the activity in the released concrete is contained in the recycled material used for road bed, and this single exposure pathway would result in a higher collective dose than dividing the activity among multiple pathways. General Public exposure parameters for the No Action Alternative, Unrestricted Release Alternative, and Limited Dispositions Alternative for concrete are listed in Table G-1.

Table G-1 Concrete End Use General Public Exposure Parameters

No Action Alternative, Unrestricted Use Alternative, and Limited Dispositions Alternative	Product mass (t)	Mass of material (t)	Fraction of material (%)	Occupancy	Exposure Duration (person-h/y)	
					Individual	Integrated
Driving on road made from RCM[a]	—	385	38.5	—	—	2,154

a - Recycled concrete material
Source: NUREG-1640 (NRC 2003d).

Ferrous Metal

The affected General Public groups for the No Action and Unrestricted Release Alternatives for ferrous metal are based on the anticipated end uses for recycled ferrous metal. General Public exposure pathways for the collective dose assessment are limited to direct radiation exposure from use of end use products containing recycled ferrous metal and use of byproducts (e.g., furnace slag cement) generated by recycling processes. Recycling of scrap ferrous metal could also result in General Public radionuclide exposure through air emissions and surface water and groundwater discharges from generation and handling of scrap ferrous metal at the licensed facility site, recycling of the scrap ferrous metal into finished recycled ferrous metal, processing of the finished ferrous metal into end use products (e.g., automobiles, home appliances, building materials), and processing and landfill disposal of wastes (e.g., EAF baghouse dust) generated by ferrous metal recycling processes. General Public exposure parameters are listed in Table G-2. The affected General Public groups for disposal of ferrous metal under the Limited Dispositions Alternative are discussed under the EPA/State-Regulated Disposal Alternative.

Table G-2 Ferrous Metal End Uses and General Public Exposure Parameters

No Action Alternative and Unrestricted Release Alternative	Product mass (t)	Mass of material (t)	Fraction of material (%)	Occupancy	Exposure Duration (person-h/y)	
					Individual	Integrated
Driving on slag road	—	35.8	30.6	—	—	125
Slag cement basement	61.2	4.5	3.0	1.78	4,200	430
Occupying automobile	0.927	253	28.1	1.59	351	153,000
Office building	7.18	427	47.4	16	2,000	1,900,000
Office furniture	0.544	9	1.0	3	2,000	99,200
Home appliances	0.288	93.6	10.4	1.78	633	464,000
Sleeping on bed	0.037	11.4	0.8	1.78	3,180	1,100,000
Sailor—operations	17,900	9	0.6	447	—	—
Sailor—deck duty	17,900	9	0.6	200	—	—

Source: NUREG-1640 (NRC 2003d)

The selection of specific end uses of recycled ferrous metal for analysis in the Draft GEIS is based on research into the disposition of recycled ferrous metal in commerce. The dose assessment calculations are based on the percentages of finished recycled ferrous metal that is used in various end uses. The total mass and activity of recycled ferrous metal generated from licensed facilities under the No Action and Unrestricted Release Alternatives is distributed amongst the various end uses for the purposes of the dose assessment. The percentages of finished ferrous metal used in various end uses is based on analysis of data on steel end-use markets obtained from the 2001 American Iron and Steel Institute (AISI) report AIS 16, “Shipments of Steel Products by Market Classification” (AISI, 2001). The AIS 16 report data, as reported and applied for the purposes of the collective dose assessment, are summarized in Table G-3.

The AIS 16 report provides a breakdown of the categories and subcategories of end use products and applications in which finished steel was used in 2001. The AIS 16 report data indicate that the construction and automotive sectors are responsible for over two-thirds of total domestic steel consumption. The subcategory data for the automotive category indicate that the majority of the steel is used in “vehicles, parts and accessories,” therefore “Automobile Users” was selected as the representative “affected environment” for this end use category. The Automobile User end use encompasses the Shipbuilding and Aircraft categories and the “passenger car” Rail Transportation sub-categories, as these are also transportation-related categories. This resulted in the steel consumption percentage for the Automobile User end use increasing from 14.2 percent to 28.1 percent, as shown in Table G-3.

Table G-3 Steel Mass/Activity Distribution

Category		AIS 16 Data	Adjusted Percentage	End Use
1	Steel for converting and processing	10.4%	—	—
2	Forgings (NEC)	0.7%	—	—
3	Industrial fasteners	0.4%	0.7%	Building
4	Steel service centers & distributors	27.4%	—	—
5	Construction & contractors' products	21.8%	43.1%	Building
7[a]	Automotive	14.2%	28.1%	Automobile
8	Rail transportation	1.0%	2.0%	Rails, Freight Railcars[b,d]
9	Shipbuilding and marine equipment	0.3%	0.6%	Automobile
10	Aircraft & aerospace	0.0%	0.0%	Automobile
11	Oil & gas industry	3.0%	5.9%	Equipment [d]
12	Mining, quarrying, and lumbering	0.2%	0.3%	Equipment [d]
13	Agriculture	0.7%	1.3%	Building
14	Machinery, industrial equipment & tools	1.5%	2.9%	Building
15	Electrical equipment	1.7%	3.4%	Equipment [d]
16	Appliances, utensils, & cutlery	1.8%	3.6%	Miscellaneous
17	Other domestic and commercial equipment	0.7%	1.5%	Miscellaneous
18	Containers, packaging and shipping equipment	3.3%	6.5%	Miscellaneous[c]
19	Ordnance & other military	0.0%	0.1%	Equipment [d]
20	Export	2.6%	—	—
	Non-classified Shipments	8.4%	—	—
	Total	100.0%	100.0%	—

[a] AIS 16 does not contain a category 6.
[b] Except for the "Passenger Rail Car" subcategory, which is allocated to the "Automobile" Category
[c] Except for the "Compressed Gas Cylinders" subcategory, which is assumed to have No General Public Dose
[d] There is No General Public Dose associated with equipment

Source: AISI 2001.

