Appendix F
Biotic Resources

APPENDIX F
BIOTIC RESOURCES

This appendix presents the plant and animal species found in the Los Alamos National Laboratory (LANL) area by biological surveys as reported by Dunham (1995), Risberg (1995), and Keller and Risberg (1995). The lists (tables F-1, F-2, and F-3) may not be complete; some species in the LANL area may not have been found or identified during these surveys or, if listed, may not presently be found in the area.

REFERENCES CITED IN APPENDIX F

Dunham, D.A., 1995, *Draft Biological and Floodplain/Wetland Assessment for Environmental Restoration Program, Operable Unit 1086, TA-15,* LAUR-95-649 February 6, Los Alamos National Laboratory, Los Alamos, New Mexico.

Keller, D., 1995, *Draft Biological and Floodplain/Wetland Assessment for the Dual-Axis Radiographic Hydrodynamics Test Facility (DARHT)*, LAUR-95-647, July, Los Alamos National Laboratory, Los Alamos, New Mexico.

Larson, B., 1995, *Preliminary Cultural Resource Survey Report for Expanded DARHT Area*, LANL Memorandum to D. Webb (DOE/LAAO), Los Alamos National Laboratory, Los Alamos, New Mexico.

Risberg, D., 1995, *Draft Biological and Floodplain/Wetland Assessment for the Dual-Axis Radiographic Hydrodynamics Test Facility (DARHT)*, LAUR-95-649, February, Los Alamos National Laboratory, Los Alamos, New Mexico.

TABLE F-1.—*Checklist of Plants at TA-15*

Family	Scientific Name	Common Name
Aceraceae	*Acer glabrum*	New Mexico maple
	Acer negundo	Boxelder maple
Amaranthaceae	*Amaranthus retroflexus*[a]	Pigweed
Anacardiaceae	*Rhus trilobata*	Skunk bush
Asclepiadaceae	*Asclepias asperula*	Immortal
Berberidaceae	*Berberis fendleri*	Colorado barberry
Boraginaceae	*Cryptantha fendleri*	Fendler cryptantha
	C. jamesii	James hiddenflower
	Hackelia hirsuta	Beggarlice
	Lappula sp.[b]	Stickseed
	Lithospermum incisum	Fringed puccoon
	L. multiflorum	Puccoon
Cactaceae	*Echinocereus viridiflorus*	Strawberry cactus
	Opuntia polyacantha	Starvation cactus
	O. sp.[a]	Prickly pear cactus
Chenopodiaceae	*Atriplex canescens*	Fourwing saltbush
	Chenopodium album	Lamb's quarters
	C. graveolans	Goosefoot
	Kochia scoparia	Summer cypress
	Salsola kali	Russian thistle
Compositae	*Achillea lanulosa*	Western yarrow
	Ambrosia artemisiifolia	Common ragweed
	A. confertiflora	Ragweed
	A. coronopifolia	Ragweed
	Antennaria parvifolia	Pussytoes
	Artemisia carruthii	Wormwood
	A. dracunculus	False tarragon
	A. frigida[a]	Estafiata
	A. ludoviciana	Wormwood
	A. tridentata[a]	Big sagebrush
	Aster bigelovii	Bigelow aster
	A. novae-angliae	Aster
	Bahia dissecta	Wild chrysanthemum
	Berlandiera lyrata	Lyre leaf
	Brickellia californica	California brickellia
	B. sp.	Bricklebush
	Cichorium intybus	Chickory
	Chyrsopsis foliosa	Golden aster
	C. villosa	Golden aster
	Chrysothamnus nauseosus	Chamisa, Rabbitbrush
	Conyza canadensis	Horseweed
	Erigeron divergens	Fleabane daisy
	Grindelia aphanactis	Gumweed
	Gutierrezia sarothrae	Snakeweed
	Haplopappus spinulosus	Spiny goldenweed
	Helianthus petiolaris	Sunflower
	Hymenopappus filifolius	White ragweed
	Hymenoxys argentea	Perky Sue
	H. richardsonii	Bitterweed

TABLE F-1.—*Checklist of Plants at TA-15 – Continued*

Family	Scientific Name	Common Name
Compositae (Continued)	*Kuhnia chlorolepis*	Kuhnia
	Lactuca sp.	Prickly lettuce
	Machaeranthera bigelovii	Bigelow aster
	Pericome caudata	Taperleaf
	Psilostrophe tagetina	Paperflower
	Senecio eremophilus	Groundsel
	S. longilobus	Thread-leaf groundsel
	S. multicapitatus	Groundsel
	Stephanomeria tenuifolia	Skeleton weed
	Taraxacum officinale	Dandelion
	Thelesperma megapotamicum	Indian tea
	T. trifidum[a]	Greenthread
	Townsendia exscapa	Easter daisy
	Tragopogon dubius	Salisfy, Goatsbeard
	T. pratensis	Salsify
	Viguiera multiflora	Showy goldeneye
Cruciferae	*Capsella bursa-pastoris*	Shepherd's purse
	Descurania richardsonii	Tansy mustard
	Erysimum capitatum	Western wallflower
	Lepidium medium	Peppergrass
	Thlaspi alpestre	Mountain candytuft
Cupressaceae	*Juniperus monosperma*[a]	One-seed juniper
	J. scopulorum	Rocky Mountain juniper
Cyperaceae	*Carex sp.*	Sedge
Euphorbiaceae	*Croton texensis*	Doveweed
	Euphorbia serpyllifolia	Thymeleaf spurge
	E. sp.	Spurge
Fagaceae	*Quercus gambelii*	Gambel oak
	Q. undulata	Wavyleaf oak
	Q. sp.	Hybrid oak
Fumariaceae	*Corydalis aurea*	Golden smoke
Geraniaceae	*Erodium cicutarium*	Cranesbill
	Geranium caespitosum	James geranium
Gramineae	*Agropyron smithii*	Western wheatgrass
	Andropogon gerardii	Big bluestem
	A. scoparius	Little bluestem
	Aristida sp.	Three-awn
	Blepharoneuron tricholepis	Pine dropseed
	Bouteloua curtipendula[a]	Side-oats grama
	B. eriopoda	Black grama
	B. gracilis	Blue grama
	Bromus anomalus	Nodding brome
	B. tectorum	Downy Chess
	Elymus canadensis	Canada wildrye
	Festuca sp.	Fescue
	Koeleria cristata	Junegrass
	Lycurus phleoides	Wolftail
	Muhlenbergia montana	Mountain muhly
	Oryzopsis hymenoides	Indian rice grass
	Poa fendleriana	Bluegrass

TABLE F-1.—*Checklist of Plants at TA-15 – Continued*

Family	Scientific Name	Common Name
Gramineae (Continued)	*Poa sp.*	Blue grass
	Sitanion hystrix	Bottlebrush squirreltail
	Sporobolus contractus	Spike dropseed
	S. cryptandrus	Sand dropseed
	S. sp.	Dropseed
	Stipa comata	Needle and thread grass
Hydrophyllaceae	*Phacelia corrugata*	Scorpionweed
Labiatae	*Monarda menthaefolia*[a]	Beebalm
	M. pectinata	Ponymint
	Prunella vulgaris	Selfheal
Leguminosae	*Astragalus sp.*	Milkvetch
	Lotus wrightii	Deervetch
	Lupinus caudatus	Lupine
	Melilotus albus	Yellow sweet clover
	M. officinalis	Yellow wild clover
	Petalostemum candidum[a]	White prairie clover
	Robinia neomexicana[a]	New Mexico locust
	Trifolium sp.	Clover
	Vicia americana	American vetch
Liliaceae	*Allium cernuum*	Nodding onion
	Yucca angustissima	Narrowleaf yucca
	Y. baccata[a]	Datil yucca
Linaceae	*Linum lewisii*	Blue flax
	L. neomexicanum	New Mexico yellow flax
Loasaceae	*Mentzelia pumila*	Stickleaf
Malvaceae	*Sphaeralcea coccinea*	Red globe mallow
	S. sp	Scarlet globe mallow
Nyctaginaceae	*Mirabilis multiflora*	Showy four-o'clock
	Oxybaphus linearis	Desert four-o'clock
Oleaceae	*Forestiera neomexicana*	New Mexico olive
Onagraceae	*Oenothera albicaulis*	Evening-primrose
	O. coronopifolia	Cutleaf evening-primrose
	O. hookeri	Hooker's evening-primrose
Orobanchaceae	*Orobanche fasciculata*	Broomrape
Pinaceae	*Abies concolor*[a]	White fir
	Pinus edulis[a]	Piñon pine
	P. ponderosa	Ponderosa pine
	Pseudotsuga menzesii[a]	Douglas fir
Plantaginaceae	*Plantago purshii*	Wooly Indian wheat
Polemoniaceae	*Ipomopsis aggregata*	Scarlet trumpet
Polygonaceae	*Eriogonum cernuum*	Skelton weed
	E. jamesii	Antelope sage
	Rumex sp.	Dock
Portulacaceae	*Portulaca oleracea*[a]	Common purslane
Primulaceae	*Androsace septentrionalis*	Western rock-jasmine

TABLE F-1.—*Checklist of Plants at TA-15 – Continued*

Family	Scientific Name	Common Name
Ranunculaceae	*Clematis pseudoalpina* *Thalictrum fendleri*	Rocky Mountain clematis Meadowrue
Rosaceae	*Cercocarpus montanus*[a] *Fallugia paradoxa*[a] *Prunus virginiana var. melanocarpa* *Rosa woodsii*	Mountain mahogany Apache plume Western black chokecherry Fendler's rose
Rutaceae	*Ptelea trifoliata*	Narrowleaf hoptree
Salicaceae	*Populus angustifolia* *Salix sp.*[a]	Narrowleaf cottonwood Willow
Saxifragaceae	*Heuchera parvifolia* *Philadelphus microphyllus* *Ribes cererum* *R. inerme*	Alumroot Mockorange Wax Current Gooseberry
Scrophulariaceae	*Castilleja integra* *Penstemon barbatus* *P. virgatus* *Verbascum thapsus*	Indian paintbrush Scarlet bugler Beard tongue Mullein
Solanaceae	*Physalis foetens var. neomexicana*[a]	Ground cherry
Valerianaceae	*Valeriana acutiloba*	Valerian
Violaceae	*Viola adunca*	Western dog violet
Vitaceae	*Parthenocissus inserta*	Virginia creeper

[a] These plants have been known to be used historically by the Tewa Indians of New Mexico in the early part of the 20th century (Larson 1995).
[b] Sp. indicates that the exact species has not been identified in the field.

Source: Risberg 1995.

TABLE F-2.—*Fauna Found at TA-15*

Family	Scientific Name	Common Name
AMPHIBIANS		
Hylidae	*Hyla arenicolor*	Canyon treefrog
REPTILES		
Iguanidae	*Crotaphytus collaris*	Collared lizard
	Phrynosoma douglasii	Short-horned lizard
	Sceloporus undulatus	Eastern fence lizard
Scincidae	*Eumeces obsoletus*	Great Plains skink
Teiidae	*Cnemidophorus exsanguis*	Chihuahuan spotted whiptail
Viperidae	*Crotalus atrox*	Western diamondback rattlesnake
BIRDS		
Accipitridae	*Accipiter cooperii*	Cooper's hawk
	Buteo albonotatus	Zone-tailed hawk
	B. jamaicensis	Red-tailed hawk
Aegithalidae	*Psaltriparus minimus*	Bushtit
Apodidae	*Aeronautes saxatalis*	White-throated swift
Caprimulgidae	*Chordeiles minor*	Common nighthawk
	Phalaenoptilus nuttallii	Common poorwill
Carthartidae	*Cathartes aura*	Turkey vulture
Columbidae	*Zenaida macroura*	Mourning dove
Corvidae	*Aphelocoma coerulescens*	Scrub jay
	Corvus corax	Common raven
	Cyanocitta stelleri	Steller's jay
	Gymnorhinus cyanocephalus	Piñon jay
	Nucifraga columbiana	Clark's nutcracker
Emberizidae	*Aimophila ruficeps*	Rufous-crowned sparrow
	Coccothraustes vespertinus	Evening grosbeak
	Dendroica graciae	Grace's warbler
	D. nigrescens	Black-throated gray warbler
	Guiraca caerulea	Blue grosbeak
	Junco hyemalis	Dark-eyed junco
	Molothrus ater	Brown-headed cowbird
	Oporornis tolmiei	MacGillivray's warbler
	Pheucticus melanocephalus	Black-headed grosbeak
	Pipilo chlorurus	Green-tailed towhee
	P. erythrophthalmus	Rufous-sided towhee
	P. fuscus	Canyon towhee
	Piranga ludoviciana	Western tanager
	Spizella passerina	Chipping sparrow
	Vermivora celata	Orange-crowned warbler
	V. virginiae	Virginia's warbler
Falconidae	*Falco sparverius*	American kestrel
Fringillidae	*Cardeulis pinus*	Pine siskin
	Carpodacus mexicanus	House finch

TABLE F-2.—*Fauna Found at TA-15 – Continued*

Family	Scientific Name	Common Name
Fringillidae (Continued)	*C. psaltria*	Lesser goldfinch
	Loxia curvirostra	Red crossbill
Hirundinidae	*Tachycineta thalassina*	Violet-green swallow
	Hirundo pyrrhonota	Cliff swallow
Miscicapidae	*Catharus guttatus*	Hermit thrush
	Myadestes townsendi	Townsend's solitaire
	Polioptila caerulea	Blue-grey gnatcatcher
	Regulus calendula	Ruby-crowned kinglet
	Sialia mexicana	Western bluebird
	Turdus migratorius	American robin
Paridae	*Parus gambeli*	Mountain chickadee
	P. inornatus	Plain titmouse
Phasianidae	*Callipepla gambelii*	Gambel's quail
Picidae	*Colaptes auratus*	Northern flicker
	Melanerpes formicivorus	Acorn woodpecker
	Picoides pubescens	Downy woodpecker
	P. villosus	Hairy woodpecker
Sittidae	*Sitta pygmaea*	Pygmy nuthatch
Strigidae	*Bubo virginianus*	Great horned owl
	Otus flammeolus	Flammulated owl
	Strix occidentalis lucinda	Mexican spotted owl
Trochilidae	*Archilocus alexandri*	Black-chinned hummingbird
	Selasphorus platycercus	Broad-tailed hummingbird
Troglodytidae	*Catherpes mexicanus*	Canyon wren
	Salpinctes obsoletus	Rock wren
	Thryomanes bewickii	Bewick's wren
Tyarannidae	*Contopus borealis*	Olive-sided flycatcher
	C. sordidulus	Western wood-pewee
	Empidonax hammondii	Hammond's flycatcher
	E. oberholseri	Dusky flycatcher
	E. occidentalis	Cordilleran flycatcher
	E. wrightii	Gray flycatcher
	Myiarchus cinerascens	Ash-throated flycatcher
	Sayornis nigricans	Black phoebe
	S. saya	Say's phoebe
	Tyrannus vociferans	Cassin's kingbird
Vireonidae	*Vireo gilvus*	Warbling vireo
	V. solitarius	Solitary vireo
MAMMALS		
Canidae	*Canis latrans*	Coyote
	Vulpus vulpus	Red fox
Cervidae	*Cervus elaphus*	Elk
	Odocoileus hemionus	Mule deer
Muridae	*Neotoma mexicana*	Mexican woodrat
	Peromyscus boylei	Brush mouse
	P. maniculatus	Deer mouse

TABLE F-2.—*Fauna Found at TA-15 – Continued*

Family	Scientific Name	Common Name
Muridae (Continued)	*P. truei*	Piñon mouse
	Reithrodontomys megalotis	Western harvest mouse
Molossidae	*Tadarida brasiliensis*	Brazilian free-tailed bat
Vespertilionidae	*Antrozous pallidus*	Pallid bat
	Eptesicus fuscus	Big brown bat
	Lasionycteris noctivagans	Silver-haired bat
	Lasiurus cinereus	Hoary bat
	Myotis californicus	California myotis
	M. evotis	Long-eared myotis
	M. leibi	Small-footed myotis
	M. thysanodes	Fringed myotis
	M. volans	Long-legged myotis
	M. yumanensis	Yuma myotis
	Pipistrellus hesperus	Western pipistrelle
	Plecotus townsendi	Townsend's big-eared bat

For bird habitats see Travis, J. R., *Atlas of the Breeding Birds of Los Alamos County*, New Mexico Pajarito Ornithological Survey.

Source: Dunham 1995

TABLE F-3.—*Wintering Birds of Potrillo Canyon, February and March 1986*

Family	Scientific Name	Common Name
Accipitridae	*Buteo jamaicensis*	Red-tailed hawk
Columbidae	*Zenaida macroura*	Mourning dove
Corvidae	*Aphelocoma coerulescens*	Scrub jay
	Corvus corax	Common raven
Fringillidae	*Carpodacus mexicanus*	House finch
	Junco hyemalis	Dark-eyed junco
	Pipilo erythrophthalmus	Rufous-sided towhee
	P. fuscus	Brown towhee
Meleagrididae	*Meleagris gallopavo*	Wild turkey
Paridae	*Parus gambeli*	Mountain chickadee
	P. inornatus	Plain titmouse
Picidae	*Colaptes auratus*	Yellow-shafted flicker
	Picoides pubescens	Downy woodpecker
	P. villosus	Hairy woodpecker
	Sphyrapicus thyroideus	Williamson's sapsucker
Sittidae	*Sitta carolinensis*	White-breasted nuthatch
	S. pygmaea	Pygmy nuthatch
Troglodytidae	*Catherpes mexicanus*	Canyon wren
	Troglodytes aedon	House wren
Turdidae	*Myadestes townsendi*	Townsend's solitaire
	Sialia currucoides	Mountain bluebird
	S. mexicana	Western bluebird
	Turdus migratorious	American robin

For Bird habitats see Travis, J. R., *Atlas of the Breeding Birds of Los Alamos County*, New Mexico, Pajarito Ornithological Survey.

Source: Dunham 1995

Appendix G
Socioeconomics

APPENDIX G
SOCIOECONOMICS

G.1 REGIONAL ECONOMIC MODELING

The IMPLAN (Impact analysis for Planning) regional economic modeling system was used to construct a baseline economic model for the region-of-interest, and to measure the possible impacts of EIS alternatives on regional employment, labor income, and output of goods and services (MIG, Inc. 1993). The stock regional IMPLAN model uses Standard Industrial Classification (SIC) information provided by the Bureau of Economic Analysis (BEA) on employment, income, and production activities within the region-of-interest, which in this case is Los Alamos, Santa Fe, and Rio Arriba counties of north-central New Mexico.

IMPLAN employs a static, non-survey, input-output model which uses a 528-sector adaptation of the 538-sector BEA national input-output transactions table otherwise known as the "national table." This table was derived by BEA based on information from its national income and product accounts (NIPA accounts) covering the production and sales of all commodities. The most recent national table was released by BEA in 1994 and represents the industrial technologies in place in 1987. These values have been price-updated to 1994 constant dollars. IMPLAN provides the flexibility to update the 1987-level technology of any industry, as represented in the national table, to an improved representation of the technology currently being employed. IMPLAN also performs adjustments to the national table to permit regional tables to be constructed for application to any region of the country.

Among the more important considerations in applying the stock IMPLAN model are that: 1) the model is static in the sense of reflecting economic conditions and production technologies in place at a given point in time, with no allowance for technological changes; 2) the model uses exogenous estimates of "regional repurchasing coefficients," (RPCs) critical parameters reflecting the locally produced portion of goods or services used by industry in the region-of-interest; 3) the model characterizes all industrial production processes as requiring fixed proportional use of factors of production, making no allowances for input substitutions due to relative-price changes.

This stock IMPLAN model was modified to reflect 1993 levels of economic activity specific to the tri-county area based on two additional data files: 1) ES-202 employment data obtained from New Mexico Department of Labor, which covers 1993 annualized employment levels at the two-digit SIC level; and 2) published information on regional consumption expenditures made by LANL during FY 1992, as described in a DOE-funded study (Lansford et al. 1993). The modified IMPLAN model of the region-of-interest reflects these additional county-level data files and, correspondingly, the recent experience underlying employment and expenditures within the tri-county region.