The subcategory data for the construction category do not specify which subcategories of construction used the majority of steel, only that the steel was used in "general construction." Therefore, "Office Workers" was selected to be the representative "affected environment" for the construction category. Office Workers would typically spend approximately one fourth of their time within the office building. Other general construction projects (e.g., bridges) would have few, if any, people in the vicinity for any length of time. The Office Worker end use encompasses other work place-related categories, including Industrial Fasteners, Agriculture, and Machinery. This resulted in the steel consumption percentage for the Office Worker end use increasing from 43.1 percent to 48.0 percent.

Several categories included in the AIS 16 report data involve utilization of steel in end use locations that are essentially removed from contact with the general public. Examples include "Oil & Gas Industry", 'Mining", 'Electrical Equipment" (e.g., transmission towers), Rail Transportation (subcategories other than passenger rail cars), and Containers (compressed gas cylinder subcategory). These categories are assumed to have no significant potential for public exposure.

The remaining end use categories in the AIS 16 report are Appliances, Utensils, and Cutlery; Other Domestic and Commercial Equipment; and Containers, Packaging and Shipping Equipment. Three end use scenarios have been selected to represent these three categories. The Appliances, Utensils, and Cutlery category is represented by Home Appliances, specifically use of domestic kitchen ranges, dishwashers, and refrigerators manufactured from recycled steel scrap in a residential kitchen. This end use was selected for analysis because a kitchen range, dishwasher, and refrigerator collectively contain a large amount of steel (as opposed to kitchen utensils, cookware, and cutlery) and the primary exposure pathway from steel is direct radiation exposure, not leaching of radionuclides from the steel article into prepared food (USGS 2000a), and also because persons in a residential location spend a significant amount of their time at home in the kitchen.

The Other Domestic and Commercial Equipment category is represented by two subcategories - Domestic Beds and Office Furniture. The Domestic Beds end use includes a bed frame, box spring, and mattress, manufactured from recycled steel and used in a residential bedroom. This end use was selected for analysis because persons in a residential location would spend approximately one third (8 hours) of their time sleeping. The Office Furniture end use includes office desks and cabinets manufactured from recycled steel scrap and used in a typical office environment. This end use was selected for analysis because typical office workers would spend approximately one-fourth of their time at work, and office furniture contains a significant amount of steel. The percentage of steel utilization from these three AIS 16 report categories (including the amount of steel reported in the Containers, Packaging and Shipping Equipment category, other than the compressed gas cylinder subcategory) was apportioned to the three end uses selected for analysis based upon the actual amount of steel used in bed and office furniture production, as reported in the subcategory data, with the remainder of the steel consumption being allocated to the home appliances end use, which is not reported as a separate subcategory in the AIS 16 report.

The end uses selected for analysis, along with the fraction of activity (i.e., steel) allocated to each end use, are shown in Table G-4. This Draft GEIS has not attempted to categorize every potential end use of recycled ferrous metal, because the number of end uses is too diverse to

Table G-4 Final Ferrous metal Mass/Activity Distribution

End Use	Fraction	Tons (2001)
Building	48.0%	46,290,974
Automobile	28.8%	27,777,647
Miscellaneous	11.4%	10,990,447
Home Appliances	9.6%	9,233,301
Bed Springs	0.8%	754,650
Office Furniture	1.0%	1,002,496
Negligible dose to general public [1]	11.8%	11,345,338
Total	100.0%	96,404,406

facilitate a collective dose analysis. The end uses are intentionally categorized into broad categories that represent the most common uses of recycled scrap ferrous metal and a reasonable estimate of the resultant collective dose exposures associated with those end uses.

Recycling of scrap ferrous metal involves smelting operations and other processes that generate airborne emissions, including particulate emissions from ferrous metal recycling furnace air emissions control equipment. The collective dose assessment includes transport of radionuclides that are not removed from the furnace gas by the air emissions control equipment and that are emitted to the atmosphere. These particulate radionuclides are assumed to deposit on the ground in the vicinity of the steel mill and result in exposure through both inhalation of the particulate and direct radiation from radionuclides deposited on the ground. Deposited radionuclides also result in General Public exposure through uptake of radionuclides from the soil into food, including meat, milk, and vegetables.

Recycling furnace operations also generate Electric Arc Furnace (EAF) baghouse dust and furnace slag waste products. Furnace slag may either be disposed of in landfills or used to make furnace slag cement. Furnace slag cement is typically used in road building and building construction, and drivers on roads built using furnace slag cement and occupants of buildings built using furnace slag cement would be exposed to direct radiation from the radionuclide content of the material. The exposure pathway for drivers on roads built using furnace slag cement is similar to the exposure pathway for drivers on roads built using recycled concrete.

Furnace slag, if not recycled into end use products, is typically disposed of in Subtitle D landfills, while EAF baghouse dust may be disposed of either in Subtitle D landfills or Subtitle C landfills, depending upon whether the EAF baghouse dust is treated prior to disposal. The landfill disposal of furnace slag and EAF baghouse dust generated from ferrous metal recycling processes could contribute radionuclides to leachate generated from the landfills in which those materials are

[1] Does not include disposal.

disposed. Migration of leachate to persons in the vicinity of landfills represents public exposure pathways for ferrous metal recycling.

Transportation of scrap ferrous metal from the points of generation to the ferrous metal recycling facilities, and transportation of finished ferrous metal and associated waste materials from the recycling facilities to the point of end use or disposal has the potential to expose persons along the transportation routes to direct radiation from the radionuclide content of the materials. Transportation of end use products also has the potential to expose persons to direct radiation. General Public exposure to direct radiation along material transportation routes represent public exposure pathways for ferrous metal recycling.

<u>Aluminum</u>

As discussed above, the overall collective dose associated with released aluminum for the No Action and Unrestricted Release Alternatives, including both Non-Licensed Facility Workers and the General Public is evaluated for the No Action, Unrestricted Release, EPA/State-Regulated Disposal, and Limited Dispositions Alternatives using a screening model, because the collective dose associated with the small amount of aluminum generated would be minimal as compared to the collective dose associated with ferrous metal.

<u>Copper</u>

As discussed above, the overall collective dose associated with released copper, including both Non-Licensed Facility Workers and the General Public is evaluated for the No Action, Unrestricted Release, EPA/State-Regulated Disposal, and Limited Dispositions Alternatives using a screening model, because the collective dose associated with the small amount of copper generated would be minimal as compared to the collective dose associated with ferrous metal.

<u>Trash</u>

The affected General Public groups for the No Action, Unrestricted Release, EPA/State-Regulated Disposal, and Limited Dispositions Alternatives for trash are based on the anticipated transportation to and disposal of trash in an EPA/State-regulated Subtitle D landfill. The radionuclide transport and exposure pathways for Subtitle D landfill disposal of trash are the same as for Subtitle D landfill disposal of concrete, ferrous metal, aluminum, and copper, described above, and include surface water and groundwater transport pathways. The collective dose from the incineration of trash is not assessed under the No Action Alternative, Unrestricted Release Alternative, and Limited Dispositions Alternative, but is assessed under the EPA/State-Regulated Disposal Alternative discussed below.

Non-Licensed Facility Workers

These workers are members of the public who may experience work-related exposure while handling or otherwise encountering released material at their place of employment. Examples of these individuals include workers in scrap yards, iron and steel mills, EPA/State-regulated landfills, and EPA/State-regulated incinerators; truck drivers transporting released material; and building and road construction workers utilizing released material or byproducts of processing released material. Truck drivers transporting LLW to LLW disposal facilities are not workers situated at licensed facilities and are therefore categorized for the purposes of the Draft GEIS as Non-Licensed Facility Workers.

Concrete

Non-Licensed Facility Worker activities and groups of affected workers for the No Action, Unrestricted Release, and Limited Dispositions Alternatives for concrete are based on a single end use for recycled concrete, use as road building material. Non-Licensed Facility Worker activities include processing of the concrete rubble into road building material at satellite facilities, transportation of concrete rubble, and application of the road building material. Disposal of concrete dust generated from concrete recycling activities and transportation of wastes generated from processing and road building activities are not included in the collective dose assessment. The amount of concrete dust that can become airborne depends mainly on its moisture content, physical properties, and engineered measures used to minimize such releases. The analysis assumed that the amounts of materials released via fugitive emissions are small, such releases are short-lived in duration, and long-term exposures associated with end uses are dominant in terms of collective doses. One hundred percent of the activity in the concrete is assumed to contribute to the collective dose through its end use application. Non-Licensed Facility Worker activities and parameters for concrete are listed in Tables G-5 and G-6.

Table G-5 Non-Licensed Facility Workers Activity Characteristics - Concrete

No Action Alternative, Unrestricted Release Alternative, and Limited Disposition Alternative	Fraction of material (%)	Nominal productivity (t/y)	Work year (h/y)	Work hours per kt of material
Process Activities				
Processing concrete rubble at satellite facility	100	42,525	1,500	29.4
Building road using recycled concrete	50	22,250	1,500	19.5

a Anigstein et al. 2001, Chapter 5
b Tons of scrap consumed by EAF per worker per year
Source: NUREG-1640 (NRC 2003d)

Table G-6 Non-Licensed Facility Workers Activity Characteristics - Concrete

No Action Alternative, Unrestricted Release Alternative, and Limited Disposition Alternative	Distance (mi)	Speed (mph)	Fraction of material (%)	Total mass of material (t)	Work hours per kt of material
Transportation Activities					
Truck driver hauling concrete rubble	231	50	100	1,000	231

a Average duration of trip = 1¼ h
b Based on 58 percent of ferrous metal scrap being consumed by EAF mills and assuming that the dust is evenly divided between the two representative types of truck trailers
c Comprises 4.40 h driving, 3.74 h sleeping in berth, 0.08 h standing by during loading and unloading

Source: NUREG-1640 (NRC 2003d)

Materials Recycling Association (Turley 2002). Therefore analysis of recycling of concrete to make building material is not included in the Draft GEIS.