The stock IMPLAN model was also adjusted to better approximate the local economic impacts of incremental construction and operations expenditures under each EIS alternative. These adjustments bear on the accuracy of IMPLAN's RPCs for heavy construction (SIC 16) and facility operations (SIC 28). Based on DARHT's local construction expenditures during FY 1993, IMPLAN's RPC for heavy construction was adjusted downward to 0.15 to reflect the fact that most of the value of Heavy Construction services is being procured from outside the region of influence, and in fact, from outside the state. This parameter adjustment provides a more realistic estimate of the RPC for heavy construction in the region-of-interest. On the contrary, IMPLAN's RPC for industrial facility operations was adjusted upward to 0.80. This upward adjustment reflects the understanding that most of PHERMEX's local expenditures are on specialized equipment made onsite at other LANL defense production facilities.

Given the above adjustments, the modified IMPLAN model was run with alternative expenditure scenarios in order to estimate the consequential impacts of the various EIS alternatives on regional employment, labor income, and output of goods and services. These alternative data sets reflect the following expenditures information provided by LANL: 1) annual capital and operating expenditures for the DARHT and PHERMEX facilities under each EIS alternative (tables G-1 and G-2) and 2) estimated duration of construction and timing of operations for the DARHT and PHERMEX facilities under each EIS alternative. Upon applying a DOE price escalation index for general construction and defense programs to these alternative expenditure projections, IMPLAN was run to estimate the consequential impacts of each DARHT alternative on employment, labor income, and output of goods and services in the region-of-interest for each year in the 1995 to 2002 period. These impacts are reported by year for that period (see table G-3).

Sums and products of numbers in this appendix may not appear consistent due to rounding.

G.2 ENVIRONMENTAL JUSTICE ANALYSIS

The geographic region underlying the analysis of environmental justice encompasses various Census tracts spanning four county boundaries, i.e., Los Alamos, Santa Fe, Rio Arriba, and Sandoval counties. Census tract boundaries within these counties are derived from a coverage of census block group boundaries provided by Geographic Data Technology, Lebanon, New Hampshire. This coverage was derived from the TIGER/Line Files of 1990 census geography provided by the U.S. Bureau of Census. In addition, the geographic region underlying the analysis of environmental justice encompasses the Native American reservations of the Cochiti, Santa Clara, Jemez, and San Ildefonso DOE/LANL accord tribes. The geographic boundaries of these reservations were derived from digital data provided by the Bureau of Indian Affairs.

Note that the scope of coverage used in the analysis excludes boundaries or locations of several categories of lands that are generally associated with tribal lands: 1) ceded lands (lands ceded to the U.S. Government to which some tribes retain treaty-protected rights); 2) possessory and usage areas that were established, in some cases, in the course of U.S. Land Claims Commission hearings; and 3) in-holdings within the tribal reservation boundaries. Such in-holdings are lands not held in trust for tribes. These may include fee lands owned by non-Indians, or public domain lands withdrawn from their former trust status (e.g., for National Park Service management or interstate highway rights-of-way).

Given the geographic coverage described above, the following demographic data were used to measure minority and low-income populations: total persons (100 percent count), total households, persons by race, persons by Race and Hispanic Origin, and household counts by income class. The data were extracted from Summary Tape File 3A of the 1990 decennial census, provided by the U.S. Bureau of Census for census block groups. Each block group is identified by its unique block group identifier and the Federal

TABLE G-1.—*Capital-funded Construction Costs by Alternative (in millions of 1995 dollars)*

Alternative	1995	1996	1997	1998	1999	2000	2001	2002	Total
No Action	6.6	5.8	1.0	0	0	0	0	0	13.4
DARHT Baseline	6.6	29.5	17.9	26.8	24.0	0.6	0	0	105.3
PHERMEX Upgrade	6.6	36.6	33.7	21.7	14.8	10.2	3.1	0	126.7
Enhanced Containment Vessel Option	6.6	29.6	32.4	41.1	24.9	0.6	0	0	135.2
Enhanced Containment Building Option (150 lb)	6.6	28.3	26.9	29.9	15.5	13.9	0.8	0	121.9
Enhanced Containment Building Option (500 lb)	6.6	29.1	40.5	33.2	15.5	13.9	0.8	0	139.5
Enhanced Containment Phased Option	6.6	30.6	21.9	34.4	30.1	6.7	5.8	5.8	142.0
Plutonium Exclusion	6.6	29.5	17.9	26.8	24.0	0.6	0	0	105.3
Single Axis	6.6	29.5	17.9	5.7	0	0	0	0	59.6

Notes: The underlying capital funded cost data were provided by the DARHT field office (Burns 1995a; Burns 1995b). The costs do not include any expenses associated with site cleanup, decontamination, or decommissioning of either the DARHT or PHERMEX facilities.

TABLE G-2.—*Operations and Maintenance Costs by Alternative (in millions of 1995 dollars)*

Alternative	1995	1996	1997	1998	1999	2000	2001	2002	Total
No Action	4.2	4.1	4.1	4.0	4.0	4.0	3.9	3.9	32.2
DARHT Baseline	4.2	4.1	4.1	4.0	5.9	5.8	5.8	5.7	39.6
PHERMEX Upgrade	4.2	4.1	4.1	4.0	4.0	4.0	3.9	6.0	34.3
Enhanced Containment Vessel Option	4.2	4.1	4.1	4.0	9.7	9.6	9.5	9.4	54.7
Enhanced Containment Building Option (150 lb)	4.2	4.1	4.1	4.0	4.0	4.0	3.9	9.4	37.7
Enhanced Containment Building Option (500 lb)	4.2	4.1	4.1	4.0	4.0	4.0	3.9	9.4	37.7
Enhanced Containment Phased Option	4.2	4.1	4.1	4.0	6.3	6.1	5.8	5.6	40.3
Plutonium Exclusion	4.2	4.1	4.1	4.0	7.9	7.8	7.8	7.6	47.4
Single Axis	4.2	4.1	4.1	4.0	5.3	5.2	5.2	5.1	37.2

Notes: The underlying O&M cost data were provided by the DARHT field office (Burns 1995a; Burns 1995b). This primary data was adjusted using an escalation price change index for DOE defense-related construction projects (Pearman 1994). The resulting O&M cost estimates presented in the table recognize varying periods of operation of PHERMEX prior to operations at the DARHT Facility based on the DARHT implementation schedule (Burns 1995a; Burns 1995b).

TABLE G-3.—*Summary of Economic Impacts by Alternative (FY 1996 to FY 2002)*

Alternative	Employment (FTE-Equivalent)	Labor Income (in millions)	Output (in millions)
DARHT Baseline	total 191 direct 80 indirect 111	total $4.1 direct $1.7 indirect $2.4	total $6.8 direct $3.4 indirect $3.4
PHERMEX Upgrade	total 199 direct 82 indirect 117	total $4.3 direct $1.8 indirect $2.5	total $6.9 direct $3.3 indirect $3.7
Enhanced Containment Vessel Option	total 321 direct 137 indirect 185	total $6.8 direct $2.9 indirect $3.9	total $12.0 direct $6.2 indirect $5.8
Enhanced Containment Building Option (150 lb)	total 209 direct 87 indirect 122	total $4.5 direct $1.9 indirect $2.6	total $7.6 direct $3.6 indirect $4.0
Enhanced Containment Building Option (500 lb)	total 238 direct 99 indirect 139	total $5.1 direct $2.1 indirect $3.0	total $8.4 direct $4.0 indirect $4.4
Enhanced Containment Phased Option	total 253 direct 106 indirect 147	total $5.4 direct $2.3 indirect $3.1	total $9.0 direct $4.4 indirect $4.6
Plutonium Exclusion	total 233 direct 99 indirect 134	total $4.9 direct $2.1 indirect $2.9	total $8.6 direct $4.5 indirect $4.1
Single Axis	total 104 direct 44 indirect 60	total $2.2 direct $0.9 indirect $1.3	total $3.8 direct $1.9 indirect $1.9

Notes: All monetary amounts are reported in 1995 dollar values.

Information Procedures System (FIPS) identifier for American Indian and Alaska Native Area (AIANAFP). The block group data were then aggregated by tracts generally, and by tracts for the Cochiti, Jemez, San Ildefonso, and Santa Clara Reservation populations only.

Minority population distributions were derived using census tract data on race and Hispanic origin. The size of the minority population within a specific scope of coverage [10, 30, or 50 mi (16, 48, or 80 km)] was measured as the difference between the general population and the white Non-Hispanic subgroup of the general population. The ratio between the derived minority subgroup and the general population constitutes the percentage of "minority population" residing within the various scopes of coverage. This percentage is greater than one half in both the 30- (48-) and 50-mi (80-km) radius, reflecting the large number of Hispanic and Native American persons residing in the region-of-interest.

Similarly, the low-income population distribution was derived using census tract data on household income. Household income data reflects wages and salaries earned by persons of 15 years of age and beyond who reside in the same household. For the region-of-interest the income class of $15,000 or less was chosen as the poverty threshold measure for the low-income population. This income level is the reported 1990 poverty threshold for the average-sized household in the region-of-interest. The ratio between these households and the total number of households in a specific scope of coverage [10, 30 or 50 mi (16, 48, or 80 km)] constitutes the percentage of the "low-income" households in the region-of-interest.

Finally, the presentation of both the minority and low-income distributions of the population can take a variety of forms. In the present analysis, maps and tables were constructed taking into consideration that census tracts (or block) areas tend to sprawl across the varying scopes of coverage, e.g. certain census tracts tend to lie on both sides of the 10-, 30-, and 50-mi radius (16-, 48-, and 80-km). In these instances, a detailed atlas was used to apportion persons and households situated in these census tracts to one or the other side of the boundary.

G.3 REFERENCES CITED IN APPENDIX G

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Appendix H
Human Health

APPENDIX H
HUMAN HEALTH

This appendix presents the methods and results of calculations to estimate human health effects that could result from the airborne releases of test assembly detonations at the DARHT or PHERMEX sites under the six alternatives. The detonations would result in the aerosolization and atmospheric dispersal of a portion of the materials contained in each assembly. The hazardous components may include depleted uranium, tritium, beryllium, lead, and lithium hydride. Depleted uranium and tritium were evaluated for their radiological hazard, and uranium, beryllium, lead, and lithium hydride were evaluated for their chemical hazard. Unless otherwise stated, dose is the effective dose equivalent. Sums and products of numbers in this section may not appear consistent due to rounding.

This appendix addresses only the potential human health impacts from chronic exposures under routine operations. Appendix I (Facility Accidents) covers the health impacts from acute exposures that could result from accident events.

H.1 COMPUTER CODES

The potential health impacts of the atmospheric releases were evaluated with two computer codes. GENII (Napier et al. 1988a; Napier et al. 1988b; and Napier et al. 1988c) was used to calculate radiation dose from uranium and tritium. The Multimedia Environmental Pollutant Assessment System (MEPAS) (Droppo et al. 1989; Droppo et al. 1991; Whelan et al. 1987; Strenge et al. 1989; Buck et al. 1995) was used to calculate toxicological impacts of all constituents, except tritium, and carcinogenic risk from beryllium. The HOTSPOT code (Homann 1994) was used in a limited manner to compare explosive atmospheric dispersion to the point-source atmospheric dispersion estimates of GENII and MEPAS.

H.1.1 GENII

The GENII code was used to calculate radiation doses from depleted uranium and tritium releases. GENII models the environmental transport, accumulation, and radiation dose to an individual or population. It may be used for acute (less than 24 h) or chronic exposure scenarios. Atmospheric dispersion is modeled using a straight-line Gaussian-plume model, and the release point may be either ground level or elevated. Although it accounts for the material deposition to determine exposure to ground surface deposition, the GENII code generates conservative plume concentration estimates in part because, the code does not mathematically remove the deposition from the plume. Therefore, the material deposited is double counted and health impacts are overestimated, especially for those located at greater downwind distance.

Depleted uranium is modeled as a particulate, but GENII includes a special algorithm for modeling tritium vapor. The tritium model of GENII assumes that the tritium released is in the form of tritiated water (HTO), whereas tritium released from either the DARHT or PHERMEX facilities is in the form of tritium gas (T_2). Tritium gas is about 14,000 times less a radiological hazard than tritiated water because it is taken up by the body to a far lesser extent. GENII calculations were made assuming the tritium to be in the form of HTO for atmospheric dispersion and environmental accumulation. Radiation dose output was then corrected by replacing HTO dose factors with those for T_2.

H.1.2 MEPAS

The MEPAS code was used to model the release, atmospheric transport, and receptor exposure of test assembly constituents that could cause toxicological effects (uranium, beryllium, lead, and lithium hydride) or cancer risks (beryllium). Uranium, as a heavy metal, may cause toxicological effects as well as be a source of radiation dose. MEPAS has the capability to model only chronic releases. Like GENII, MEPAS uses a straight-line Gaussian-plume model for atmospheric dispersion modeling, from either ground-level or elevated release points.

The MEPAS code output for toxicological effects from uranium, beryllium, lead, and lithium hydride is in terms of hazard index (HI). Hazard index is used to estimate the potential occurrence of noncarcinogenic effects that may result from chronic exposure to a metal or chemical. Toxicological effects are nonprobabilistic and have an occurrence threshold. They are specific to a given substance because the toxicological endpoints differ for different substances. The HI is equal to the individual's estimated exposure divided by the U.S. Environmental Protection Agency (EPA) constituent-specific reference dose (EPA 1994b). This EPA reference dose is based on a contamination level where a deleterious effect is noted following chronic exposure. No toxicological effects would be expected where the HI was less than unity (1). The reference doses and their bases are provided in table H-1.

TABLE H-1.—*Reference Doses (Rfd) for Beryllium, Lead, Lithium Hydroxide, and Uranium and Their Bases*

Element	Rfd (mg/kg/d)	Basis
Beryllium	Ingestion Rfd = 0.005 Inhalation Rfd = undefined	Low confidence in Rfd which is based on soluble beryllium salts. The deleterious effect of the Rfd is based on weight changes.
Lead	Ingestion Rfd = 0.0014 Inhalation Rfd = 0.00043	High level of confidence in Rfd. Health effect bases are changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development.
Lithium Hydroxide[a]	Ingestion Rfd = 0.007 Inhalation Rfd = 0.007	Low confidence in Rfd. Symptoms of lithium toxicity resemble those of sodium deficiency and include drowsiness, anorexia, nausea, tremors, blurred vision, coma, and death. Rfd is based on sodium hydroxide threshold limit values (TLV). The TLV, however, is most likely based on the caustic nature of sodium hydroxide.
Uranium	Ingestion Rfd = 0.003 Inhalation Rfd = 0.0014	Medium confidence in Rfd. Uranium is a classic nephrotoxin.

[a] Lithium hydroxide used as surrogate for lithium hydride in test assemblies.

Source: EPA 1994b and ACGIH 1991

MEPAS output for carcinogens is presented as risk of cancer incidence. Beryllium is a potential carcinogen as well as a toxicological hazard. EPA (EPA 1994a) has published a beryllium slope factor, based on chronic exposure, that is used to estimate the probability that an individual will contract cancer in his or her lifetime. The carcinogenic effect results from the inhalation of beryllium. The inhalation slope factor is 8.4 $[mg_{Be}/(kg_{body\ wt} \cdot d)]^{-1}$; slope factors for other exposure pathways are undefined.

H.1.3 HOTSPOT

HOTSPOT is a code developed for the initial assessment of accidents involving atmospheric releases of radioactive material. The code module used for these analyses was the "uranium explosion." HOTSPOT was used in one limited application to compare its explosive atmospheric dispersion estimates to the single-point atmospheric dispersion estimates of GENII and MEPAS. The initial plume of the postdetonation release modeled in HOTSPOT is more disperse and spacious than the point release modeled by GENII and MEPAS. The dispersion estimate comparison, while rather extensive in examining dispersion estimates at several different locations, for different quantities of high explosives, and under various meteorological conditions, was limited due to the relatively unsophisticated meteorological input used by HOTSPOT. HOTSPOT was not used for any consequence (dose, toxicological effect, or cancer risk) analysis.

H.2 METEOROLOGICAL DATA AND ATMOSPHERIC DISPERSION

This section presents an overview of the meteorological data used for the human health analyses, as well as a description of the atmospheric dispersion analyses and assumptions made in modeling human health impacts.

H.2.1 Meteorological Data

A comparison was made of available LANL site-specific meteorological data to determine which was most appropriate for use in atmospheric dispersion and transport calculations for releases from the DARHT and PHERMEX sites (Area III) in TA-15. TA-15 has no meteorological tower. Data were available for two nearby areas, TA-6 and TA-49, which are north-northwest and south, respectively, of TA-15. These two sets of meteorological data were selected for comparison because they were from towers closest to TA-15, approximately equidistant from TA-15, and from towers with topography similar to TA-15.

To make a determination on which data set to use, GENII code analyses were carried out using three alternative meteorological data sets: TA-6, TA-49, and the average of TA-6 and TA-49. Doses to three different receptor locations (Los Alamos, Bandelier, and White Rock) were modeled using three different exposure scenarios (i.e., acute, chronic annual, and 30-yr cumulative exposure), as well as the 50-mi (80-km) population. Unit releases of depleted uranium and tritium were used as the source term and held constant among the different comparison cases.

The hourly meteorological data from TA-6 was selected as the input data set for modeling the atmospheric dispersion from the DARHT and PHERMEX sites in TA-15 because it consistently resulted in the highest dose estimates; therefore, potential impacts would less likely be underestimated. In the 3 of 13 cases where the TA-6 data did not result in the highest dose, the difference between the maximum and the TA-6 dose estimate was less than a factor of two.

Both GENII and MEPAS use the site-specific, hourly meteorological data in the form of joint frequency data. Joint frequency data are shown in appendix C, exhibit C1-1. Ninety-fifth-percentile, $\overline{\chi}/Q'$ atmospheric dispersion values were calculated by GENII and MEPAS and used for chronic release calculations. GENII calculates 95th-percentile E/Q values for acute releases. Where hand calculations were necessary for acute release calculations (appendix I), these 95th-percentile E/Q values were used as the atmospheric dispersion input.

H.2.2 Atmospheric Dispersion

The GENII and MEPAS codes are routinely used for point (e.g., a building vent) or area (e.g., buried waste near the soil surface) source releases. However, material from the DARHT and PHERMEX sites would be released via explosive detonations. Initial post-detonation source term plumes for open-air detonations (as described below for the five uncontained alternatives) are roughly a vertical cylinder or stem-and-cap shape. Several analyses were performed to compare the impacts of using the GENII and MEPAS point sources release models to simulate the explosive detonation releases.

The initial analysis evaluated the model release geometry. The HOTSPOT code (Homann 1994) was used to compare post-detonation dispersion to point-source dispersion estimates used in GENII and MEPAS. HOTSPOT models five plumes stacked vertically for its model of nonnuclear detonations of uranium. The dispersion estimates for HOTSPOT and GENII/MEPAS were compared at several different receptor locations, for different quantities of high explosives, and under various meteorological conditions. The comparison was limited due to the relatively unsophisticated, generic meteorological input used by HOTSPOT. This analysis determined that the GENII and MEPAS point-source estimates could significantly *under estimate* atmospheric dispersion of explosive dispersal and therefore *over estimate* the human health impacts.

HOTSPOT has only limited air dispersion and dose modeling capabilities and was not used for any consequence analysis. However, HOTSPOT proved useful by providing an equation for effective release height that would allow GENII and MEPAS to more realistically simulate atmospheric dispersion from uncontained detonations. The effective release height is defined by the following empirical equation (Church 1969, as cited by Homann 1994):

$$eff_{ht} = 0.6(76w^{0.25})$$

where eff_{ht} = effective release height (m) and
w = amount of high explosives (lb).