<u>Ferrous Metal</u>

Non-Licensed Facility Worker activities and groups of affected workers for the No Action and Unrestricted Release Alternatives for ferrous metal are based on the anticipated end uses for recycled ferrous metal and the anticipated processes that would be used in recycling ferrous metal. Non-Licensed Facility Worker activities for ferrous metal include activities associated with transporting the ferrous metal scrap to recycling facilities, recycling of the scrap into finished recycled ferrous metal, processing of the finished ferrous metal into end use products (e.g., automobiles, home appliances, building materials), installation of end use products (e.g., building materials), processing and disposal of wastes (e.g., EAF baghouse dust) generated by recycling processes, processing and use of byproducts (e.g., furnace slag) generated by recycling processes, and transportation of the materials, byproducts, and wastes generated from these activities. Non-Licensed Facility Worker activities and parameters for ferrous metal are listed in Tables G-7 and G-8. The affected Non-Licensed Facility Worker groups for disposal of ferrous metal under the Limited Dispositions Alternative are discussed under the EPA/State-Regulated Disposal Alternative.

<u>Aluminum and Copper</u>

Inventory information on other metals, besides ferrous, indicated these were primarily copper or aluminum, and present in insignificant amounts as compared to ferrous metals. Non Licensed Facility Worker activities for aluminum and copper that would contribute to the collective dose are similar to those for ferrous metal. NUREG-1640 considers dose factors for both copper and aluminum for individual dose estimating purposes. However, regarding collective dose, the detailed results were developed for ferrous metal and the small amounts of copper and aluminum inventory were evaluated using a scoping analysis. A detailed dose assessment was not

Table G-7 Non-Licensed Facility Worker Activity Characteristics – Ferrous metal

No Action Alternative and Unrestricted Release Alternative	Fraction of material (%)	Nominal productivity (t/y)	Work year (h/y)	Work hours per kt of material
Process Activities				
Processing steel scrap at scrap yard	100	1,568–1,950	1,500	323
Handling slag at steel mill	100	400[b]	1,000	200
Handling metal product at steel mill or foundry	100	400[b]	1,500	300
Crane operator (at EAF mill)[a]	100	400[b]	1,750	350
EAF furnace operator[a]	100	400[b]	1,750	350
Operator of continuous caster (at EAF mill)[a]	100	400[b]	1,750	350
Transferring EAF dust at steel mill	58	—	—	0.324
EAF Baghouse maintenance	58	—	27.5	0.024
Processing EAF dust	58	4,990	1,000	1.73
Processing steel slag for road construction	30.6	6,111	1,000	5.86
Handling BOF/foundry dust at landfill	42	4,067	1,500	1.57
Handling slag at landfill	61.5	4,067	1,500	26.6
Handling EAF dust at landfill	58	4,067	1,500	1.29
Building road using steel slag	30.6	35,328	2,000	2.02

a Anigstein et al. 2001, Chapter 5
b Tons of scrap consumed by EAF per worker per year
Source: NUREG-1640 (NRC 2003d)

Table G-8 Non-Licensed Facility Workers Activity Characteristics - Ferrous metal

No Action Alternative and Unrestricted Release Alternative	Distance (mi)	Speed (mph)	Fraction of material (%)	Total mass of material (t)	Work hours per kt of material
Transportation Activities					
Truck driver hauling steel scrap	[a]		100	1,000	62.5
Truck driver hauling slag	60	45	100	117	10
Truck driver hauling EAF dust in dry bulk trailer	1,022	50	29[b]	4.31	4.4
Truck driver hauling EAF dust in dump trailer	1,022	50	29[b]	4.31	8.22[c]
Truck driver hauling steel products	276	50	100	900	248

a Average duration of trip = 1¼ h (as reported in NUREG-1640 (NRC 2003d).
b Based on 58 percent of steel scrap being consumed by EAF mills and assuming that the dust is evenly divided between the two representative types of truck trailers
c Comprises 4.40 h driving, 3.74 h sleeping in berth, 0.08 h standing by during loading and unloading
Source: NUREG-1640 (NRC 2003d)

performed for aluminum and copper because of the small amount of aluminum and copper generated compared to ferrous metal. The results indicate that collective dose for copper and aluminum are about one to two orders of magnitude lower than that of ferrous metals for all alternatives.

Trash

Non-Licensed Facility Worker activities for trash for the No Action, Unrestricted Release, and Limited Dispositions Alternatives include truck drivers transporting trash to EPA/State-regulated disposal facilities and the EPA/State-regulated disposal facility workers that dispose of the trash at the facility. There are no end uses for trash other than EPA/State-regulated disposal considered in the Draft GEIS, and therefore Non-Licensed Facility Worker activities for trash are similar to those described below for trash for the EPA/State-Regulated Disposal Alternative. NRC has assumed that trash generated from licensee facilities will not be reused in commerce and will not be recycled into commerce. Sorting and handling of the trash may be conducted prior to transportation and disposal. The exposure parameters for these activities are anticipated to be similar to the activities conducted by survey workers for trash and result in similar exposure to Non-Licensed Facility Workers as for Licensed-Facility Workers.

2. EPA/State-Regulated Disposal Alternative

Non Licensed Facility Workers

Concrete

Non-Licensed Facility Worker activities and groups of affected workers for the EPA/State-Regulated Disposal Alternative for concrete are based on the activities associated with processing and transportation and disposal of concrete in a EPA/State-regulated Subtitle D landfill. These include activities associated with processing concrete rubble at satellite facilities, transportation of the concrete rubble to the landfill, and unloading and disposal of the concrete rubble by landfill workers. Non-Licensed Facility Worker activities and parameters for the EPA/State-Regulated Disposal Alternative for concrete are listed in Tables G-9 and G-10.

Ferrous metal

Non-Licensed Facility Worker activities and groups of affected workers for the EPA/State-Regulated Disposal Alternative, and also the Limited Dispositions Alternative, for ferrous metal are based on the activities associated with transportation and disposal of ferrous metal scrap in a EPA/State-regulated Subtitle D landfill. These include activities associated with transportation of the ferrous metal scrap to the landfill, and unloading and disposal of the ferrous metal scrap by landfill workers. Non-Licensed Facility Worker activities and parameters for the EPA/State-Regulated Disposal Alternative and Limited Dispositions Alternative for ferrous metal are listed in Tables G-11 and G-12.

Table G-9 Non-Licensed Facility Worker Activity Characteristics – Concrete

EPA/State-Regulated Disposal Alternative	Fraction of material (%)	Nominal productivity (t/y)	Work year (h/y)	Work hours per kt of material
Process Activities				
Processing concrete rubble at satellite facility	100	42,525	1,500	29.4
Handling concrete rubble at landfill	50	4,067	1,500	184

a Anigstein et al. 2001, Chapter 5
Source: NUREG-1640 (NRC 2003d)

Table G-10 Non-Licensed Facility Worker Activity Characteristics – Concrete

EPA/State-Regulated Disposal Alternative	Distance (mi)	Speed (mph)	Fraction of material (%)	Total mass of material (t)	Work hours per kt of material
Transportation Activities					
Truck driver hauling concrete rubble	231	50	100	1,000	231

Source: NUREG-1640 (NRC 2003d)

Table G-11 Non-Licensed Facility Worker Activity Characteristics – Ferrous metal

EPA/State-Regulated Disposal Alternative and Limited Dispositions Alternative	Fraction of material (%)	Nominal productivity (t/y)	Work year (h/y)	Work hours per kt of material
Process Activities				
Handling ferrous metal scrap at a Subtitle D landfill	100	4,067	1,500	368

a Anigstein et al. 2001, Chapter 5
Source: NUREG-1640 (NRC 2003d)

Table G-12 Non-Licensed Facility Worker Activity Characteristics – Ferrous metal

EPA/State-Regulated Disposal Alternative and Limited Dispositions Alternative	Distance (mi)	Speed (mph)	Fraction of material (%)	Total mass of material (t)	Work hours per kt of material
Truck driver hauling ferrous metal scrap	[a]		100	1,000	62.5

a Average duration of trip = 1¼ h (as reported in NUREG-1640 (NRC 2003d).
Source: NUREG-1640 (NRC 2003d)

Aluminum and Copper

As discussed above, the overall collective dose associated with released aluminum and copper for both Non-Licensed Facility Workers and the General Public is evaluated for the No Action, Unrestricted Release, EPA/State-Regulated Disposal, and Limited Dispositions Alternatives using a screening model because the collective dose associated with the small amount of aluminum and copper generated would be minimal as compared to the collective dose associated with ferrous metal.

Trash

Non-Licensed Facility Worker activities and groups of affected workers for the EPA/State-Regulated Disposal Alternative for trash are based on the activities associated with transportation and disposal of trash in an EPA/State-regulated Subtitle D landfill and also with processing of trash in an EPA/State-regulated incinerator and subsequent disposal of incinerator ash in an EPA/State-regulated Subtitle D landfill. These include activities associated with transportation of trash to the landfill and unloading and disposal of the trash by landfill workers, and transportation of trash to the incinerator, processing of the trash in the incinerator, and disposal of the incinerator ash by landfill workers.

The collective dose assessment for trash for Non-Licensed Facility Workers accounts for work activities involving truck drivers hauling trash, trash disposal in a landfill, trash incineration and ash disposal in a landfill, and a crane operator loading trash into an incinerator.

Based on light water reactor (LWR) industry practices, separate waste streams for various types of scrap metals (e.g., plastic, wood, glass, etc.) are not considered for recycling. First, these materials may be thrown into a trash bin for disposal in landfills and not sorted out as is done for residential trash and recyclables. Secondly, the composition of LWR trash primarily (90 percent), in decreasing order, consists of plastics that are not of recyclable grades, paper, PVC, cloth, rubber, absorbent materials, and wood. Consequently, no analysis was made for separate types of trash. Only the composite category defined as “trash” was considered and analyzed for landfill disposal and incineration.

General Public

Potential exposure of the General Public associated with the EPA/State-Regulated Disposal Alternative for trash includes both disposal of the trash in Subtitle D landfills and disposal of the trash by incineration in EPA/State-regulated incinerators, and subsequent disposal of the incinerator ash in an EPA/State-regulated landfill.

Concrete

General Public exposure parameters for the EPA/State-Regulated Disposal Alternative for concrete is based on the radionuclide transport pathways associated with disposal of this material in an EPA/State-regulated Subtitle D landfill. NRC has assumed that concrete is not incinerable and that all EPA/State-regulated disposal of concrete would be to Subtitle D landfills. Radionuclide transport pathways associated with Subtitle D landfill disposal include groundwater and surface water transport pathways by which radionuclides could be transported from the landfill to the General Public. Processing of concrete, transportation of the concrete rubble to the landfill, and unloading of the concrete rubble by landfill workers have the potential to create fugitive dust emissions, however, these potential transport pathways are not evaluated in the collective dose assessment. The collective dose assessment is based on the assumption that one hundred percent of the activity associated with the released concrete transported to the General Public is transported through groundwater and surface water transport pathways and subsequently to drinking water and irrigation water. The collective dose assessment is based on exposure of the General Public through consumption of drinking water and consumption of food, including meat, milk, and vegetables, grown with irrigation water. This assumption provides for a higher collective dose than would partitioning the transport between the groundwater and surface water transport pathways and the air (fugitive dust) pathway.