This equation defines the mid-point of the explosively dispersed plume, with approximately 50 percent of the aerosolized source term above and 50 percent below the effective release height. The height of release is dependent on the amount of high explosives used; larger amounts of high explosives result in greater initial dispersion and a higher effective release height. The amounts of high explosives used in hydrodynamic tests may range from approximately 10 to 500 lb (5 to 225 kg), with corresponding effective release heights of 270 to 700 ft (80 to 215 m). The release height used for all uncontained detonations of chronic exposure scenarios is 400 ft (120 m) corresponding to the use of 50 lb (22 kg) of high explosives.

A second evaluation compared the single-point release and dispersion model to the stem-and-cap (mushroom-shaped) atmospheric dispersion model. This comparison was made to ensure that the single-point release model was adequate to represent the explosive atmospheric dispersion that may be more appropriately represented by the stem-and-cap model.

Stem-and-cap releases are most accurately represented by double plume releases, with cap and stem sections modeled at different release elevations (Shinn et al. 1989). The stem-and-cap evaluation was performed for a variety of high explosive amounts with unit releases of depleted uranium. Using effective release height information gained from the initial comparison, dose consequences were calculated for a dose receptor in Los Alamos, [2.7 mi (4.4 km) NNW of TA-15]. For large amounts of explosives, the estimated dose from the stem-and-cap, double-plume release could be a maximum of 40 percent higher than that modeled for an elevated, single-point release. The dose from a representative test, using 20 lb (9 kg) of high explosives, could be up to 10 percent higher. Considering the ordinarily assumed factor of 10 uncertainty in atmospheric dispersion model results, a 10 to 40 percent difference (i.e., factor of 1.1 to 1.4) in dose estimates did not warrant the additional effort of stem-and-cap modeling. Table H-2 presents atmospheric dispersion data typical of that used in the stem-and-cap release geometry evaluations.

TABLE H-2.—*Atmospheric Dispersion Values Used to Compare Different Explosive Dispersion Models*

Location	$\bar{\chi}/Q'$		
	GENII/MEPAS	HOTSPOT[a]	Stem & Cap
10 lb (4.5 kg) of high explosives			
Los Alamos	4.0×10^{-8}	4.6×10^{-10}	4.5×10^{-8}
Bandelier	3.5×10^{-8}	3.6×10^{-10}	5.5×10^{-8}
White Rock	4.3×10^{-8}	2.6×10^{-10}	7.3×10^{-8}
500 lb (230 kg) of high explosives			
Los Alamos	1.6×10^{-8}	1.1×10^{-10}	2.3×10^{-8}
Bandelier	2.9×10^{-9}	7.1×10^{-11}	1.1×10^{-8}
White Rock	4.2×10^{-9}	1.1×10^{-10}	1.4×10^{-8}

[a] Most conservative (nighttime) $\bar{\chi}/Q'$ values from HOTSPOT.

The Enhanced Containment Alternative release scenarios differ from those of the uncontained alternatives. The Vessel Containment and Phased Containment options assume some detonations are contained within a vessel and some are uncontained; all Building Containment Option detonations are contained. The contained releases were modeled as ground-level releases. The results of the point-release versus explosively dispersed plume and the stem-and-cap evaluations, above, are not applicable to these contained ground-level releases.

Materials from 6 percent of the contained detonations of the Enhanced Containment Alternative were assumed to be released to the environment, based on previous operational experience at LANL. The bounding assumption of 6 percent containment release is used to account for potential leakage or failure of the vessel or building containment in a nonaccident scenario. Accidents are examined separately in appendix I.

H.2.3 Summary

Site-specific hourly meteorological data was evaluated and data from TA-6 was selected for use in atmospheric dispersion estimates. Several different atmospheric dispersion models were evaluated and it was determined that estimates made using the single-point release model in GENII and MEPAS were acceptable to conservatively represent the explosive dispersal of material from detonations. The single-point release model may overestimate potential impacts by up to a factor of 100. This potential over estimation would not apply to ground-level releases from contained detonations.

H.3 SOURCE TERM

The constituents of test assemblies that may be released to the atmosphere and have the potential to adversely impact humans include uranium, tritium, beryllium, lead, and lithium hydride. At detonation, test assembly material is dispersed in various size fractions ranging from large pieces or chunks to very small, micron or sub-micron size particles. Of particular interest is the aerosolized fraction of the material with particles sizes that are considered respirable, 10 μm or less aerodynamic diameter (see appendix C).

H.3.1 Usages and Environmental Releases

The estimated releases of materials to the environment from detonation activities are indicated in table H-3. The annual usages of materials in uncontained detonations under the No Action, DARHT Baseline, Upgrade PHERMEX, Plutonium Exclusion, and Single Axis alternatives are identical. The impacts of each of these alternatives are identical as well. The impacts of the Enhanced Containment Alternative were evaluated separately. The values listed are the largest foreseeable annual releases. The releases listed for the Vessel Containment Option represent 25 percent of the annual inventory used during uncontained detonations and the use of a containment vessel for the remaining 75 percent of the inventory. It was conservatively assumed, based on operating experience, that 6 percent of the inventory detonated in a vessel annually would be released to the atmosphere. The Building Containment Option similarly assumed 6 percent of the total annual inventory is released from the building. The Phased Containment Option assumed 5 percent vessel containment during the first 5 years of the project 30-year operational period, 40 percent vessel containment during the second 5 years, and 75 percent vessel containment for the final 20 years.

The radionuclide source term used in the health effects evaluation is based on the radionuclides present in 10-year-old Rocky Flats depleted uranium, containing, by mass, 99.8 percent uranium-238, 0.22 percent uranium-235, and 0.00057 percent uranium-234. Depleted uranium is a usable residual product left after extracting some portion of uranium-235 from uranium ore. Naturally occurring uranium has typical uranium isotope mass fractions of 99.3 percent uranium-238, 0.7 percent uranium-235, and minute

TABLE H-3.—*Maximum Anticipated Annual Environmental Releases of Materials from Test Assemblies*

Constituent	Uncontained Alternatives[a]	Vessel Containment Option	Building Containment Option
Deleted uranium (lb)	1540	385 uncontained 70 contained	92 contained
Tritium (Ci)	3	3	3
Beryllium (lb)	22	5.5 uncontained 1.1 contained	1.3 contained
Lead (lb)	33	9 uncontained 2 contained	2 contained
Lithium Hydride (lb)	220	55 uncontained 11 contained	13 contained

[a] No Action, DARHT Baseline, Upgrade PHERMEX, Single Axis, and Plutonium Exclusion alternatives.

quantities of uranium-234 and uranium-236. The mass percentage and activity of the constituents 10-year-old Rocky Flats depleted uranium constituents are presented in table H-4. Radionuclides other than uranium in this table are the radioactive progeny produced by decay of the parent uranium radionuclides.

Lithium hydroxide (LiOH) was used in MEPAS as a surrogate for lithium hydride (LiH), which was not part of the MEPAS database. Lithium hydride readily converts to LiOH upon contact with water. A stoichiometric correction was made in the modeled release of the LiH because the LiOH surrogate has three times the mass of LiH because of the addition of the oxygen atom. Therefore, the release source terms of the surrogate LiOH used in the risk calculations are three times those listed in table H-3.

H.3.2 Aerosolization

Upon detonation of the test assembly, the depleted uranium is ejected in the form of large fragments, small fragments (from 0.08 to 1.1 in^2 [0.5 to 7 cm^2]), and aerosols, as discussed in appendix B (McClure 1995). The amount of depleted uranium aerosolized and available for atmospheric dispersion beyond the firing site could range from 0.2 to 10 percent of the test assembly inventory (Mishima et al. 1985; Dahl and Johnson 1977; McClure 1995). All analyses performed for the EIS assume 10 percent aerosolization of depleted uranium.

There is uncertainty about the magnitude of the aerosolization fraction of the detonated hazardous constituents. Much of the uncertainty results from the difficulty in sampling close to high explosive detonations (Baskett and Cederwall 1991). Dahl and Johnson estimated that 2 percent of the beryllium is aerosolized, whereas Shinn et al. estimate 8 percent based on their re-analysis of the Dahl and Johnson results (Dahl and Johnson 1977; Shinn et al. 1989). Little information was available on the aerosolization of the lead and lithium hydride. Due to the lack of a strong basis for constituent-specific aerosolization fractions, an aerosolization fraction of 10 percent was used for all constituents, the same as for depleted uranium.

TABLE H-4.—*Radionuclide Constituents of Depleted Uranium by Mass Activity*

Radionuclide	Mass Percent	Activity of Depleted Uranium Constituents (Ci/g)[a]
Uranium-234	0.00057	3.7×10^{-8}
Uranium-235	0.22	4.9×10^{-9}
Uranium-238	99.8	3.4×10^{-7}
Protactinium-234	(negligible)	3.4×10^{-7}
Thorium-231	(negligible)	4.9×10^{-9}
Thorium-234	(negligible)	3.4×10^{-7}

[a] Activity of constituents is based on 10-year-old Rocky Flats Plant depleted uranium.

Respirable-size particles (less than 10 μm AMAD) may comprise 20 to 90 percent of the aerosolized fraction (2 to 9 percent of the total source term); however, for the purposes of these analyses, the aerosolized fraction of the depleted uranium and other constituents was assumed to be 100 percent respirable (10 percent of the total source term).

H.4 EXPOSURE SCENARIOS

Human health impacts resulting from routine, chronic exposure of the public and workers were evaluated by making exposure assumptions about the individuals and population. Annual chronic exposure scenarios consider impacts from routine releases over a one-year period. Cumulative exposure scenarios, an extension of the annual chronic exposure scenario, sum the annual exposures during the 30-yr operational life of the facility and exposure to any soil accumulation that had occurred as a consequence of the 30-yr operational period. The annual and cumulative radiological dose and risk, and the carcinogenic risk from beryllium exposure to the population residing within 50 mi (80 km) of TA-15 were also estimated. The potential impact to the 50-mi (80-km) population from toxicological effects due to chemical exposure (indicated by Hazard Index) were not calculated. These effects are nonprobabilistic and have an occurrence threshold, so low results for the maximally exposed individual were an adequate indication that population calculations were not needed.

Three residential locations around LANL (Los Alamos, White Rock, and Bandelier) were chosen at which to evaluate the maximally exposed individual (MEI) for radiation dose and chemical exposure. Residents were assumed to be at their homes continuously and to consume home-grown crops. Assessing impacts at multiple locations provided a better indication of possible impacts, and also provided allowance for slight differences in the atmospheric dispersion and deposition algorithms used in the two consequence assessment codes (GENII and MEPAS) to ensure that individuals with the highest potential impacts were identified.

H.4.1 Receptor Type and Location

The general categories of individual receptors evaluated included the annual-chronic MEI, cumulative (over 30 years of operations) MEI, and noninvolved worker (see table H-5). Both public MEI categories considered offsite residents nearest to TA-15 (i.e., Los Alamos, White Rock, and Bandelier). The noninvolved worker was assumed to be located on the road leading to DARHT or PHERMEX about 2,500 ft (750 m) away. This distance is based on a series of administrative hazard radii that LANL has established for protection of personnel from fragment injury and would be a typical exclusion for test assembly detonations. The hazard radius determinations are included in LANL operating procedures, based on principles presented in the DOE Explosives Safety Manual (DOE 1994). The above individual receptor locations are presented in the table H-5. Table H-6 presents the 1993 population distribution data for the 50-mi (80-km) area surrounding TA-15, used in population impact calculations.

Due to the close proximity of DARHT and PHERMEX sites [0.4 mi (0.6 km) apart], the MEI distances used for each site were assumed to be equivalent. The PHERMEX facility was modeled in the No Action Alternative as operational for an additional 30 years.

H.4.2 Exposure Pathways

Table H-7 lists the exposure pathways included in evaluating impacts of routine exposures. The annual chronic MEI's pathways included external exposure and dermal absorption, inhalation of airborne constituents and resuspended soil, ingestion of food crops, and the inadvertent ingestion of soil. The cumulative MEI and population included these same pathways as well as additional pathways of meat and milk ingestion. The noninvolved worker pathways were more limited. The noninvolved worker would be present onsite, and only for a fraction of the year, during working hours. Exposure pathways included were external exposure, dermal absorption and inhalation of the airborne plume, and inhalation of resuspended soil. Table H-8 presents the code input parameters of most interest that were used to evaluate the human health impacts.

H.5 RESULTS

Results are presented for potential radiological, toxicological, and carcinogenic impacts of releases of uranium, tritium, lead, beryllium, and lithium hydride. Radiation dose estimates are presented in terms of effective dose equivalent (EDE). The radiation dose estimates were translated into a measure of latent cancer fatalities (LCFs) using recommendations of the International Commission on Radiological Protection in its Publication 60 (ICRP 1991). The ICRP estimated the risk of cancer from data based on populations exposed to relatively high doses and dose rates. A dose reduction factor of 2 was used when doses were below 20 rad, as is the case with all doses estimated in these analyses. The dose-to-risk conversion factors used for estimating cancer deaths from exposure to low dose rates of ionizing radiation were 500 cancer deaths (latent cancer fatalities) per million person-rem effective dose equivalent (5×10^{-4} deaths per person-rem) for the general population and 400 cancer deaths per million person-rem (4×10^{-4} deaths per person-rem) for workers. The difference is attributable to more diverse age groups in the general population. These values include the dose reduction factor. For purposes of explaining potential

TABLE H-5.—*Locations of Individuals Evaluated for Impacts from Chronic and Cumulative Exposures*

Category	Location Name	Location
Maximally Exposed Individual (MEI) Chronic (Annual) and Cumulative (30 Years of Operation)	Bandelier White Rock Los Alamos	3 mi (5 km) SSE 3.8 mi (6 km) ESE 2.7 mi (4.4 km) NNW
Noninvolved worker		2,500 ft (750 m) NW

TABLE H-6.—*The 1993 Population Distribution within the 50-mi (80-km) Polar Grid Centered on TA-15*

Direction (Sector)	Distance (mi)										
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Sector Total
S	0	0	0	0	1	0	1,295	3,511	697	6,195	11,699
SSW	0	0	1	0	1	0	216	38	4,310	114,102	118,668
SW	0	0	1	0	1	0	0	37	1,048	45	1,132
WSW	0	0	1	3	1	0	17	516	2,198	6	2,742
W	0	0	0	2	1	11	268	489	29	146	946
WNW	0	0	0	0	1	10	53	41	149	1,970	2,224
NW	0	0	0	0	0	0	17	24	357	632	1,030
NNW	0	0	5	3,961	148	0	10	42	231	206	4,603
N	0	0	39	4,459	65	0	56	232	1,038	655	6,544
NNE	0	0	39	1,827	472	1	262	1,450	821	360	5,232
NE	0	0	12	241	37	1	12,500	5,898	2,594	2,167	23,450
ENE	0	0	0	6	2	865	5,591	5,057	1,332	1,147	14,000
E	0	0	0	220	3,631	1	1,179	1,175	74	186	6,466
ESE[a]	0	0	0	498	1,518	1	481	41,322	1,955	2,782	48,557
SE	0	0	0	5	43	0	797	33,390	5,735	293	40,263
SSE	0	0	0	49	0	3	9	1,161	2,291	202	3,715
Population Total	0	0	98	11,271	5,922	893	22,751	94,383	24,859	131,094	291,271
Distance Midpoint (km)	0.8	2.4	4.0	5.6	7.2	12	24	40	56	72	

[a] The ESE sector was determined to be the maximally exposed population sector for accident analysis (appendix I).

impacts to individual members of the public or individual workers, these dose-to-risk conversion factors have also been used to estimate the "probability" of contracting a latent cancer for the representative member of the public or worker.

The HI is used to estimate potential occurrence of toxicological effects resulting from chronic exposure to a chemical. The basis is the EPA's constituent-specific reference dose (EPA 1994a) which is based on

TABLE H-7.—*Exposure Pathways Evaluated for Impacts from Routine Releases*

Pathway	Chronic MEI[a]	Cumulative MEI[a]	Noninvolved Worker	Population
External exposure from:				
plume	x	x	x	x
ground surface	x	x	x	x
Dermal absorption[b]	x	x	x	x
Inhalation of plume and resuspended soil/dust	x	x	x	x
Ingestion of:				
incidental soil	x	x	x	x
crops [c]	x	x	NA	x
animal products[d]	NA	x	NA	x

[a] MEI = maximum exposed individual.
[b] Nonradioactive constituents only.
[c] Leafy vegetables, "other" vegetables, fruit, grains.
[d] Meat and milk.

chronic exposure at a contamination level where a deleterious effect is noted. The HI for a specific contaminant is equal to the individual's estimated exposure divided by the EPA reference dose, and thus is a unitless measure. The critical value – 1.0 – indicates that the individual is exposed at a level equivalent to the reference dose and, therefore, would be expected to experience the health effect upon which the reference dose is based. No deleterious effects would be expected when the hazard index is less than 1.0.

The risk of cancer incidence (as compared to the risk of cancer fatalities, as is estimated from radiation dose) from exposure to beryllium was also calculated, using the EPA slope factor for beryllium (EPA 1994a).

Estimated impacts of expected normal releases under the uncontained detonation alternatives (No Action, DARHT Baseline, Upgrade PHERMEX, Plutonium Exclusion, and Single Axis) are described in section H.5.1. Analysis and results of these impacts apply to all uncontained alternatives. The estimated impacts of the Enhanced Containment Alternative are shown in section H.5.2. Results are presented for individuals and population, for annual and cumulative exposures. Results of accident analyses are presented in appendix I.

For all alternatives, the radiation dose from tritium, in the form of T_2, was determined to be approximately 1×10^{-7} (1/10,000,000) that of depleted uranium. An analysis was performed, using GENII along with hand calculations to correct for the tritium chemical form difference, to compare dose consequences of the projected chronic annual releases of depleted uranium and tritium. Because it was determined to be an insignificant contributor to the radiation dose, tritium impacts were not explicitly calculated.

TABLE H-8.—*Code Input Parameters and Values Used in Evaluating Human Health Effects of Routine Releases*

Pathway/Parameter	Chronic MEI	Cumulative MEI[a]	Noninvolved Worker (Chronic)	Population
External exposure from:				
plume (h)	8,766	8,766	2,000	8,766
ground surface (h)	8,766	8,766	2,000	8,766
dermal absorption (h)	8,766	8,766	2,000	8,766
Inhalation (h)	8,766	8,766	2,000	8,766
Ingestion of:				
incidental soil (mg/d)	100	100	100	100
crops (kg)[b]				
leafy vegetables	16.5	16.5	0	16.5
other vegetables	34.9	34.9	0	34.9
fruit	55.7	55.7	0	55.7
grain	73.9	73.9	0	73.9
meat (kg)[c]	0	95	0	95
milk (kg)[c]	0	110	0	110

[a] For Hazard Index (HI) and post-operation calculations, 30 years of previous facility operation have been assumed. MEI = maximum exposed individual.
[b] All crops 1 day holdup.
[c] Beef 20 day holdup, 75 percent fresh forage consumption.
Milk 2 day holdup, 75 percent fresh forage consumption.

Note: Annual exposure times are shown unless otherwise indicated.

Miscellaneous parameters:
absolute humidity – 3×10^{-4} lb/ft^3 (0.0048 kg/m^3)
soil density – 100 lb/ft^3 (1.6×10^3 kg/m^3)
roots – 60 percent upper soil, 40 percent deep soil
manual redistribution factor – 0.15
surface soil density – 15 lb/ft^2 (240 kg/m^2)
mass loading – 4.5×10^{-9} lb/ft^3 (7.2×10^{-5} g/m^3)

H.5.1 Uncontained Alternatives

Analysis of the uncontained alternatives – No Action, DARHT Baseline, Upgrade PHERMEX, Plutonium Exclusion, and Single Axis – involved only uncontained detonation and atmospheric releases of test assembly material, including depleted uranium, tritium, beryllium, lead, and lithium hydride.

H.5.1.1 Public

Health impacts would not be expected in the maximally exposed members of the public, located at Los Alamos, Bandelier, and White Rock, from routine annual releases under the uncontained alternatives (see tables H-9 and H-10). Neither would health impacts be expected in maximally exposed members of the public at these locations from exposure over the projected 30 years of facility operations (tables H-11 and H-12). This table includes values calculated from releases of uranium, tritium, and beryllium, as well as the dose and risk projected in the first year immediately following 30 years of operations from the deposition and accumulation of depleted uranium and beryllium in the soil. Table H-12 presents an estimate of the potential toxicological effects that would occur as a result of deposition and accumulation of uranium, beryllium, lead, and lithium hydride in the soil. The results are presented for the first year immediately following 30 years of operations, when buildup of the materials in the soil would be at a maximum. All values are well below 1.0; therefore, toxicological effects would not be expected. These results indicate that any environmental accumulation of released materials in the soil would create a negligible residual health risk to members of the public living around LANL after termination of DARHT or PHERMEX operations.

The projected annual dose to the population of 290,000 individuals living in the 50-mi (80-km) radius of TA-15 would be 0.91 person-rem. Latent cancer fatalities would not be expected among the population from this population dose (5×10^{-4} LCFs). Beryllium-induced cancer would not be expected in this population (4×10^{-7} cancers). Cumulative dose to the population over 30 years would be 27 person-rem; latent fatal cancers would not be expected (1×10^{-2} LCFs). Cancer from cumulative exposure to beryllium would not be expected (1×10^{-5} total cancers).

H.5.1.2 Noninvolved Worker

Health impacts would not be expected in noninvolved workers as a result of releases to the atmosphere under the uncontained alternatives (see tables H-9 and H-10). Neither would any health impacts be expected from cumulative exposures over the 30-yr anticipated life of the project (table H-11).

H.5.1.3 Workers

The average annual dose to workers at the facility was estimated to be no more than 0.01 rem. The maximum probability of such a worker contracting a latent fatal cancer would be 4×10^{-6}. Over the 30-yr operating life of the facility, an involved worker's maximum probability of contracting a latent fatal cancer would be 1×10^{-4}. An annual collective worker dose similar to that observed for PHERMEX in the past was assumed to be representative for future operation, or about 0.3 person-rem/year. Latent cancer fatalities would not be expected among the worker population (1×10^{-4} LCFs). Collective worker dose over the anticipated 30 years of operations would be about 9 person-rem. Latent cancer fatalities would not be expected among the worker population (4×10^{-3} LCFs). The collective dose estimate was based on a maximum of 100 workers at the facility, each receiving an average of 0.003 rem per year. No operating information was available on exposure to chemicals or metals. The risks of exposure to these materials would be expected to be similarly low to those for radiation exposure.

H.5.2 Enhanced Containment Alternative

Under the Enhanced Containment Alternative, three operations were evaluated: the Vessel Containment Option, the Building Containment Option, and the Phased Containment Option. The Vessel Containment

TABLE H-9.—*Estimated Annual Doses and Carcinogenic Risks for Members of the Public and the Noninvolved Worker for Routine Release from All Uncontained Alternatives*

Maximally Exposed Individual Location	Annual Dose (rem)	Annual Probability of Radiation-Induced LCF[a]	Annual Probability of Beryllium-Induced Cancer
Los Alamos	2×10^{-5}	1×10^{-8}	3×10^{-11}
Bandelier	1×10^{-5}	7×10^{-9}	6×10^{-12}
White Rock	2×10^{-5}	8×10^{-9}	4×10^{-11}
Noninvolved Worker	2×10^{-5}	9×10^{-9}	3×10^{-11}

[a] LCF = latent cancer fatality.

TABLE H-10.—*Estimated Toxicological Effects to Members of the Public and the Noninvolved Worker for Annual Routine Releases from All Uncontained Alternatives*

Individual Location	Hazard Index (HI)[a]			
	Uranium	Beryllium	Lead	Lithium Hydride
Los Alamos	1×10^{-7}	5×10^{-10}	8×10^{-9}	1×10^{-8}
Bandelier	3×10^{-8}	1×10^{-10}	2×10^{-9}	2×10^{-9}
White Rock	1×10^{-7}	1×10^{-9}	5×10^{-9}	8×10^{-9}
Noninvolved Worker	2×10^{-7}	0	1×10^{-8}	1×10^{-8}

[a] Toxicological effects would not be expected for a hazard index value less than 1.

TABLE H-11.—*Estimated Cumulative Dose and Probability of Cancer from Radiation and Beryllium Exposure from 30 Years of Operation for all Uncontained Alternatives*

Individual Location	Cumulative Dose (rem)	Cumulative Probability of Radiation-Induced LCF[a]	Soil Buildup Dose[b] (rem)	Cumulative Probability of Beryllium-Induced Cancer	Soil Buildup Probability of Beryllium-Induced Cancer[b]
Los Alamos	7×10^{-4}	4×10^{-7}	2×10^{-8}	9×10^{-10}	1×10^{-11}
Bandelier	4×10^{-4}	2×10^{-7}	1×10^{-8}	2×10^{-10}	2×10^{-12}
White Rock	5×10^{-4}	3×10^{-7}	1×10^{-8}	1×10^{-9}	9×10^{-12}
Noninvolved Worker	7×10^{-4}	3×10^{-7}	–	9×10^{-10}	–

[a] LCF = latent cancer fatality.
[b] Reflects the potential impact from buildup of released material in soil; evaluated during the first year following 30 years of operations.

TABLE H-12.—*Estimated Toxicological Effects to Members of the Public after 30 Years of Facility Operation for All Uncontained Alternatives*[a]

Maximally Exposed Individual Location	Hazard Index[b] (HI)			
	Uranium	Beryllium	Lead	Lithium Hydride
Los Alamos	1×10^{-7}	4×10^{-10}	8×10^{-9}	1×10^{-8}
Bandelier	3×10^{-8}	9×10^{-11}	2×10^{-9}	2×10^{-9}
White Rock	9×10^{-8}	7×10^{-10}	4×10^{-9}	6×10^{-9}

[a] Reflects the potential impact from buildup of released material in soil; evaluated during the first year immediately following 30 years of operations.
[b] Toxicological effects would not be expected for a hazard index value less than 1.

Option assumed 25 percent of annual usages were uncontained detonations, and 6 percent of the contained inventory of the detonations was released routinely via ground-level leakage. The Building Containment Option assumed that all detonations were contained and that 6 percent of the inventory was released routinely via ground-level leakage. The Phased Containment Option assumed 5 percent vessel containment during the first 5 years of the project 30-year operational period, 40 percent vessel containment during the second 5 years, and 75 percent vessel containment for the final 20 years. The Vessel Containment Option would have slightly higher potential impacts than the Building Containment Option in all cases. The Phased Containment Option impacts would be essentially the same for impacts to individuals, but somewhat higher than the other two options for population impacts; about 30 percent higher than the Vessel Containment Option and twice the Building Containment Option over the 30-year operating lifetime of DARHT. Over the last 20 years of the operating period potential impacts would be identical to those of the Vessel Containment Option.

H.5.2.1 Public

Health impacts would not be expected in maximally exposed members of the public, located at Los Alamos, Bandelier, and White Rock, from routine annual releases under the Enhanced Containment Alternative (see tables H-13 and H-14). Neither would health impacts be expected in maximally exposed members of the public at these locations over the projected 30 years of facility operations (see table H-15). This table includes the projected cumulative impact from releases of uranium, tritium, and beryllium, as well as the dose projected in the first year immediately following 30 years of operations from the deposition and accumulation of depleted uranium and beryllium in the soil. Table H-16 presents an estimate of the potential toxicological effects that would occur as a result of deposition and accumulation of uranium, beryllium, lead, and lithium hydride in the soil. The results are presented for the first year immediately following 30 years of operations, when buildup of the materials in the soil would be at a maximum. All values are well below 1.0; therefore, toxicological effects would not be expected. These results indicate that any environmental accumulation of released materials in the soil would create a negligible residual health risk to members of the public living around LANL after termination of the enhanced containment operations.

TABLE H-13.—*Estimated Annual Doses and Carcinogenic Risk for Members of the Public for the Enhanced Containment Alternative*

Enhanced Containment Option	Maximally Exposed Individual Location	Annual Total Dose (rem)	Annual Probability of Radiation-Induced LCF[a]	Annual Probability of Beryllium-Induced Cancer
Vessel and Phased	Los Alamos	1×10^{-5}	5×10^{-9}	1×10^{-11}
	Bandelier	1×10^{-5}	6×10^{-9}	2×10^{-12}
	White Rock	2×10^{-5}	8×10^{-9}	1×10^{-11}
Building	Los Alamos	5×10^{-6}	2×10^{-9}	4×10^{-12}
	Bandelier	1×10^{-5}	5×10^{-9}	8×10^{-13}
	White Rock	2×10^{-5}	8×10^{-9}	4×10^{-12}

[a] LCF = latent cancer fatality.

TABLE H-14.—*Estimated Toxicological Effects to Members of the Public for Annual Routine Releases for the Enhanced Containment Alternative*

Enhanced Containment Option	Maximally Exposed Individual Location	Hazard Index (HI)[a]			
		Uranium	Beryllium	Lead	Lithium Hydride
Vessel and Phased	Los Alamos	5×10^{-8}	2×10^{-10}	4×10^{-9}	6×10^{-9}
	Bandelier	1×10^{-8}	4×10^{-11}	7×10^{-10}	1×10^{-9}
	White Rock	5×10^{-8}	4×10^{-10}	2×10^{-9}	4×10^{-9}
Building	Los Alamos	2×10^{-8}	7×10^{-11}	1×10^{-9}	2×10^{-9}
	Bandelier	4×10^{-9}	2×10^{-11}	2×10^{-10}	4×10^{-10}
	White Rock	2×10^{-8}	1×10^{-10}	9×10^{-10}	2×10^{-9}

[a] Toxicological effects would not be expected for a hazard index value less than 1.

The projected annual dose to the population of 290,000 individuals living in the 50-mi (80-km) radius of TA-15 from the Vessel Containment, Phased Containment, and Building Containment options would be about 0.44, 0.57, and 0.27 person-rem, respectively. No LCFs would be expected among the population from these population doses (2×10^{-4}, 2×10^{-4}, and 1×10^{-4} LCFs, respectively). Beryllium-induced cancer would not be expected in this population (1×10^{-7}, 1×10^{-7}, and 5×10^{-8} cancers, respectively).

Cumulative impacts over the anticipated 30-year life of the project for the Vessel Containment, Phased Containment, and Building Containment options would be about 13, 17, and 8 person-rem, respectively. Latent cancer fatalities would not be expected (6×10^{-3}, 8×10^{-3}, and 4×10^{-3} LCFs, respectively). Cancers from cumulative exposure to beryllium would not be expected (1×10^{-4}, 1×10^{-4}, and 6×10^{-5}, respectively).

TABLE H-15.—*Estimated Cumulative Dose and Probability of Cancer from Radiation and Beryllium Exposure from 30 Years of Operation for the Enhanced Containment Alternative*

Enhanced Containment Option	Maximally Exposed Individual Location	Cumulative Dose (rem)	Probability of Radiation-Induced LCF[a]	Soil Buildup Dose[b] (rem)	Probability of Beryllium-Induced Cancer	Soil Buildup Probability of Beryllium-Induced Cancer[b]
Vessel and Phased	Los Alamos	3×10^{-4}	1×10^{-7}	8×10^{-8}	3×10^{-10}	3×10^{-12}
	Bandelier	3×10^{-4}	2×10^{-7}	8×10^{-8}	7×10^{-11}	6×10^{-13}
	White Rock	(5×10^{-4})[c] (6×10^{-4})[d]	(2×10^{-7})[c] (3×10^{-7})[d]	1×10^{-7}	3×10^{-10}	2×10^{-12}
Building	Los Alamos	1×10^{-4}	5×10^{-8}	4×10^{-8}	1×10^{-10}	3×10^{-13}
	Bandelier	3×10^{-4}	7×10^{-8}	8×10^{-8}	2×10^{-11}	7×10^{-14}
	White Rock	5×10^{-4}	2×10^{-7}	1×10^{-7}	1×10^{-10}	3×10^{-13}

[a] LCF = latent cancer fatality.
[b] Reflects the potential impact from buildup of released material in soil; evaluated during the first year immediately following 30 years of operations.
[c] Vessel Containment Option.
[d] Phased Containment Option.

TABLE H-16.—*Estimated Toxicological Effects to Members of the Public after 30 Years of Facility Operation for the Enhanced Containment Alternative*[a]

Enhanced Containment Option	Maximally Exposed Individual Location	Hazard Index[b] (HI)			
		Uranium	Beryllium	Lead	Lithium Hydride
Vessel and Phased	Los Alamos	4×10^{-8}	1×10^{-10}	3×10^{-9}	4×10^{-9}
	Bandelier	7×10^{-9}	2×10^{-11}	5×10^{-10}	8×10^{-10}
	White Rock	3×10^{-8}	2×10^{-10}	1×10^{-9}	2×10^{-9}
Building	Los Alamos	6×10^{-9}	1×10^{-11}	4×10^{-10}	6×10^{-10}
	Bandelier	1×10^{-9}	3×10^{-12}	7×10^{-11}	1×10^{-10}
	White Rock	4×10^{-9}	1×10^{-11}	2×10^{-10}	4×10^{-10}

[a] Reflects the potential impact from buildup of released material in soil; evaluated during the first year immediately following 30 years of operations.
[b] Toxicological effect would not be expected for a hazard index value less than 1.

H.5.2.2 Noninvolved Worker

The annual radiation dose from chronic exposure of a noninvolved worker under the Vessel Containment and Phased Containment Options would be about 2×10^{-5} rem. The maximum probability of this worker contracting a latent fatal cancer from this dose would be about 6×10^{-9}. The cumulative dose over the 30-year operating life of the facility to the same worker would be about 5×10^{-4} rem. The worker's cumulative maximum probability of contracting a latent fatal cancer from this dose would be about 2×10^{-7}. The maximum annual probability of a beryllium-induced cancer in a noninvolved worker would be about 2×10^{-11}. This worker's cumulative probability of contracting a beryllium-induced cancer over the 30-year operating life of the facility would be about 5×10^{-10}.

The annual radiation dose from chronic exposure of a noninvolved worker under the Building Containment Option would be about 1×10^{-5} rem. The maximum probability of this worker contracting a latent fatal cancer would be about 5×10^{-9}. The cumulative dose over the 30-yr operating life of the facility to the same worker would be about 4×10^{-4} rem. The worker's maximum probability of contracting a latent fatal cancer from this dose would be about 2×10^{-7}. The maximum annual probability of a beryllium-associated cancer in a noninvolved worker would be about 1×10^{-11}. This worker's cumulative probability of contracting a beryllium-associated cancer over the 30-year operating life of the facility would be about 3×10^{-10}.

Potential toxicological impacts to noninvolved workers under the Vessel Containment, Phased Containment, and Building Containment options are presented in table H-17. Toxicological effects would not be expected, as Hazard Index values are all well below 1.0.

TABLE H-17.—*Estimated Toxicological Effect to Noninvolved Workers for Annual Routine Releases for the Enhanced Containment Alternative*

Enhanced Containment Alternative	Hazard Index (HI)[a]			
	Uranium	Beryllium	Lead	Lithium Hydride
Vessel and Phased	9×10^{-8}	0	8×10^{-9}	8×10^{-9}
Building	6×10^{-8}	0	4×10^{-9}	4×10^{-9}

[a] Toxicological effects would not be expected for a hazard index value less than 1.

H.5.2.3 Workers

Impacts to workers under the Enhanced Containment Alternative could be somewhat higher than those previously observed under PHERMEX operating conditions or projected for the uncontained alternatives because cleanup of contained space (vessels or buildings) could involve exposure to greater quantities and concentrations of materials. Worker exposures were projected to be higher than that previously observed at PHERMEX or those for other alternatives. The average annual worker dose would probably not exceed 0.020 rem. The maximum probability of a latent cancer fatality from this dose would be 8×10^{-6}. The annual collective worker dose, assuming a maximum of 100 workers, would probably not exceed 2 person-rem. No latent cancer fatalities would be expected from this dose (8×10^{-4} LCFs). The collective worker dose over the assumed 30-yr lifetime of the facility would probably not exceed 60 person-rem. No latent cancer fatalities would be expected from this dose (2×10^{-2} LCFs).

Involved worker exposures to radiation and radioactive materials under normal operations would be controlled under established procedures that require doses to be kept as low as reasonably achievable (ALARA). Any potential hazards would be evaluated as part of the radiation worker and occupational safety programs at LANL, and no impacts outside the scope of normal work activities would be anticipated.

H.5.3 Routine Operations Involving Plutonium

This section summarizes evaluations of the potential impacts to the public and workers from routine operations that could involve plutonium. Details about these impact evaluations are included in a classified supplement that is not available to the general public. Any use of plutonium would be the same under each alternative, so distinctions between alternatives are not made. Potential health consequences of exposure to plutonium are well understood and have been greatly exaggerated by the popular press (Sutcliffe et al. 1995).

Routine operations for plutonium experiments were assumed to be conducted in a double-walled containment vessel with high-efficiency particulate air (HEPA) filters having particulate retention efficiencies of 99 percent to 99.9 percent (gases would not be impeded) and an effluent monitor with a detection limit of 6×10^{-10} Ci. Under routine operating conditions, a doubly contained plutonium experiment would not be expected to release any gases or particulates to the atmosphere. However, to conservatively estimate the consequences from potential releases associated with routine operations during plutonium experiments, the release for each experiment was assumed to equal the detection limit of the monitoring instrument. Thus, a maximum of 6×10^{-10} Ci of plutonium was assumed to be released to the atmosphere during each experiment. Other methods and assumptions used were as described earlier in this appendix.

H.5.3.1 Public

The dose to the MEI among the general public over the 30-year life of the project would be about 2×10^{-10} rem. This would be the same whether the tests were conducted at the PHERMEX site or the DARHT site. The maximum probability of contracting a latent fatal cancer from this dose would be about 8×10^{-14}. The population dose over the life of the project would be about 3×10^{-7} person-rem. No LCFs would be expected (1×10^{-10} LCFs).

H.5.3.2 Noninvolved Workers

The dose to a noninvolved worker 2,500 ft (750 m) away over the 30-year life of the project would be about 6×10^{-10} rem. This would be the same whether the tests were conducted at the PHERMEX site or the DARHT site. The maximum probability of contracting a latent fatal cancer from this dose would be about 2×10^{-13}. Assuming a noninvolved work force of 15 workers at this point, the collective dose over 30 years would be 9×10^{-9} person-rem. No latent cancer fatalities (3×10^{-12} LCFs) would be expected.

H.5.3.3 Workers

No exposure to plutonium would be expected for DARHT or PHERMEX workers during any normal operations. This is based on past operating experience with dynamic experiments involving plutonium. Any radiological impacts on workers would come from the handling of depleted uranium and would be the same as reported under each of the alternatives. There would be no incremental increase in impacts due to routine operations involving plutonium.

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Appendix I
Facility Accidents

APPENDIX I
FACILITY ACCIDENTS

This appendix presents the approach used to determine and analyze impacts of accidents that might occur at the PHERMEX or DARHT facilities under all of the alternatives examined in this EIS. Section I.1 describes the Preliminary Hazards Analysis that identifies potentially hazardous conditions and potential accidents that might result. Section I.2 describes the identification of representative or bounding accidents selected for detailed evaluation. Section I.3 provides information on the consequence evaluation of these accidents, if they were to occur. Much of the technical basis for evaluating the human health impact of accidental releases is included in appendix H, Human Health. These analyses do not include the impacts from accidents involving transportation of materials, which are included in appendix J, Transportation. Unless otherwise stated, dose is the effective dose equivalent. Sums and products of numbers in this section may not appear consistent due to rounding.