Ferrous Metal, Aluminum, and Copper

General Public exposure parameters for the EPA/State-Regulated Disposal Alternative and the Limited Dispositions Alternatives for ferrous metal, aluminum, and copper are based on the radionuclide transport pathways associated with disposal of these materials in a EPA/State-regulated Subtitle D landfill. NRC has assumed that these solid materials are not incinerable and that all EPA/State-regulated disposal of these materials under the EPA/State-Regulated Disposal Alternative and the Limited Dispositions Alternative would be to Subtitle D landfills. Radionuclide transport pathways associated with Subtitle D landfill disposal include groundwater and surface water transport pathways by which radionuclides could be transported from the landfill to the General Public. The collective dose assessment is based on exposure of the General Public through consumption of drinking water and consumption of food, including meat, milk, and vegetables, grown with irrigation water. This assumption provides for a higher collective dose than would partitioning the transport between the groundwater and surface water transport pathways and the air (fugitive dust) pathway.

<u>Trash</u>

The radionuclide transport and exposure pathways for Subtitle D landfill disposal of trash are the same as for Subtitle D landfill disposal of concrete, ferrous metal, aluminum, and copper, described above, and include surface water and groundwater transport pathways. The radionuclide transport and exposure pathways for incineration of trash include exposures associated with air emissions from trash incineration and exposures associated with releases of landfill leachate to surface water and groundwater from landfill disposal of both trash and incinerator ash.

The collective dose assessment for incineration of trash includes transport of radionuclides that are not removed from the incinerator off gas by the air emissions control equipment and that are emitted to the atmosphere. These particulate radionuclides are assumed to deposit on the ground in the vicinity of the incinerator and result in General Public exposure through both inhalation of the particulate and direct radiation from radionuclides deposited on the ground. Deposited radionuclides also result in General Public exposure through uptake of radionuclides from the soil into food, including meat, milk, and vegetables.

3. Radiological Impact Assessment Methodology

An assessment of the potential radiation dose to critical groups was conducted in NUREG-1640. A critical group is defined as the group receiving the highest mean dose from among all of the exposure pathways associated with the given type of material (e.g., ferrous metal, concrete, trash) for the Alternative. The critical group for a given material and a given Alternative may be a group of members of the General Public exposed to radiation from end use products made from recycled material, or a group of Non-Licensed Facility Workers exposed to radiation from disposal of the materials in Subtitle D landfills. The critical group dose assessment for the Limited Dispositions Alternative for concrete is based on use of recycled concrete in road bed, as are the assessments for the No Action and Unrestricted Release Alternatives. The critical group dose assessment for ferrous metal, concrete, aluminum, and trash for the Limited Dispositions Alternative is based on disposal of these materials in an EPA/State-regulated landfill. The level of radiation exposure to the critical group is directly related to the dose limit associated with the Alternative. For a dose limit of 1 mrem/yr, for example, no critical group would experience a radiation dose greater than 1 mrem/yr.

Collective dose considers the amount of radiation, time of exposure, and number of individuals exposed and is reported in units of “person-rem.” The collective dose report (SC&A 2003) provided estimates of collective doses to the Licensed Facility Workers, Non-Licensed Facility Workers, and the General Public. Details of this collective dose assessment are provided in Appendix D.

Concrete

Figure G-1 illustrates the radiation exposure scenarios for concrete for all the Alternatives. The collective dose assessment for concrete for the No Action, Unrestricted Release, and Limited Dispositions Alternatives evaluates the collective dose associated with the recycling of concrete into road bed material. The collective dose assessment for concrete for the EPA/State-Regulated Disposal Alternative evaluates the collective dose associated with disposal of the concrete in Subtitle D landfills.

Ferrous Metal

Figure G-2 illustrates the radiation exposure scenarios for ferrous metal for all the alternatives. The collective dose assessment for ferrous metal for the No Action and Unrestricted Release Alternatives evaluates the collective dose associated with the recycling of ferrous metal into various end use products. The collective dose assessment for ferrous metal for the EPA/State-Regulated Disposal and Limited Dispositions Alternatives evaluates the collective dose associated with disposal of the ferrous metal in Subtitle D landfills.

Trash

Figure G-3 illustrates the radiation exposure scenarios for trash for all the alternatives. The collective dose assessment for trash for the No Action, Unrestricted Release, and Limited Dispositions Alternatives evaluates the collective dose associated with the disposal of trash in an EPA/State-regulated Subtitle D landfill. The collective dose assessment for trash for the EPA/State-Regulated Disposal Alternative evaluates the collective dose associated with disposal of the trash in Subtitle D landfills and with disposal of the trash in an EPA/State-regulated incinerator and subsequent disposal of the incinerator ash in an EPA/State-regulated landfill. There are no recycling or reuse scenarios for trash included in the collective dose assessment. Even if there were some recycling of this trash, its amount, compared to the much larger volumes of other materials intended for recycling, would be insignificant in terms of collective doses. The collective dose assessment accounts for work activities involving truck drivers hauling trash, trash disposal in a landfill, trash incineration and ash disposal in a landfill, and crane operator loading trash into an incinerator. Doses to offsite receptors consider the impacts associated with effluent discharges from landfill and incinerator operations.