I.1 PRELIMINARY HAZARDS ANALYSIS

The first step in the accident analysis process was to prepare a preliminary hazards analysis (PHA). The objective of a PHA is to identify the potentially hazardous conditions in a system and to determine the significance of the potential accidents. The PHA defines a set of abnormal operations and potential accidents that could occur at the PHERMEX or DARHT facilities. The PHA examined causes of potential accidents and qualitatively evaluated the possible consequences. A tabular summary of the PHA is shown in table I-1.

Potential hazards were identified using a modified energy barrier approach, in which abnormal events or potential accidents were selected by considering energy sources potentially capable of being released from control or containment barriers. Barriers between the source and the receptor may be present to prevent or restrict the release of energy. For example, major portions of the DARHT facilities are located below grade, using the earth as a barrier between the firing point and occupied areas. In this example, the high explosives on the firing point represent the energy source potentially capable of being released. Other examples of energy sources include radioactive materials and radiation, kinetic energy (e.g., moving vehicles, hoisting equipment), potential energy (hoisted loads), hazardous chemical materials, electrical energy, and flammable materials.

In the process described above, components associated with the PHERMEX and DARHT facilities under each alternative were analyzed using engineering judgment based on previous operating experience with PHERMEX and similar types of firing-site operations in Technical Area (TA) 15. Each of the major work locations or processes in the facilities was evaluated for potential hazards to the general public, onsite personnel, and the operating staff.

Safety features provided to prevent or mitigate hazards were also identified. Review of the hazards led to generating a list of potentially hazardous events and associated safety features.

The PHA is intended to identify hazards from which accidents are selected that may be bounding, and considers only accident pathways that for a given frequency category may have significant effects. The

TABLE I-1.—*Preliminary Hazards Analysis for DARHT and PHERMEX Facility Operations (All Alternatives)*

Facility Area	Hazardous Element	Event Description	Frequency Categorization[a]	Consequence	Mitigation/Control Measures
Firing Site	Explosives	Inadvertent detonation	U – Procedures and training; lockout on firing set (detonators)	Fatal to all persons on the firing site (up to 15); evaluate public impact	Building design and location; firing site isolation; blast shadow of buildings; access control
Firing Site	Explosives/ radiation	Worker enters firing site during detonation sequence	E – Interlocks on facility doors; cameras at firing site; access control; warning lights and sirens; procedures and training	Fatal to worker	Building design and location; firing site isolation; access control
General Facility	Explosives	Inadvertent detonation	E – HE & radioactive material prohibited from facility; no storage or staging locations; procedures and training	Fatalities among facility personnel	Building design and location; firing site isolation; procedures and training
Exclusion Zone	Explosives, hazardous materials	Noninvolved worker inside the exclusion zone during detonation	U – Access control; procedures & training; warning signs and sirens; physical lockouts	Inhalation of radioactive & other detonated material; possible injury from fragments; evaluate impact	Access control; procedures & training; warning signs and sirens
Firing Site	Radiation	Exposure to accelerator beam on firing site	E – Physical lockout of accelerator operation; limited accelerator keys; beam stop in place during testing; procedures & training	Possible large, localized radiation dose to a worker	Physical lockout of accelerator operation; limited accelerator keys; beam stop in place during testing; procedures & training
Accelerator Bay	Hazardous materials	Spill of insulator liquids or transformer oil	U – Procedures and training; low frequency of change-out	Minimal impact to workers unless ingested; no offsite impacts	System design; berms around tanks and accelerators; dedicated drains and tanks for material spills
Entire Facility	Flammable	Facility is set afire internally: rags/paper ignite spontaneously; cable fire	U – Sprinklers; cable integrity and inspection; manual fire extinguishing; fire department response	Normal fire hazard for workers; no offsite impact	Alarms; emergency procedures and training

TABLE I-1.—*Preliminary Hazards Analysis for DARHT and PHERMEX Facility Operations (All Alternatives) – Continued*

Facility Area	Hazardous Element	Event Description	Frequency Categorization[a]	Consequence	Mitigation/Control Measures
Entire Facility	Natural initiator - lightning - brush fire	Facility is set afire by a lightning strike or brush fire	A – High lightning area; explosive detonation often sets brush afire	Normal fire hazard for workers; no offsite impacts	Brush control; lightning control; canyons as natural fire breaks; fire department response capability; non-flammable facility construction (concrete); control of combustible loading
Entire Facility	Natural initiator - earthquake - tornado - high wind - heavy snowfall	Major structural damage to facility	U – Infrequent occurrence of events; building structural integrity; little material at risk in facility	Significant for workers in facility; no offsite impacts	Building structural integrity; no HE or radioactive material in facility
Entire Facility	Natural initiator - flood	Major structural damage to facility	I – Facility not sited in floodplain	Incredible event not requiring additional evaluation	Building siting
Entire Facility	Aircraft	Aircraft strikes facility causing detonation of assembly on firing site	I – Distance from airport; direct overflights are limited; amount of aircraft traffic;	Incredible event not requiring additional evaluation	Amount of time assemblies at facility or on firing site
General Facility	Explosives/ radiation	Electrical power fails at facility	A – Normal electrical failures; no back-up power for facility except data back-up	No impact	Detonation system de-energized when power fails; accelerator de-energized; recovery plans; procedures and training
Containment Structure or Vessel	Explosive	Catastrophic loss of containment	E – Design specifications of vessel or building; administrative controls on HE quantities; procedures and training	Evaluate impact	Building design and location; firing site isolation; access control
Confinement Vessel for Pu Experiments	Explosives/ plutonium	Catastrophic loss of double confinement	I-Based on related DOE safety studies	Evaluate impacts regardless of frequency categorization	Design and location; testing; double & triple contingency factors; access control; procedures and training
General Facility	Explosives/ plutonium	Inadvertent detonation of plutonium-containing assembly	E,U-Based on related DOE safety studies	Evaluate impacts	Building design and location; firing site isolation; access control; procedures and training

[a] A is anticipated; U is unlikely; E is extremely unlikely, I is incredible.

initial estimate of safety significance is based on historical experience with similar hazards and engineering judgment. Not all of the events described in the PHA were analyzed in detail to assign frequency categories or to determine expected consequences. Instead, conservative estimates were made to select a limited number of accident scenarios for detailed review (evaluation or analysis) as potentially bounding accidents.

Frequency categories are based on the entire set of events included in the accident scenario, not just the initiating event frequency. The entire event includes the initiating event and any subsequent equipment failures or human errors. As a result, it is possible for accidents with similar (or identical) initiating events to have greatly different frequency assignments. This is due to the assumptions regarding subsequent events and system failures.

The form of the PHA does not allow a detailed listing of all of the specific event assumptions. The PHA summary table succinctly describes the overall event or scenario and initiating event. Where lack of historical data or prior experience forces frequencies to be estimated based on engineering judgment, conservative assumptions were made.

The frequency categorization column of the table lists those items considered in assigning a frequency category and consequence to the event. The last column, mitigation/control measures, lists measures present principally for limiting the consequences of the event. An event in the anticipated frequency category may be constrained by physical systems (e.g., shielding walls) and administrative controls (e.g., procedures and training). Another event may be in the unlikely or extremely unlikely frequency category based on the same considerations, but may also consider the failure of one or more of the mitigation/ control measures. The event frequency determination may consider the existing or planned administrative control to limit frequency or to limit consequences.

Frequency categories used in the PHA are the following.

- Anticipated (A) (1 to 10^{-2} per year) – accidents and natural phenomena that may occur a few times during the lifetime of the operation or facility.
- Unlikely (U) (10^{-2} to 10^{-4} per year) – accidents and natural phenomena that will probably not occur during the lifetime of the operation or facility.
- Extremely Unlikely (EU) (10^{-4} to 10^{-6} per year) – accidents and natural phenomena that are credible but very unlikely to occur during the lifetime of the operation or facility.
- Incredible (I) ($<10^{-6}$ per year) – scenarios of exceedingly small probability. By definition, scenarios determined to occur less than once every 1,000,000 years are not credible.

The PHERMEX and DARHT facilities are rather unique from a hazard analysis and accident selection perspective in that the source of potential consequences to the general public from the normal operation – that is, detonation of high explosives and dispersal of depleted uranium and other materials from the site – is also the source of bounding consequences for accidents. Consequences of most accidents impact only the involved workers. For this reason, hazards and potential accidents that impact only involved workers are included in table I-2.

TABLE I-2.—*Preliminary Hazards Analysis of Hazards and Potential Accidents that Would Affect Facility Workers (Involved Workers) Only*

Facility Area	Hazardous Element	Event Description	Frequency Categorization[a]	Consequence	Mitigation/Control Measures
Accelerator Rooms	Electrical energy	Workers contacts accelerator injector power supply	U – Procedures and training	Potentially fatal to involved workers	
Accelerator Bay & Laser Room	Electrical energy	Worker contacts with laser power supply	U – Procedures and training	Potentially fatal to involved workers	
General Facility Areas	Potential/ kinetic energy	Failure of mechanical lift	U – Periodic inspections; preventive maintenance; procedures & training	Potentially fatal to involved workers	First aid available; hospital nearby
General Facility Areas	Toxic materials	Worker spills solvents used in facility	A – Frequent but small usage	Minor inhalation or uptake	Room ventilation
Camera Room	Potential/ kinetic energy	High-speed camera flies apart, producing fragments	U – Camera construction and reliability	Worker could be injured by fragment	Camera room is an exclusion area when cameras operating
Accelerator Hall	Inert gas	Confined space entry into accelerator during maintenance	U – Procedures and training; confined space entry program	Possible asphyxiation due to SF_6 inhalation	SF_6 required to be vented from area prior to accelerator entry
Laser Room	Radiation (non-ionizing)	Exposure to laser beam during maintenance or operations	U – Procedures and training	Possible eye injury or skin burn	
Accelerator Rooms	Radiation (ionizing)	Exposure to accelerator beam scattered radiation or bremsstrahlung	U – Exclusion area; shielding	Radiation exposure within LANL administrative guidelines	Procedures and training

[a] A is anticipated; U is unlikely; E is extremely unlikely, I is incredible.

I.2 BOUNDING ACCIDENT SELECTION

As noted in section I.1, the source of potential impacts to the public from PHERMEX or DARHT accidents is identical to normal operations, namely the detonation of high explosives and dispersal of materials from the firing site. Most of the differences between accidents are noted in potential impacts to involved workers, and less difference in impacts to noninvolved workers and members of the public.

The PHA provided the basis for selecting bounding accidents. Bounding accidents are those which, if they occurred, would result in the highest potential consequences (impacts) to members of the public and noninvolved or involved workers. Bounding accidents were selected from the PHA based on potential consequences, with little or no consideration of the frequency of occurrence; that is, they were considered as "what if" accidents, although the likelihood of occurrence would be small. Accidents with expected smaller consequences than the bounding accidents were eliminated from further consideration. The accident selected for more detailed analysis under all alternatives was the inadvertent uncontained detonation of a test assembly. Under the Enhanced Containment Alternative, the catastrophic failure of a containment vessel was selected for the Vessel Containment and Phased Containment options. Under the Building Containment Option, the bounding accident was the cracking and loss of integrity of the containment walls or major failure of the HEPA-filtered overpressure release system.

For involved workers at and around the firing site, inadvertent detonation is clearly the bounding case for all alternatives. The number of workers and observers on the firing site when explosives are present is limited to 15; under an inadvertent detonation scenario all of these individuals could be killed. Other accidents, mainly industrial-type accidents, could also result in worker fatalities. However, only an explosives-type accident has the capability of injuring or killing a large number of workers. In addition, for all alternatives, the direct exposure of a worker to the accelerator beam pulse was selected because it falls well outside the scope of hazards typically encountered in an industrial or laboratory setting.

Two postulated accidents involving plutonium, an inadvertent detonation and the breach of a double-walled containment vessel, identified in table I-1, were selected and evaluated on a "what if" basis. Impacts to the public maximally exposed individual (MEI), the population, noninvolved workers, and involved workers were all evaluated.

I.3 ACCIDENT ANALYSES

This section presents the methods used to analyze the human health impacts from facility accidents, and also presents the detailed results of the analyses. Some of the technical basis for evaluating the impacts of accidents is the same as for evaluating impacts from normal operations. Therefore, some of the technical basis for these analyses is contained in appendix H, Human Health.

The detonation of a test assembly results in the aerosolization and atmospheric dispersal of a portion of the materials contained in the assembly. Depleted uranium and tritium were evaluated for their radiological hazard; and uranium, beryllium, lead, and lithium hydride were evaluated for their chemical hazard. The potential for carcinogenesis from exposures to uranium, tritium, and beryllium was evaluated, as well as the potential occurrence of toxicological effects from exposure to uranium, beryllium, lead, and lithium hydride.

An inadvertent uncontained detonation was evaluated as the bounding accident for all uncontained alternatives, that is the No Action, DARHT Baseline, PHERMEX Upgrade, Plutonium Exclusion, and Single Axis alternatives, as well as the uncontained detonations under the Vessel Containment and Phased

Containment options of the Enhanced Containment Alternative. This accident considered the impact from uncontained inadvertent detonation of a test assembly with release of all assembly materials to the environment.

Two accident scenarios, applicable for the three options, were evaluated under the Enhanced Containment Alternative. The vessel accident scenario considered a catastrophic failure of a containment vessel, releasing all test assembly materials to the environment. The building accident scenario considered a building wall cracking or a HEPA filter failure during a detonation, allowing the release of a portion of the detonated inventory.

Evaluation of impacts from accidents involving plutonium are applicable for each of the alternatives in the EIS.

I.3.1 EXPOSURE MODELING

The GENII code, spreadsheet, and hand calculations were used for the health impact evaluation of accident scenarios. A description of the GENII code and model approach can be found in appendix H, Human Health. Whereas the MEPAS code was used in the evaluation of the chronic exposures in appendix H, it was not appropriate to use this code for the acute exposure scenarios of accidental releases. Therefore, hand calculations were used to estimate the intake of the nonradioactive hazardous releases.

Hazard indexes (HI) are to be used to describe the potential for toxicological effects only in situations of chronic exposures; they are inappropriate to use for acute exposure evaluations. Therefore, only the acute intake of nonradioactive constituents via the inhalation pathway over the plume passage period was evaluated. GENII acute-scenario atmospheric dispersion estimates (using 95th percentile E/Q values) were used in the spreadsheets to determine the amount of nonradioactive constituent inhaled. Inhalation intakes were then calculated and compared to equivalent intakes for the NIOSH Immediately Dangerous to Life or Health (IDLH) values (NIOSH 1995).

A test assembly inventory was established for each of the accident release cases that would be within the operating limits of the facility, represent normal assembly configuration, but would maximize possible consequences. Each inventory has the same quantity of potentially hazardous constituents as presented in table I-3. The radionuclide composition of the depleted uranium is presented in appendix H, table H-4. The high-explosive content for the uncontained detonation case was assumed to be relatively low to decrease dispersion and therefore *increase* potential impacts; thereby conservatively estimating impacts. The high-explosive content of assemblies under the containment breach cases would be higher, to effect the loss of containment.

For the uncontained detonation accident case, the effective point of material release is based on the amount of explosives used in the detonation (see appendix H). The amount of explosives detonated in the test assembly was assumed to be 22 lb (10 kg), with an effective midpoint release height of 330 ft (100 m). As discussed in appendix H for chronic releases, the single-point release assumption used in the modeling may cause potential impacts to be overestimated by up to a factor of 100.

TABLE I-3.—*Assumed Inventory of an Individual Test Assembly for Accident Analysis*

Accident Release Scenario	Inventory				
	DU	Tritium	Be	Pb	LiH
Uncontained Detonation	50	0.75	0.5	4	25
Enhanced Containment Vessel Containment Breach Building Containment Breach	50	0.75	0.5	4	25

Note: All inventories in kg, except for tritium, which is in Ci.

For both of the containment-breach accident scenarios under the Enhanced Containment Alternative, a ground-level release was modeled because the containment was assumed to diminish the upward pressure of the blast. This assumption minimizes atmospheric dispersion and, as a consequence, increases calculated potential impacts.

For the uncontained detonation and vessel breach cases, 100 percent of the test assembly inventory was assumed to be released to the environment. For the building containment breach case, only 10 percent of the test assembly inventory was assumed to be released. For all accident cases, only a portion of the released hazardous constituents would be of respirable size. An aerosolization fraction of 0.1 (10 percent) was assumed for this EIS (see appendix H), with the entire aerosolized portion assumed to be respirable. Therefore, the percentage of the test assembly inventory available for intake by human receptors would be 10 percent for uncontained detonations and the vessel containment breach, and 1 percent for the building containment breach.

Potential impacts to the MEI were evaluated at three points of public access near the PHERMEX and DARHT facilities: the nearest point of State Road 4, Pajarito Road, and Bandelier National Monument. A nearby noninvolved worker was evaluated in each case for onsite impacts. For the uncontained alternatives, impacts to noninvolved workers were evaluated at hazard radius boundary 2,500 ft (750 m), a typical hazard radius for hydrodynamic tests. For the Enhanced Containment Alternative, the noninvolved worker location, 1,300 ft (400 m), was applicable to the scenario where the noninvolved worker was located at the assumed vessel containment hazard radius boundary that was assumed to be reduced from the uncontained detonation hazard radius boundary. This scenario is also bounding for impacts to a noninvolved worker inside the hazard radius during an uncontained release. Involved workers were assumed to be near the blast and killed or seriously injured by overpressure or fragments. Table I-4 presents the locations of these individuals.

The basis for selecting the public access locations was the frequented points of closest approach by offsite individuals. These individuals are assumed to remain at that point for a brief period of time; for example, an individual changing a tire located on State Road 4 or Pajarito Road or a hiker in the Bandelier National Monument at the time of the acute release.

The noninvolved worker was located on the roadway just outside the hazard radius, approximately 2,500 ft (750 m) away for uncontained detonations. The hazard radius was assumed to be smaller for the contained detonations under the Enhanced Containment Alternative, with the noninvolved worker 1,300 ft

TABLE I-4.—*Locations of Individuals Evaluated for Accidental Release Cases*

Category	Location Description	Location
MEI[a]	State Road 4 (SR4)	0.9 mi (1.5 km) SW
Public Individual	Pajarito Road	1.7 mi (2.7 km) NE
Public Individual	Bandelier	3 mi (5 km) SSE
Noninvolved Worker Uncontained Detonation		2,500 ft (750 m) NW
Noninvolved Worker Containment Breach		1,300 ft (400 m) NW

[a] MEI is the maximally exposed individual.

(400 m) away. These distances are based on administrative hazard radii that LANL has established for protection of personnel from fragment injury and would be a typical exclusion for test assembly detonations. The hazard radius determinations are included in LANL operating procedures, based on principles presented in the DOE Explosives Safety Manual (DOE 1994).

The exposure pathways and parameters values for those of greatest importance and interest are presented in table I-5. For radioactive material, the exposure pathways considered under the acute accidental release scenarios included inhalation and external exposure from the material in the plume and deposited on the ground surface. This was principally depleted uranium because for all six alternatives, the radiation dose from tritium, in the form of T_2, was determined to be about 1×10^{-8} (about 1 in 100 million) that of depleted uranium. An analysis was performed, using GENII, to compare dose consequences of the acute releases of depleted uranium and tritium. Because it was determined to be an insignificant contributor to the radiation dose, tritium impacts were not explicitly calculated. To evaluate the potential toxicological effects of uranium, beryllium, lead, and lithium hydride, and the carcinogenic risk from beryllium, only the inhalation exposure pathway was considered.

In the past, DOE has conducted dynamic experiments with plutonium at LANL. Future experiments with plutonium would always be conducted in double-walled containment vessels; these experiments could not reasonably be expected to result in any release of plutonium to the environment. DOE has evaluated the potential impacts of two types of accidents that could involve plutonium: inadvertent detonation and containment breach. It is important to note that any accidents involving plutonium would not be nuclear detonations, but rather detonations of the high explosive that could disperse particles of plutonium. This analysis is documented in a classified supplement to the EIS. Results and unclassified calculation assumptions and modeling methods are included in this appendix and in applicable sections of Chapter 5.

Radionuclide-independent exposure modeling assumptions and methods for accidents involving plutonium were the same as those presented for depleted uranium with the following exceptions for population dose calculations:

TABLE I-5.—*Code Input Parameters Used to Evaluate Accident Release Consequences*

Pathway	Dose Receptor/Applicable Accident Scenario[a]		
	Public Individual All Accident Scenarios	Noninvolved Worker Uncontained Detonation	Noninvolved Worker Containment Breach
External exposure			
external plume	Plume passage	Plume passage	Plume passage
ground surface (hours)	1	0.25	0.25
Inhalation	Plume passage	Plume passage	Plume passage

[a] Individuals are located in the plume centerline during the entire time of its passage.

Miscellaneous parameters:
soil density, 100 lb/ft^3 (1.6×10^3 kg/m^3)
surface soil density, 15 lb/ft^3 (240 kg/m^2)
mass loading, 4.5×10^{-9} lb/ft^3 (7.2×10^{-5} g/m^3)

- Plume depletion due to natural settling and deposition processes was taken into account.
- Diffusion of released material across an entire exposed sector was taken into account, rather than assuming that all exposure took place on the plume centerline.
- Estimates of population dose were made using both the 50th and 95th percentile atmospheric dispersion factors, rather than just the 95th percentile value.

Accounting for plume depletion and diffusion of released material resulted in lowering values for the atmospheric dispersion factors, with consequently lower estimated atmospheric concentrations for a given unit of release. This resulted in estimates of plutonium air concentrations approximately 38 and 10 times lower for ground-level (containment breach) and elevated (inadvertent detonation) releases, respectively, than would have been estimated had these factors not been taken into account. Use of the 50th and 95th percentile atmospheric dispersion factors provide a range of estimates using realistic (50th) and a reasonable upper bound (95th) of atmospheric dispersion conditions.

In addition to calculating the potential dose to the population in the hypothetical maximally exposed sector, at the request of the State of New Mexico Environment Department and various American Indian pueblos, the potential dose to the populations of a number of individual communities in the vicinity of LANL were calculated. The communities included in this evaluation and community-specific input parameters are presented in table I-6. As was done for other accidental release calculations, it was assumed that the plume released from the accident passed directly over the community. This explains why results are presented for communities in opposite directions; for example, Cochiti Pueblo that is south-southwest, and Santa Clara Pueblo that is north-northeast. These calculations included plume depletion but did not account for the diffusion of material in the plume; that is, the communities were assumed to be on the centerline of the plume of released material. Calculations were done using both the 50th and 95th percentile atmospheric dispersion factors.

TABLE I-6.—*Additional Communities Evaluated for Impacts from Postulated Accidents Involving Plutonium*

Communities	Population	Distance [mi (km)]	Direction from TA-15	E/Q (s/m^3)	
				50th	95th
Cochiti Pueblo[a]	936	13 (21)	SSW	3.6×10^{-7}	8.6×10^{-7}
Santa Clara Pueblo[a]	1742	10 (16)	NNE	3.7×10^{-7}	1.1×10^{-6}
San Ildefonso Pueblo[a]	634	8 (12)	NE	6.8×10^{-7}	1.4×10^{-6}
Jemez Pueblo[a]	2642	13 (21)	SW	1.2×10^{-7}	8.3×10^{-7}
Española[b]	9026	12 (20)	NNE	3.3×10^{-7}	8.8×10^{-7}
Pojoaque Pueblo[a]	162	15 (24)	E	3.0×10^{-7}	6.4×10^{-7}
Los Alamos[b]	3965	3.5 (6)	NNW	4.2×10^{-7}	3.2×10^{-6}
White Rock[b]	498	4 (6)	ESE	5.3×10^{-7}	2.4×10^{-6}
Santa Fe[b]	41300	25 (40)	ESE	1.8×10^{-7}	4.4×10^{-7}

[a] Population data from the Pueblo Cultural Center.
[b] Population data from the 1990 U.S. Census.

I.3.2 ACCIDENT ANALYSIS RESULTS

The estimated radiation dose and carcinogenic risk impacts to members of the public and noninvolved workers from exposure to radioactive material and beryllium released during an accident are presented in table I-7. The maximum radiation dose to a member of the public was estimated to be 0.011 rem to the MEI, located at State Road 4, in the event of a catastrophic failure of a containment vessel during a detonation. The maximum probability of a latent cancer fatality (LCF) from this accident scenario would be 6×10^{-6}. Dose to members of the public at Pajarito Road, Bandelier, and other locations would be lower than those at the State Road 4 location. The estimated maximum dose to the surrounding population within 50 mi (80 km), also from a containment vessel failure, would be about 17 person-rem. No LCFs would be expected among the population from this dose (9×10^{-3} LCFs).

The maximum probability of a beryllium-induced cancer, again to the MEI at the State Road 4 location from a containment vessel failure, would be 8×10^{-9}. Inhalation intakes of material released during the accidents are presented in table I-8, and calculated air concentrations and their comparison to the IDLH values are presented in table I-9. The transitory air concentrations that would be experienced by the MEI at the State Road 4 location would be, at the greatest, less than 1 percent of the IDLH values.

A noninvolved worker would receive the highest dose from the vessel containment failure, receiving a dose of about 0.05 rem (table I-7). The maximum probability of a LCF from this accident scenario would be 2×10^{-5}. The maximum probability of a beryllium-induced cancer would be about 3×10^{-8}. Inhalation intakes of material released during the accidents are presented in table I-8. The amount of material inhaled was estimated from the E/Q information. However, the IDLH health impact guidelines for acute exposures to hazardous materials are based on air concentrations (NIOSH 1995). The IDLH values are the best available for determining health impact, but are not ideal, given the original intended

TABLE I-7.—*Estimated Doses and Carcinogenic Risk from Bounding Case Accidents*

Accidental Release Case	Total dose (rem EDE)	Probability of Radiation-Induced LCF[c]	Probability of Beryllium-Induced Cancer
Uncontained Detonation			
Public MEI[b], State Road 4	6×10^{-4}	3×10^{-7}	4×10^{-10}
Public, Pajarito Road	3×10^{-4}	2×10^{-7}	2×10^{-10}
Public, Bandelier	3×10^{-4}	1×10^{-7}	2×10^{-10}
Noninvolved worker	7×10^{-4}	3×10^{-7}	5×10^{-10}
Population (ESE)[a] (number of LCFs)	1.9 person-rem	none (9×10^{-4} LCFs)	none (1×10^{-6} total cancers)
Vessel Containment Breach			
Public MEI, State Road 4	1×10^{-2}	6×10^{-6}	8×10^{-9}
Public, Pajarito Road	8×10^{-3}	4×10^{-6}	5×10^{-9}
Public, Bandelier	3×10^{-3}	2×10^{-6}	3×10^{-9}
Noninvolved worker	5×10^{-2}	2×10^{-5}	3×10^{-8}
Population (ESE) (number of LCFs)	17 person-rem	none (9×10^{-3} LCFs)	none (1×10^{-5} total cancers)
Building Containment Breach			
Public, MEI, State Road 4	1×10^{-3}	6×10^{-7}	8×10^{-10}
Public, Pajarito Road	8×10^{-4}	4×10^{-7}	5×10^{-10}
Public, Bandelier	4×10^{-4}	2×10^{-7}	3×10^{-9}
Noninvolved worker	5×10^{-3}	2×10^{-6}	3×10^{-9}
Population (ESE)[a] (number of LCFs)	1.7 person-rem	none (9×10^{-4} LCFs)	none (1×10^{-6} total cancers)

[a] The east-southeast (ESE) sector.
[b] MEI is the maximally exposed individual.
[c] LCF is latent cancer fatality.

Note: Population impacts are shown as expected number of LCFs and cancers rather than an individual probability of occurrence.

use of the IDLHs for emergency response purposes. IDLH values are based on 30-minute exposure times. The exposure times of the modeled individuals are much shorter than 30 minutes (see table I-8).

The IDLHs are based on breathing 353 ft^3 (10 m^3) of air over the 30-minute exposure time. Since it would be difficult to draw health impact conclusions from air concentrations that are based on 30-minute exposure levels for the MEI 1 to 8 min exposure levels, the IDLH-equivalent intake was calculated for comparison to the MEI intakes. The IDLH-equivalent intake values are the product of the constituent-specific IDLH ($\mu g/m^3$) (NIOSH 1995) and the volume of air intake [353 ft^3 (10 m^3)] and are listed in table I-8 for the constituents of interest. All MEI intakes of the hazardous constituents are less than their respective IDLH-equivalent intake values. Table I-9 indicates each individual's exposure as a percent of

TABLE I-8.—*Inhalation Intakes of Materials Released in the Accident Release Cases*

Accidental Release Case	E/Q[a] (s/m^3)	Plume Exposure Time(s)	U (μg)	Be (μg)	Pb (μg)	LiH (μg)
Uncontained Detonation						
Public MEI, State Road 4	7.5×10^{-6}	180	9	0.09	0.7	4
Public, Pajarito Road	4.4×10^{-6}	182	5	0.05	0.4	4
Public, Bandelier	3.5×10^{-6}	309	4	0.04	0.3	2
Noninvolved worker	8.9×10^{-6}	140	10	0.4	0.8	5
Vessel Containment Breach						
Public MEI, State Road 4	1.4×10^{-4}	160	200	2	10	80
Public, Pajarito Road	9.6×10^{-5}	218	100	1	9	60
Public, Bandelier	4.7×10^{-5}	500	50	0.5	4	30
Noninvolved worker	6.2×10^{-4}	51	700	7	60	400
Building Containment Breach						
Public MEI, State Road 4	1.4×10^{-4}	160	20	0.2	1	8
Public, Pajarito Road	9.6×10^{-5}	218	10	0.1	0.9	6
Public, Bandelier	4.7×10^{-5}	500	5	0.05	0.4	3
Noninvolved worker	6.2×10^{-4}	51	70	0.7	6	40
IDLH[b] Value (mg/m^3)			10,000	4,000	100,000	500
Equivalent intake (μg)			100,000	40,000	1,000,000	5,000

[a] The E/Q (E over Q) is a measure of atmospheric dispersion for short-term (acute) atmospheric releases using gaussian dispersion plume modeling, with units of s/m^3. For a given point or location at some distance from the source, it represents the time-integrated air concentration (e.g., Ci-s/m^3) divided by the total release from the source (e.g., Ci). Integrated air concentrations used are usually plume centerline values. E/Qs are typically used for releases lasting no longer than 8 to 24 hours.
[b] IDLH (Immediately dangerous to life or health) values from NIOSH 1995.

the IDLH. Most intakes are less than 1 percent of the IDLH; the highest is for the noninvolved worker exposed to a level of 8 percent of the LiH IDLH during a vessel containment failure.

Containment breach releases have greater potential impacts than uncontained releases (tables I-7 to I-9) mainly because there is less atmospheric dispersion of ground-level containment releases than for the explosive elevated uncontained releases. This can result in a greater atmospheric concentration at the nearby point of exposure. Other important considerations are the quantity of material released and the population distribution (for population dose calculations). Appendix C (section C.1.3.3) provides some additional discussion on comparative impacts of releases from containment and uncontained detonations.

Potential impacts from postulated accidents involving plutonium are shown in tables I-10 and I-11. Potential health consequences of exposure to plutonium are well understood and have been greatly exaggerated by the popular press (Sutcliffe et al. 1995). These results include hypothetical impacts to the

TABLE I-9.—*Percent of the IDLH Intake Basis Inhaled by the Individual*

Accidental Release Case	U	Be	Pb	LiH
Uncontained Detonation	9×10^{-3}	2×10^{-4}	7×10^{-5}	8×10^{-2}
Public MEI, State Road 4	5×10^{-3}	1×10^{-4}	4×10^{-5}	8×10^{-2}
Public, Pajarito Road	4×10^{-3}	1×10^{-4}	3×10^{-5}	4×10^{-2}
Public, Bandelier				
	1×10^{-2}	1×10^{-3}	8×10^{-5}	1×10^{-1}
Noninvolved worker 2,500 ft (760 m)				
Vessel Containment Breach				
Public MEI, State Road 4	2×10^{-1}	5×10^{-3}	1×10^{-3}	2
Public, Pajarito Road	1×10^{-1}	3×10^{-3}	9×10^{-4}	1
Public, Bandelier	5×10^{-2}	1×10^{-3}	4×10^{-4}	6×10^{-1}
Noninvolved worker 1,300 ft (400 m)	7×10^{-1}	2×10^{-2}	6×10^{-3}	8
Building Containment Breach				
Public MEI, State Road 4	2×10^{-2}	5×10^{-4}	1×10^{-4}	2×10^{-1}
Public, Pajarito Road	1×10^{-2}	3×10^{-4}	9×10^{-5}	1×10^{-1}
Public, Bandelier	5×10^{-3}	1×10^{-4}	4×10^{-5}	6×10^{-2}
Noninvolved worker 1,300 ft (400 m)	7×10^{-2}	2×10^{-3}	6×10^{-4}	8×10^{-1}
IDLH[a] equivalent intake (mg)	100	40	1,000	5

[a] IDLH (Immediately Dangerous to Life or Health).

public MEI, population in the maximally exposed sector, noninvolved workers, and involved workers. The MEI, located at State Road 4, could receive up to 76 rem in the event of an accident. The maximum probability of a LCF occurring in this hypothetical individual would be 0.04. The dose to the potentially maximally exposed sector of the population, east-southeast of the DARHT and PHERMEX sites that includes the communities of White Rock and Santa Fe, could be between 9,000 and 24,000 person-rem, taking into consideration the 50th and 95th percentile meteorology, respectively. Between 5 and 12 LCFs would be projected from radiation doses such as these to the population.

Impacts to noninvolved workers could be as high as 160 rem, for a worker 1,300 ft (400 m) away from an uncontained detonation. The maximum probability of an LCF occurring in a worker from this radiation dose would be 0.06. More likely, a noninvolved worker would be no closer than 2,500 ft (750 m). The dose to a worker at this distance would be about 90 rem, with a corresponding maximum probability of about 0.04 of an LCF occurring.

Table I-12 shows hypothetical impacts to nearby communities in the event of an inadvertent uncontained detonation involving plutonium. These values are likely to be overestimated because of the assumption that all of the community population is located on or near the plume centerline. In particular, the value for Los Alamos is likely to be overestimated because the airborne plume would be relatively narrow at this distance and would expose only a small fraction of the population shown in table I-6, leaving most of the population unexposed. Because of its closeness to LANL, however, Los Alamos could be one of the most affected communities if the plume passed that way. Some of the other small communities could receive

TABLE I-10.—*Hypothetical Impacts to Workers and the Public from Postulated Accidents Involving Plutonium*

Affected Category	Inadvertent Detonation		Containment Breach	
	Dose (rem)	Maximum Probability of LCFs	Dose (rem)	Maximum Probability of LCFs
Workers	—[a]	NA	no impact	no impact
Noninvolved Workers				
750 m	90	0.04	20	0.009
400 m	160	0.06	60	0.02
Public MEI	76	0.04	14	0.007

[a] No radiological impact estimated; up to 15 fatalities could result from explosion blast effects.
[b] NA = not applicable

TABLE I-11.—*Hypothetical Impacts to the Maximally Exposed Sector of the Population from Postulated Accidents Involving Plutonium*

Atmospheric Dispersion Assumption	Inadvertent Detonation		Containment Breach	
	Population Dose (person-rem)	Number of LCFs	Population Dose (person-rem)	Number of LCFs
50th[a]	9,000	5	210	0 (0.1)
95th[b]	24,000	12	560	0 (0.3)

[a] 50th percentile of atmospheric dispersion conditions.
[b] 95th percentile of atmospheric dispersion conditions.
Note: The communities of Santa Fe and White Rock are included within the population of this sector.

high enough population doses in the event of an accident under the specific exposure conditions assumed in the analysis that some LCFs could occur. Up to one LCF could occur at White Rock and Santa Clara Pueblo, up to two at Jemez Pueblo, between two and six at Española, and between three and nine in Santa Fe. No LCFs would be projected for the other communities evaluated. Values for communities in different compass directions are not additive (see table I-6). Only values for Santa Clara and Española, and White Rock and Santa Fe, may be added since these two sets of communities lie in the same direction from TA-15.

Some individuals may wish to explore potential human health consequences of hypothetical accidental releases of plutonium from proposed PHERMEX or DARHT activities. Estimates of the potential dose impact from unit releases of plutonium isotopes are provided in tables I-13, I-14, and I-15 for ground-level, 330-ft (100-m), and 400-ft (120-m) releases, respectively.

TABLE I-12.—*Hypothetical Impacts to Nearby Communities from a Postulated Inadvertent Detonation Accident Involving Plutonium*

Community	50th Percentile Meteorology[a]		95th Percentile Meteorology[b]	
	Population Dose (person-rem)	Number of LCFs	Population Dose (person-rem)	Number of LCFs
Cochiti Pueblo	300	0	800	0
Santa Clara Pueblo	1000	0	2900	1
San Ildefonso Pueblo	400	0	900	0
Jemez Pueblo	600	0	4400	2
Española	4400	2	12100	6
Pojoaque Pueblo	50	0	100	0
Los Alamos	5900	3	45100	22
White Rock	500	0	2400	1
Santa Fe	7500	3	18700	9

[a] 50th percentile of atmospheric dispersion conditions.
[b] 95th percentile of atmospheric dispersion conditions.

Note: Values for communities in different compass directions are not additive (see table I-6).

TABLE I-13.—*Plutonium Isotope Unit Dose Factors for Evaluation of Potential Human Health Impacts from Acute, Ground-Level Releases*[a]

Accident Release Case Dose Receptor	Pu-236	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242	Pu-244
Public (rem/μCi released)[b]							
MEI, State Road 4	6.2×10^{-6}	1.3×10^{-5}	1.4×10^{-5}	1.4×10^{-5}	2.3×10^{-7}	1.3×10^{-5}	1.3×10^{-5}
Pajarito Road	4.3×10^{-6}	9.2×10^{-6}	9.7×10^{-6}	9.7×10^{-6}	1.6×10^{-7}	9.3×10^{-6}	9.2×10^{-6}
Bandelier	2.0×10^{-6}	4.3×10^{-6}	4.6×10^{-6}	4.6×10^{-6}	7.4×10^{-8}	4.4×10^{-6}	4.3×10^{-6}
Population (person-rem per μCi released)							
East-southeast	9.6×10^{-3}	2.0×10^{-2}	2.2×10^{-2}	2.2×10^{-2}	3.6×10^{-4}	2.1×10^{-2}	2.1×10^{-2}
Noninvolved Worker (rem/μCi released)							
1,300 ft (400 m)	2.7×10^{-5}	5.7×10^{-5}	6.1×10^{-5}	6.1×10^{-5}	9.8×10^{-7}	5.8×10^{-5}	5.8×10^{-5}
2,500 ft (760 m)	9.8×10^{-6}	2.1×10^{-5}	2.2×10^{-5}	2.2×10^{-5}	3.6×10^{-7}	2.1×10^{-5}	2.1×10^{-5}
Specific Activity (μCi/g)	5.3×10^{8}	1.7×10^{7}	6.2×10^{4}	2.3×10^{5}	1.0×10^{8}	3.9×10^{3}	1.8×10^{1}

[a] Includes all applicable exposure pathways described in table I-5.
[b] Release can be estimated as follows: inventory x fraction released x respirable fraction.