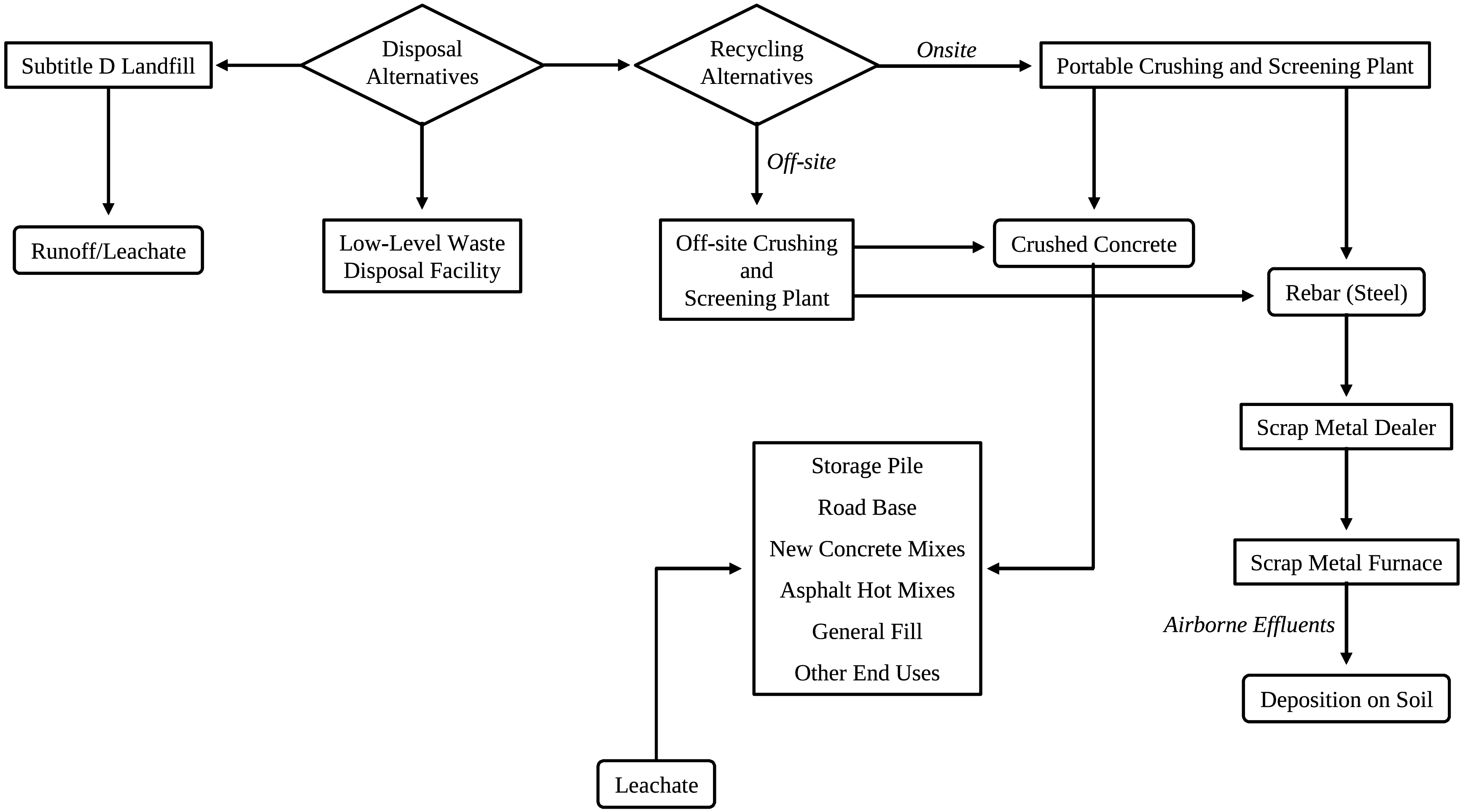
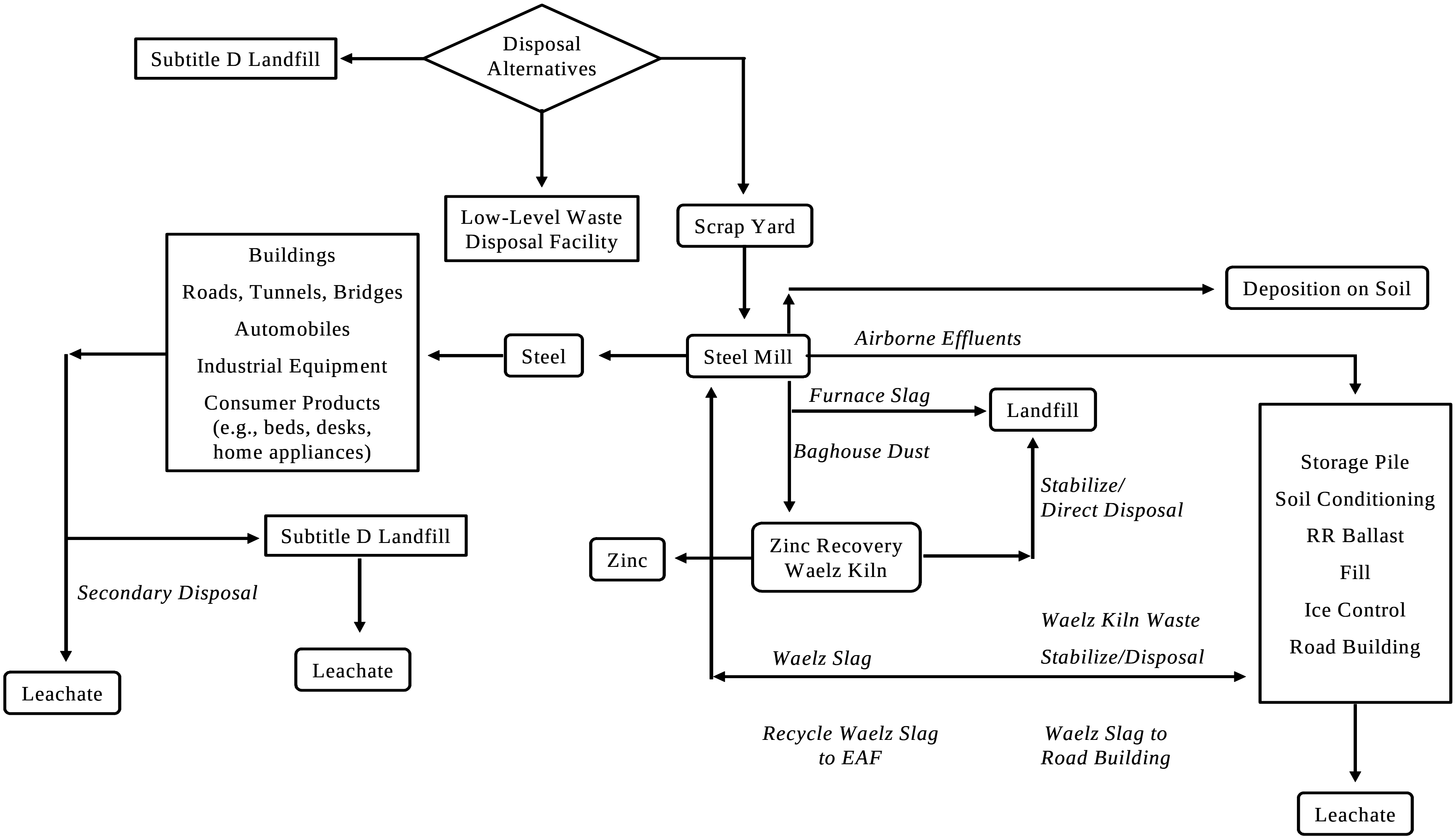