TABLE I-14.—*Plutonium Isotope Unit Dose Factors for Evaluation of Potential Human Health Impacts from Acute, 330-ft (100-m) Releases*[a]

Accident Release Case Dose Receptor	Pu-236	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242	Pu-244
Public (rem/μCi released)[b]							
MEI, State Road 4	3.4×10^{-7}	7.2×10^{-7}	7.6×10^{-7}	7.6×10^{-7}	1.2×10^{-8}	7.3×10^{-7}	7.2×10^{-7}
Pajarito Road	2.0×10^{-7}	4.3×10^{-7}	4.6×10^{-7}	4.6×10^{-7}	7.4×10^{-9}	4.4×10^{-7}	4.3×10^{-7}
Bandelier	1.6×10^{-7}	3.4×10^{-7}	3.6×10^{-7}	3.6×10^{-7}	5.9×10^{-9}	3.5×10^{-7}	3.5×10^{-7}
Population (person-rem per μCi released)							
East-southeast	1.1×10^{-3}	2.3×10^{-3}	2.4×10^{-3}	2.4×10^{-3}	4.1×10^{-5}	2.3×10^{-3}	2.3×10^{-3}
Noninvolved Worker (rem/μCi released)							
1,300 ft (400 m)	7.0×10^{-7}	1.5×10^{-6}	1.6×10^{-6}	1.6×10^{-6}	2.6×10^{-8}	1.5×10^{-6}	1.5×10^{-6}
2,500 ft (760 m)	3.9×10^{-7}	8.3×10^{-7}	8.8×10^{-7}	8.8×10^{-7}	1.4×10^{-8}	8.5×10^{-7}	8.4×10^{-7}
Specific Activity (μCi/g)	5.3×10^{8}	1.7×10^{7}	6.2×10^{4}	2.3×10^{5}	1.0×10^{8}	3.9×10^{3}	1.8×10^{1}

[a] Includes all applicable exposure pathways described in table I-5.
[b] Release can be estimated as follows: inventory x fraction released x respirable fraction.

TABLE I-15.—*Plutonium Isotope Unit Dose Factors for Evaluation of Potential Human Health Impacts from Acute, 400-ft (120-m) Releases*[a]

Accident Release Case Dose Receptor	Pu-236	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242	Pu-244
Public (rem/μCi released)[b]							
MEI, State Road 4	2.4×10^{-7}	5.2×10^{-7}	5.5×10^{-7}	5.5×10^{-7}	8.9×10^{-9}	5.2×10^{-7}	5.2×10^{-7}
Pajarito Road	1.1×10^{-7}	2.4×10^{-7}	2.6×10^{-7}	2.6×10^{-7}	4.2×10^{-9}	2.5×10^{-7}	2.5×10^{-7}
Bandelier	1.1×10^{-7}	2.3×10^{-7}	2.4×10^{-7}	2.4×10^{-7}	3.9×10^{-9}	2.3×10^{-7}	2.3×10^{-7}
Population (person-rem per μCi released)							
East-southeast	7.3×10^{-4}	1.6×10^{-3}	1.6×10^{-3}	1.6×10^{-3}	2.7×10^{-5}	1.6×10^{-3}	1.6×10^{-3}
Noninvolved Worker (rem/μCi released)							
1,300 ft (400 m)	4.7×10^{-7}	1.0×10^{-6}	1.1×10^{-6}	1.1×10^{-6}	1.7×10^{-8}	1.0×10^{-6}	1.0×10^{-6}
2,500 ft (760 m)	3.1×10^{-7}	6.6×10^{-7}	7.0×10^{-7}	7.0×10^{-7}	1.1×10^{-8}	6.7×10^{-7}	6.6×10^{-7}
Specific Activity (μCi/g)	5.3×10^{8}	1.7×10^{7}	6.2×10^{4}	2.3×10^{5}	1.0×10^{8}	3.9×10^{3}	1.8×10^{1}

[a] Includes all applicable exposure pathways described in table I-5.
[b] Release can be estimated as follows: inventory x fraction released x respirable fraction.

I.4 REFERENCES CITED IN APPENDIX I

DOE (U.S. Department of Energy), 1994, *DOE Explosives Safety Manual*, DOE/EV/06194, August, Washington, D.C.

NIOSH (National Institute for Occupational Safety and Health), 1995, *NIOSH Pocket Guide to Chemical Hazards*, in Tomes-Toxicological, Occupational Medicine, and Environmental Series (CD-ROM), Database used: NIOSH Pocket Guide.

Sutcliffe, W.G., et al., 1995, *A Perspective on the Dangers of Plutonium*, April 14, UCRL-ID-118825, Center for Security and Technology Studies, Lawrence Livermore National Laboratory, Livermore, California.

Appendix J
Transportation

APPENDIX J
TRANSPORTATION

This appendix discusses the methods, data, and results used to analyze the impacts of transporting test assemblies from the assembly facility to the firing site. With respect to transportation impacts, there are only two different transportation scenarios and analyses. The No Action and Upgrade PHERMEX alternatives, in which activities at the DARHT site would be terminated, are slightly different from the other alternatives, which would take place at the DARHT site. The No Action and Upgrade alternatives are discussed as the No Action Alternative while the other alternatives are discussed collectively as the DARHT Baseline Alternative.

J.1 SHIPPING SCENARIOS

The options for shipping test assemblies from the assembly facility to firing sites are discussed in this section. All scenarios assume that the test assembly is assembled by the WX division, and that the fully assembled test assembly would be transported via truck to the magazine for interim storage, and following interim storage would be transported via truck to the firing site. It was further assumed that only one test assembly would be transported at a time and all testing apparatus would be installed at the firing site. There may be up to six supporting equipment shipments associated with each test assembly detonation. These would not involve hazardous materials and would occur within the facility boundary; therefore, these supporting shipments have not been included in this analysis.

The test assembly would consist of a steel frame work, high explosive, and depleted uranium. Although the quantity of high explosives may vary per test assembly, it is assumed that the quantity of depleted uranium will remain constant. The test assemblies were assumed to be transported on a flat bed truck. Once the device is assembled, all testing equipment, consisting of x-ray triggering devices and the high explosives detonators, would be installed at the firing site. In accordance with U. S. Department of Transportation (DOT) regulations, the detonators would not be transported on the same vehicle as the high explosives.

The following subsections discuss the shipping scenarios, transportation and packaging systems, and the affected facilities.

J.1.1 Facilities

For both transportation scenarios, the test assembly would be assembled at the WX facility (TA-16-410) and transported to a magazine (Building R–242), which is used for interim storage. From the magazine, the test assemblies would be transported to the PHERMEX (No Action Alternative) or to the DARHT Facility (DARHT Baseline Alternative). These facilities were identified to estimate the consequences to LANL facility workers during normal or incident-free shipping and during shipping accidents.

J.1.2 Transport Scenario

The test assembly would be fully assembled, without detonators, by the WX division in TA-16-410 and transported to the PHERMEX or the DARHT Facility via truck on roads internal to TA-16 and TA-15. The fully assembled device would be loaded and secured at TA-16-410 on a flat bed truck and transported to a magazine (Building R–242). If required, the device could be staged at the magazine on the transport vehicle for a few hours with attending personnel before being shipped from the magazine to the receiving facility where it would be unloaded.

J.2 SHIPPING SYSTEM DESCRIPTION

This section describes the shipping container and the truck used to transport the test assembly. The information presented in this discussion focuses primarily on the parameters that would affect the analysis results, that is, the shipping container, the radionuclide inventory, the hazardous chemical inventory, and the quantity and characteristics of the high explosives.

The test assembly would be secured to a flat bed truck and would not be transported in a shipping container. The estimated radionuclide and hazardous chemical inventories for depleted uranium, beryllium, lead, copper, tritium, and lithium hydride are presented in section 3.11, table 3-4. It is anticipated that there would be 20 shipments per year, with a maximum of 110 lb (50 kg) depleted uranium per test assembly and a maximum annual usage of 1,540 lb (700 kg). The high explosives used in test assemblies may be sensitive to heat and impact. Three bounding test assemblies have been identified: Test Assembly 1 containing 22 lb (10 kg) high explosive, Test Assembly 2 containing 500 lb (230 kg) explosive, and Test Assembly 3 containing 1,010 lb (460 kg) high explosives. These larger high explosives tests were assumed not to contain any additional depleted uranium.

J.3 TRANSPORTATION ROUTE INFORMATION

The assembled test assemblies would be transported from TA-16-410 to the PHERMEX or the DARHT Facility using roads internal to TA-16 and TA-15. The truck would be loaded at TA-16-410 and transported nonstop approximately 5 mi (8 km) to the magazine (Building R–242). From the magazine, the test assembly would be transported nonstop approximately 1.2 mi (2 km) to the PHERMEX gate or 1 mi (1.5 km) to the DARHT gates. At each of the facilities, the test assembly would be transported approximately 1,600 ft (490 m) from the facility gate to the firing site. It was assumed that 10 people would be exposed to the shipment at each of the stops (i.e., magazine, and facility gates), and that approximately 60 percent of the route is through LANL open space (~5 workers/km^2) and 40 percent of the route is past occupied buildings (~360 workers/km^2). These assumptions were based on an examination of a LANL site map.

J.4 DESCRIPTION OF METHODS USED TO ESTIMATE CONSEQUENCES

This section describes the methods used to estimate the impacts to individuals at the LANL site due to transporting test assemblies for both incident-free and accident conditions. Any impacts would be due to exposures to radiological and hazardous materials and physical traumas from explosion of the high explosives. The RADTRAN 4 (Neuhauser and Kanipe 1992) and GENII (Napier et al. 1988) computer codes were used to estimate radiological consequences. The hazardous material consequences were calculated by hand using the same site meteorological characteristics data used in the GENII analyses. The consequences associated with explosions of the high explosives were calculated using explosion modeling data presented in Rhoads et al. (1986).

J.4.1 RADTRAN 4 Computer Code

The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used to perform the analyses of the radiological impacts of routine transport, and the integrated population risks of accidents during transport of the test assembly. RADTRAN was developed by Sandia National Laboratories (SNL) to calculate the risks associated with the transportation of radioactive materials. The original code was written by SNL in 1977 in association with the preparation of NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977). The code has since been refined and expanded and is currently maintained by SNL under contract with DOE. RADTRAN 4 is an update of the RADTRAN 3 (Madsen et al. 1986) and RADTRAN 2 (Taylor and Daniel 1982; Madsen et al. 1983) computer codes.

The RADTRAN 4 computer code is organized into the following seven models (Neuhauser and Kanipe 1992):

- Material model
- Transportation model
- Population distribution model
- Health effects model
- Accident severity and package release model
- Meteorological dispersion model
- Economic model

The code uses the first three models to calculate the potential population dose from normal, incident-free transportation and the first six models to calculate the risk to the population from user-defined accident scenarios. The economic model is not used in this study.

J.4.1.1 Material Model

The material model defines the source as either a point source or as a line source. For exposure distances less than twice the package dimension, the source is conservatively assumed to be a line source. For all other cases, the source is modeled as a point source that emits radiation equally in all directions. The material model also contains a library of 59 isotopes, each of which has 11 defining parameters that are used in the calculation of dose. The user can add isotopes not in the RADTRAN library by creating a data table in the input file consisting of 11 parameters.

J.4.1.2 Transportation Model

The transportation model allows the user to input descriptions of the transportation route. A transportation route may be divided into links or segments of the journey with information for each link on population density, mode of travel (e.g., trailer truck or ship), accident rate, vehicle speed, road type, vehicle density, and link length. Alternatively, the transportation route also can be described by aggregate route data for rural, urban, and suburban areas. For this analysis, the aggregate route method was used for each potential origin-destination combination.

J.4.1.3 Health Effects Model

The health effects model in RADTRAN 4 is outdated and is replaced by hand calculations. The health effects are determined by multiplying the population dose (person-rem) supplied by RADTRAN 4 by a conversion factor (ICRP 1991).

J.4.1.4 Accident Severity and Package Release Model

Accident analysis in RADTRAN 4 is performed using the accident severity and package release model. The user can define up to 20 severity categories for three population densities (such as urban, suburban, and rural), each increasing in magnitude. Eight severity categories for Spent Nuclear Fuel containers that are related to fire, puncture, crush, and immersion environments are defined in NUREG-0170 (NRC 1977). Various other studies also have been performed for small packages (Clarke et al. 1976) and large packages (Dennis et al. 1978) that also can be used to generate severity categories. The accident scenarios are further defined by allowing the user to input release fractions and aerosol and respirable fractions for each severity category. These fractions are also a function of the physical-chemical properties of the materials being transported. The source term for RADTRAN 4 is adjusted to account for the presumed explosion in an accident scenario.

J.4.1.5 Meteorological Dispersion Model

RADTRAN 4 allows the user to choose two different methods for modeling the atmospheric transport of radionuclides after a potential accident. The user can either input Pasquill atmospheric-stability category data or averaged time-integrated concentrations. In this analysis, the dispersion of radionuclides after a potential accident is modeled by the use of time-integrated concentration values in downwind areas compiled from meteorological data acquired in TA-6.

J.4.1.6 Routine Transport

The models described above are used by RADTRAN 4 to determine dose from routine transportation or risk from potential accidents. The public and worker doses calculated by RADTRAN 4 for routine transportation are dependent on the type of material being transported and the transportation index (TI) of the package or packages. The TI is defined in 49 CFR 173.403(bb) as the highest package dose rate in millirem per hour at a distance of 3.3 ft (1 m) from the external surface of the package. Dose consequences are also dependent on the size of the package, which, as indicated in the material model description, will determine whether the package is modeled as a point source or line source for close-proximity exposures.

J.4.1.7 Analysis of Potential Accidents

The accident analysis performed in RADTRAN 4 calculates population doses for each accident severity category using six exposure pathway models. They include inhalation, resuspension, groundshine, cloudshine, ingestion, and direct exposure. This RADTRAN 4 analysis assumes that any contaminated area is either mitigated or public access controlled so the dose via the ingestion pathway equals zero. The consequences calculated for each severity category are multiplied by the appropriate frequencies for accidents in each category and summed to give a total point estimate of risk for a radiological accident.

J.4.2 GENII

GENII (Napier et al. 1988), which is also referred to as the Hanford Environmental Dosimetry Software System, was developed and written by the Pacific Northwest Laboratory to analyze radiological releases to the environment. GENII is composed of seven linked computer programs and their associated data libraries. This includes user interface programs, internal and external dose factor generators, and the environmental dosimetry programs. GENII is capable of calculating:

- Doses resulting from acute or chronic releases, including options for annual dose, committed dose, and accumulated dose
- Doses from various exposure pathways evaluated including those through direct exposure via water, soil, and air as well as inhalation and ingestion pathways
- Acute and chronic elevated and ground level releases to air
- Acute and chronic releases to water
- Initial contamination of soil or surfaces
- Radionuclide decay

The pathways considered in this analysis include inhalation, submersion (in explosive cloud), and external exposures due to ground contamination.

J.4.3 Explosives Model

The explosive effects model was taken from Rhoads et al. (1986), which evaluated the effects produced by TNT explosions. The physical effects of explosions are related to the blast pressure, which will decrease with distance from the point of explosion. The assessment contained in Rhoads et al. assumed that a 27 lb/in^2 (186 kPa) peak overpressure was 100 percent fatal. Assuming that the blast wave expands equally from the center point, the distance to the peak overpressure for an unconfined explosion can be calculated using the following formula:

$$D = ZW^{1/3}$$

where D is the distance from the blast, Z ($ft/lb^{1/3}$) ($m/kg^{1/3}$) is the scaled range and W is the TNT equivalent of the explosion. For this assessment, Z was assumed to be equal to 5.5 $ft/lb^{1/3}$ (3.7 $m/kg^{1/3}$), which corresponds to a peak overpressure of 27 lb/in^2 (186 kPa).

J.4.4 Microshield

Microshield (Grove Engineering 1988) was used to analyze the shielding of gamma radiation in such areas as shielding design, container design, temporary shielding selection, source strength inference from radiation measurements, ALARA planning, and teaching. This program is a microcomputer adaptation of the main frame code ISOSHLD, a public domain "point kernel" code first written in the early 1960s. Microshield was used in this analysis to calculate the TI or estimated dose rate (mrem/h) at 3 ft (1 m) from the test assembly. This estimated dose rate is required in RADTRAN to calculate doses to truck crews and onsite and offsite individuals during routine transportation. The depleted uranium was modeled as a solid spherical source, approximately 8 in (20 cm) in diameter, shielded by plastic (high explosives). Table J-1 presents the input data used to determine the dose rate at one meter.

J.4.5 Analysis Input Parameters

Table J-2 presents the input parameters used to perform the incident-free and accident analysis using the RADTRAN computer code.

J.5 ANALYSIS OF INCIDENT-FREE (ROUTINE TRANSPORTATION) IMPACTS

The following section discusses the radiological and nonradiological impacts to the truck crew and the public during incident-free or routine transportation of the test assembly. The impacts due to interim storage of the test assembly at the magazine, if necessary, are not addressed in this analysis. The results of the analyses are presented in section 5.7.

J.5.1 Radiological Impacts due to Routine Transportation Activities

The radiological doses to the truck crew, onsite worker, and the public due to transportation activities were calculated using RADTRAN 4 (see section J.4.1). As discussed in section J.4.1, RADTRAN 4 uses a combination of meteorological, demographic, health physics, transportation, packaging, and material factors to analyze the risk due to incident-free transport activities. Input data used to perform the analysis are shown in section 5.7 and tables J-1 and J-2.

The calculated annual dose is based on 20 shipments per year. The dose to the truck crew for the No Action Alternative would be 6×10^{-6} person-rem for each shipment or 1×10^{-4} person-rem annually. The calculated dose to the public would be less than 1×10^{-10} person-rem and for this analysis is considered zero. The total dose to the onsite worker population for the No Action Alternative would be 2×10^{-4} person-rem for each shipment or 3×10^{-3} person-rem annually.

TABLE J-1.—*Microshield Input Data*

Input Parameter	Value
Sphere radius (cm)	25 (10)
Shielding material[a] - Plastic (cm)	2.5 (1)
Distance to receptor (cm)	250 (100)
Radionuclides (Ci)[b]:	
Th-231	2.5×10^{-4}
Th-234	1.7×10^{-2}
Pa-234	1.7×10^{-2}
Pa-234m	1.7×10^{-2}
U-234	1.9×10^{-3}
U-235	2.5×10^{-4}
U-238	1.7×10^{-2}

[a] Modeled as water.
[b] Appendix H.

TABLE J-2.—*Input Parameters for RADTRAN and Explosives Model*

Parameter	Value
Fraction of travel time, rural population zone[a]	60
Fraction of travel time, suburban population zone[b]	40
Fraction of travel time, urban population zone	0
Dose rate at 3.3 ft from package (mrem/h)[c]	5.9×10^{-1}
Length of package (ft)	13
Velocity (mi/h)	35
Number of crewmen	2
Distance from source to crew	10
Stop time per mi, h/mL (1hr/stop 2 stops/trip)	0.27
Persons exposed while stopped	10
Average exposure distance while stopped (ft)	66
Shipments per year	20

[a] Data taken from Romero and Jolly (1989).
[b] Estimated percentages based on a review of site layout drawings. For the purposes of this analysis the suburban population zone is used to characterize onsite activities.
[c] The dose rate from the package at 1 m calculated using microshield (Grove Engineering 1988).

The potential health effects or latent cancer fatalities (LCFs) were calculated using the methodology described in ICRP 60 (1991), i.e., 4.0 x 10^{-4} LCFs/person-rem to the onsite worker and truck crew respectively. The annual health effects for truck crews, were estimated to be 4 x 10^{-8} (No Action Alternative) and 4 x 10^{-8} (DARHT Baseline Alternative). The annual health effects for the onsite worker, were estimated to be 1 x 10^{-6} and 1 x 10^{-6} for the No Action and DARHT Baseline alternatives, respectively.

J.5.2 Nonradiological Impacts due to Routine Transportation Activities

Impacts to the public from nonradiological causes were also evaluated. This included fatalities resulting from pollutants emitted from the vehicles during normal transportation. Based on the information contained in Rao et al. (1982), the types of pollutants that are present and can impact the public are sulfur oxides (SO_x), particulates, nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbons (HC), and photochemical oxidants (O_x). Of these pollutants, Rao et al. (1982) determined that the majority of the health effects are due to SO_x and the particulates. Unit risk factors (fatalities per kilometer) for truck shipments were developed by Rao et al. (1982) for travel in urban population densities (1.0 x 10^{-7}/km for truck). Although, this unit risk factor is for urban population densities, it was combined with the total shipping distance past occupied buildings [40 percent of the total distance of 2.5 and 2.4 mi (4 and 3.8 km) for the No Action and DARHT Baseline alternatives, respectively] to calculate the nonradiological routine impacts to the public. Based on travel distances per shipment or per year, the estimated number of fatalities due to routine nonradiological impacts, as presented in section 5.7, table 5-17, are very low (roughly 4.0 x 10^{-7} per shipment or 8 x 10^{-6} annually).