Figure G-1 Potential Exposure Scenarios for Concrete



1 **Figure G-2 Potential Exposure Scenarios for Ferrous Metal**

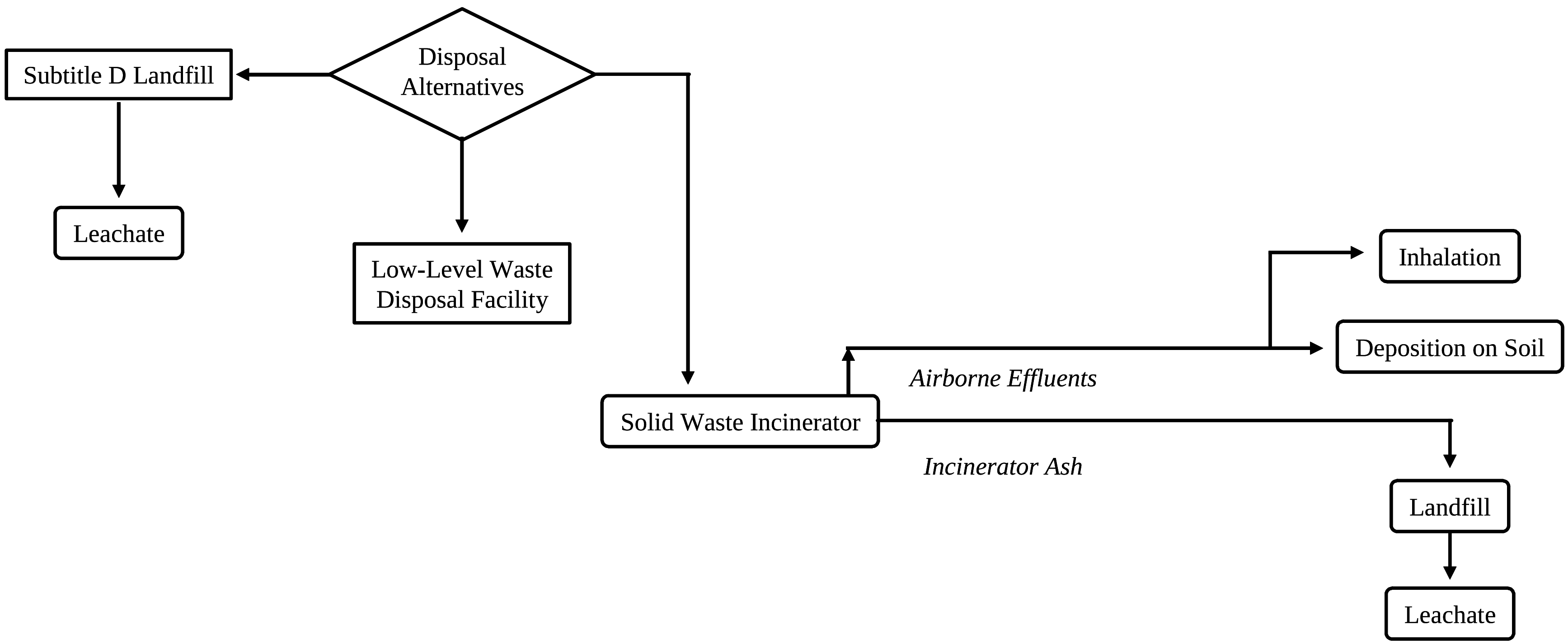


Figure G-3 Potential Exposure Scenarios for Trash