J.6 ANALYSIS OF TRANSPORTATION ACCIDENTS

The following section discusses the potential radiological and nonradiological impacts due to transportation accidents. Radiological accident impacts to the collective population (public) were calculated using the RADTRAN 4 computer code (Neuhauser and Kanipe 1992). The radiological impacts to a nearby individual and the maximally exposed individual (MEI), both onsite and offsite, were performed using GENII (Napier 1988). For analysis purposes, the nearby individual was assumed to be located 330 ft (100 m) from the point of release, the onsite MEI was assumed to be located at the nearest occupied facility, and the offsite MEI was assumed to be located at the site boundary. This scenario assumes that the high explosives detonate and the depleted uranium is released to the environment.

J.6.1 Radiological Impacts to the Public from Transportation Accidents

This section describes the analyses performed to assess radiological impacts to the public from transportation accidents.

J.6.1.1 Radiological Impacts to the Public

For these analyses the impacts were expressed as MEI doses or as integrated population risks. The integrated population risk was determined by multiplying the expected consequences by the accident frequency integrated over the entire shipping campaign or estimated number of shipments annually. The potential consequences to the population from transportation accidents were expressed in terms of radiological dose and LCFs. Typically these impacts can result from breaches in the shipping cask or damage to the cask shielding; however, in this analysis these impacts would be due to detonation and release of the radiological materials.

Once the material is released to the environment it would be dispersed and diluted by weather action and a small amount would be deposited on the ground due to plume depletion. Access to the area adjacent to the transportation accident would be controlled by emergency response personnel until the area could be remediated and the radiation monitoring personnel have declared the area safe.

The input data used to calculate the radiological dose to the public (i.e., population densities, travel times and distances) were the same as the inputs used to calculate the incident-free dose to the population and are discussed in section J.4.1. The accident frequency used in the analysis was based on a review of local or state specific accident data. It was assumed, because of the characteristics of the high explosives, that all transportation accidents were severe enough to detonate the high explosives and result in a release to the environment. This was a conservative assumption that would tend to overstate the expected consequences. The initial accident data [or rates expressed as accidents/mi (accidents/km)] used in this analysis were taken from Saricks and Kvitek (1994) for the state of New Mexico. The accident rate used, 3.78×10^{-7} accidents/mi (2.35×10^{-7} accidents/km), was a combination of accident rates for rural and urban federally aided highway systems.

It was assumed that 10 percent of the material in a test assembly was aerosolized and respirable (appendix H).

Radiological doses were calculated using RADTRAN for the two population densities of interest (i.e., LANL open space and occupied buildings). The calculated dose, on a per shipment basis, to the two populations was estimated to be 2.4×10^{-1} person-rem and 1.7×10^{1} person-rem, respectively. The integrated risk to the public (i.e., consequences times accident frequency integrated over the entire shipping distance) was estimated to be 9.8×10^{-5} person-rem and 9.3×10^{-5} person-rem for the No Action Alternative and DARHT Baseline Alternative, respectively.

J.6.1.2 Radiological Impacts to Individuals

In addition to the radiological dose to the collective population, the LANL site was reviewed to identify an onsite MEI, i.e., an individual located at the nearest occupied facility, and offsite MEI, i.e., an individual located at the site boundary. For this analysis, based on the location of the site boundary and the nearest public roadway and the meteorological data, the offsite MEI was assumed to be located approximately 1 mi (1.5 km) to the northwest and north-northwest. The location is dependent on the median effective release height (see appendix H.1). Meteorological data for TA-6 at LANL is used in the dose consequence analyses.

The location of the maximally exposed onsite worker, was determined by reviewing the LANL site drawings with respect to the location of the PHERMEX and DARHT facilities. It was assumed that the onsite MEI is located 0.50 mi (0.75 km) to the northwest and north-northwest.

Radiological accident impacts to the offsite and onsite MEIs and the MEI were calculated using GENII (Napier 1988). The source term for GENII is adjusted to account for the presumed explosion in an accident scenario; the adjustment takes the form of specifying a median effective release height. To calculate the impacts to the receptor, a median effective release height of 327 ft (99 m), 713 ft (216 m), and 848 ft (257 m) was used for Test Assembly 1, Test Assembly 2, and Test Assembly 3, respectively. This was calculated using the methodology described in appendix H. The results of the radiological analyses to the MEIs are presented in section 5.7, table 5-19.

In the past, DOE has conducted dynamic experiments at LANL with plutonium. Any future experiments with plutonium would always be conducted in double-walled containment vessels; these experiments would not reasonably be expected to result in any release of plutonium to the environment. DOE has evaluated the potential impacts of two types of accidents that could involve plutonium – inadvertent detonation and containment breach. This analysis is documented in a classified supplement to this EIS; and results, unclassified calculations, and assumption and modeling methods are included in appendix I, section I.3.2, and in applicable sections of chapter 5.

The bounding accident for accidents during transportation of materials was assumed to be a hypothetical detonation of a plutonium experiment while outside of its double containment vessel. The impacts were calculated as if the event took place at the PHERMEX or DARHT site (rather than at some other location within LANL where the experimental device might be handled) because these sites are closest to the LANL boundary. The impacts would be the same regardless of whether this accident took place at the PHERMEX site or the DARHT site. Such an accident has never happened nor has any mechanism been identified that would initiate such an event, hence it was examined only as a "what if?" accident. Related DOE safety studies indicate that the probability of an accidental uncontained detonation of the type analyzed would be less than 10^{-6} per year, which is considered to be an incredible event.

Because, under this scenario, detonation of the explosive would be uncontained, the release was modeled as a 330-ft (100-m) elevated release (see Appendix I). The MEI, located at State Road 4, could receive up to 76 rem in the event of an accident. The maximum probability of a LCF occurring in this hypothetical individual would be 0.04. The dose to the potentially maximally exposed sector of the population, east-southeast of the DARHT and PHERMEX sites that includes the communities of White Rock and Santa Fe, could be between 9,000 and 24,000 person-rem, taking into consideration the 50th and 95th percentile meteorology, respectively. Between 5 and 12 LCFs would be projected from radiation doses such as these to the population.

J.6.2 Nonradiological Impacts to the Public from Transportation Accidents

This section describes the analyses performed to assess nonradiological impacts to the public and the MEIs.

J.6.2.1 Nonradiological Impacts

The vehicle travel speed is limited to 35 mi/h (56 km/h); therefore, vehicle impacts are not considered severe enough to cause fatalities to the truck occupants or occupants of other vehicles involved in the accident. For the purposes of this analysis it was assumed that the transport vehicle impacted a stationary object with sufficient force to detonate the high explosive.

The lethal limits due to the blast wave were estimated using the formula and assumptions discussed in section J.4.3 and the high explosive inventories discussed in section 5.7. The impacts due to explosions were modelled for each of the test assemblies. Assuming that a peak overpressure of 27 lb/in^2 (186 kPa) is fatal, all individuals within an approximate radius of 15 ft (5 m), 43 ft (13 m), and 53 ft (16 m) for test assemblies 1, 2, and 3, respectively, would be subjected to potentially fatal overpressures. This would include the truck crews which are assumed to be located within 33 ft (10 m) of the test assembly. In addition to impacting the truck crew, depending on the quantity of high explosive involved, 50 percent of the individuals at distances up to 80 ft (24 m) could be killed due to the blast wave. Individuals located further away may not be impacted by overpressure but could be seriously injured or killed by fragments ejected by the detonation.

In addition to evaluating the impacts from a detonation of the high explosives, an assessment of the consequences of a release of the hazardous materials identified in section 5.7, was performed. The release fraction and percentage respirable was the same release fraction used for the depleted uranium; 10 percent of the total material in the device was assumed respirable. The results, based on the meteorological data for the LANL site, are shown in section 5.7, table 5-18. For comparison, although plume passage times are very short in duration, the immediately dangerous to life and health (IDLH) exposure limits are also provided in table 5-18.

J.7 REFERENCES CITED IN APPENDIX J

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Appendix K
Threatened and Endangered Species Consultations

APPENDIX K THREATENED AND ENDANGERED SPECIES CONSULTATIONS

This appendix describes the consultation process between the Department of Energy (DOE) and the U.S. Fish and Wildlife Service (USFWS) associated with the DARHT EIS. It also summarizes the biological assessment prepared by the Los Alamos National Laboratory (LANL) in July 1995 (Keller and Risberg 1995). The following sections discuss the threatened, endangered, or sensitive species that could potentially inhabit the proposed area, and mitigation measures to minimize potential impacts to those species.

K.1 INTRODUCTION

Under the Endangered Species Act (ESA) of 1973 [16 USC 1531-1544], Federal agencies are required to consult with the USFWS to ensure that a proposed action is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species.

The Section 7 consultation process involves the identification of the possible presence of a listed or proposed species or their critical habitat that could be affected by the proposed action. If present, a biological assessment is prepared to determine whether the proposed action is likely to adversely affect listed or proposed species or designated or proposed critical habitat and to consider modifications to the action that would avoid adverse impacts. Concurrence is requested from the USFWS if the action is not likely to adversely affect listed species or designated critical habitat. An "is likely to adversely affect" determination requires formal Section 7 consultation and a resulting biological opinion.

A biological assessment was prepared by LANL in May of 1995 (Keller and Risberg 1995) for completion of the DARHT Facility. This was forwarded to the USFWS for review. Following this initial submission, the Mexican spotted owl, a federally threatened species, was sighted within two miles of the proposed DARHT Facility area. The biological assessment was revised to include the new information on the owl and submitted to USFWS in July, 1995. The letter enclosed with the revised biological assessment requested that the USFWS (exhibit 1) concur with the DOE's determination that the proposed DARHT site will not likely adversely affect any endangered or threatened species, or modify their critical habitat as provided under 50 CFR 402.14b. After reviewing the biological assessment, concurrence was provided by the USFWS (exhibit 2).

The potential for occurrence of each threatened, endangered, and candidate species potentially inhabiting the area surrounding the DARHT site was systematically analyzed. It was determined that suitable habitats (e.g. water courses, riparian vegetation, and open grassland) are not found in the proposed project area for all potential species. This eliminated some species from consideration as shown in table 1 of the biological assessment. This assessment lists those species that have no potential for occurrence in the project area because of lack of a suitable habitat. Due to variations in findings by different researchers at various times, these species are included as potential Threatened and Endangered Species by other researchers (Dunham 1995, Risberg 1995) and are indicated in table 4-12.

K.2 AFFECTED ENVIRONMENT

The proposed DARHT project is located at LANL's TA-15, Area 3, in the central portion of LANL (see figure 4-1). Habitat in the proposed area is potentially suitable for 11 federal or state protected species.

K.2.1 Threatened, Endangered, and Sensitive Animal Species

Several threatened, endangered, or sensitive species inhabit, or potentially inhabit, the proposed DARHT area. Federal candidate species previously found (Dunham 1995), and thus having a high potential for inhabiting the area, include four species of bats; the long-eared myotis, fringed myotis, long-legged myotis, and Yuma myotis (see table 4-12). The state endangered, federal candidate wildlife that have a low potential for inhabiting the area are the spotted bat, New Mexican jumping mouse, and the Jemez Mountains salamander. The federal candidate species that has a moderate potential for inhabiting the area is the northern goshawk. The peregrine falcon is a federal and state endangered species that has a low potential for occurrence.

As stated, the federally threatened Mexican spotted owl has been observed within 2 mi (3.2 km) of the proposed DARHT site. A nesting site has been confirmed to be greater than 0.25 mi (0.4 km) from the construction site. Additional suitable nesting habitat lies within 0.25 mi (0.4 km) of the proposed area, and all of the area within 0.5 mi (0.8 km) of DARHT is suitable foraging habitat.

K.2.2 Other Protected Animal Species

There are confirmed nesting sites and hunting areas for two raptors: the red-tailed hawk, and Cooper's hawk in the general TA-15 area. Other species, such as the American kestrel, the flammulated owl, and the great-horned owl are known to use the area. All these birds are protected by the Migratory Bird Treaty Act and New Mexico Statutes Annotated, Chapter 17-2-14.

K.2.3 Threatened, Endangered, and Sensitive Plant Species

No rare, threatened, or endangered plant species have been found; however, it was determined that the checker lily and wood lily, both state endangered, could occur in the area because the habitat is suitable.

K.3 POTENTIAL IMPACTS

The following sections describe potential construction and operation impacts on the threatened and endangered species in the DARHT area.

K.3.1 Potential Construction Impacts

The biological assessment describes construction and operation impacts or protected species in the DARHT area.

Construction of the DARHT Facility has led to the loss of 7 ac (2.8 ha) of ponderosa pine/piñon-juniper habitat. This vegetation removal has resulted in minimal loss of foraging habitat and without mitigation could result in erosion on the mesa top and possibly into the adjacent canyon bottoms. Erosion control measures are in place to prevent slope disturbance during construction activities. Permanent erosion control measures will be implemented. Under the Enhanced Containment Alternative, an additional 1 ac (0.4 ha) of habitat would be altered due to construction of the vessel cleanout facility.

Construction noise and lighting could also disturb potential nesting and foraging habitats for a variety of species from several trophic levels. Noise from vehicular traffic and construction equipment could lead to both temporary and possibly permanent avoidance of the area by some wildlife species. Lighting would be used during some phases of construction, which could possibly increase predation on certain wildlife species during the breeding season or act as an artificial attractant to others.

The species that could potentially be most affected by construction activities would be the Mexican spotted owl. Foraging habitat has been diminished by DARHT construction, but this habitat loss is insignificant when compared to the existing overall foraging range. Excessive noise, above expected values, during the breeding and nesting season (March 1 to August 31) could disturb any nesting owls nearby, possibly causing nest failure, and could discourage future colonization of the area by the owls. Maximum noise levels from construction at the site would translate into a noise level of 41 dBA in the Mexican spotted owl habitat. These noise levels are well within the normal background levels in this canyon system. Therefore, the noise associated with construction of the facility would not likely adversely affect the Mexican spotted owl. The northern goshawk, if present, could also be disturbed by excessive noise during the mating and nesting season, which could lead to nest abandonment and nest failure.

Although no spotted bats, Jemez Mountains Salamanders, or New Mexican jumping mice have been identified in the DARHT project area, suitable canyon habitat exists for these species nearby. It is unlikely that completion of the project would adversely affect these habitats. Soil erosion could affect nearby streams or water sources, thus affecting potential foraging areas and habitat.

No suitable nesting habitat for the peregrine falcon exists within the range of the proposed DARHT Facility. Previous removal of 7 ac (2.8 ha) of foraging habitat has occurred, but this is very small compared to the total foraging area available to the peregrine falcon. Future DARHT construction activities would have little adverse effect on the peregrine falcon habitat.

Because most of the groundbreaking activities and tree removal have already occurred, future construction at the DARHT site would not be expected to cause any significant impacts to plants, unless vehicles are driven off established roads and large staging areas are situated in undisturbed habitat.

The many construction activities at LANL have caused significant changes in the land use of many wildlife species. If completed, a fence around the DARHT perimeter may segregate an area on the mesa top, possibly cutting off daily and/or seasonal travel corridors to wintering areas, breeding habitat, foraging habitat, bedding areas, and other necessary travel corridors. Construction may also disturb other nesting bird species in the DARHT project area.

K.3.2 Potential Operational Impacts

The DARHT project could have an increased cumulative impact when added to the disturbance from existing projects in the surrounding area. Operation would consist mainly of small amounts of time with a great deal of activity and then long periods of time with little activity. The activities at the facility would include vehicles used to set up an experiment (e.g. delivery trucks and cranes for larger experiments) and office building activity (e.g. normal vehicle traffic).

The only threatened, endangered, or sensitive species potentially affected by DARHT operations would be the Mexican spotted owl. Noise from nighttime activity could cause a greater impact at the proposed DARHT Facility than the same noise level generated during the day. Noise from an experiment would be comparable to the sound of thunder, approximately 80 dbA at 0.25 mi (0.4 km). All the secondary activity associated with an experiment would make less noise than that generated by construction. Additionally, the current experiments in the area seem to have little effect on the current success of the Mexican spotted owl habitat.

Two other impacts are possible as a result of DARHT operations. First, an increase in light pollution from outdoor lighting at the facility could decrease nighttime Mexican spotted owl prey activity and availability. The second impact is the possibility of an owl being hit by flying debris or fragments from a test event. The probability of a hit is approximately 1/8,500 shots at 600 ft (183 m) from the firing point, 1/600,000 at 800 ft (245 m), and 1/10 million at 1,200 ft (365 m).

Operation of the proposed DARHT Facility would not be expected to affect vegetation, but could possibly change any established migration corridors and foraging areas of deer, elk, mountain lion, black bear, bobcat, and various bird species.

Contaminants that could result from operation of the DARHT Facility might potentially affect both threatened and nonthreatened wildlife species through a number of pathways. Radionuclides adsorb to soils and sediments; aerial redistribution could transport radionuclides, or erosional processes might move the radionuclide-contaminated soils from slopes to stream channels by surface water runoff. Fragments could affect wildlife, both directly (by being hit by an exploded fragment) and indirectly (by being exposed to any radiological contamination from the fragments).

K.4 MITIGATION

This section describes the mitigation measures that have been implemented or would be implemented if the proposed DARHT Facility were to be completed and operated. Mitigation measures include a Storm Water Pollution Prevention Plan (SWPPP) for the facility which was implemented before construction activities commenced. The plan includes measures for erosion control (temporary and permanent), sedimentation control, surface restoration and revegetation, storm water attenuation in paved and unpaved areas, and a Best Management Plan. The Best Management Plan includes good housekeeping practices, minimization of fuel and oil spills, and control of stored materials and soil stockpiles. All storm water pollution prevention mitigations will be maintained until the site is fully recovered.

K.4.1 Threatened, Endangered, and Sensitive Species

The DOE, through LANL's Environmental Safety and Health Division (ESH) would develop a LANL-wide Habitat Management Plan for all threatened and endangered species occurring on LANL property. This plan would be used to determine the combined effects of the many projects that occur at LANL and provide long-range planning information for all future projects. Any proposed action at LANL that may affect a threatened, endangered, or sensitive species or its habitat would be coordinated with the USFWS. In the event of an emergency (e.g. a fire, flood, or storm), LANL would not need to formally consult with USFWS before responding to the incident. Instead, action may be taken immediately to control or contain the emergency and then LANL would contact USFWS as soon as reasonably possible [50 CFR 402.05].

The mitigation measures described in the following sections will be used to protect the habitat of threatened, endangered, or sensitive species and other wildlife and may become part of the Mitigation Action Plan supporting the NEPA Record of Decision for the DARHT Facility.

K.4.1.1 Mexican Spotted Owl

Part of the LANL-wide Habitat Management Plan would provide for long-term monitoring by the ecological studies team of Mexican spotted owl habitat in Potrillo, Valle, and Fish-ladder canyons, and would include sample collection (e.g., sound levels, soils, plants, small mammals, and owl pellets) for monitoring possible contaminant loading of the ecosystem. The plan would also provide long-term monitoring of Mexican spotted owl reproduction.

Minimal impact to the Mexican spotted owl is expected from construction or operation activities at the proposed DARHT Facility, even if a nest is located within 0.25 mi (0.4 km) of the facility. The following mitigation measures would be necessary to ensure no adverse impacts result from construction activities.

- The LANL ecological studies team must be contacted prior to any new removal of mature trees (live or snag) to determine the potential impact to nesting Mexican spotted owls. If no impact is determined, the tree removal will be allowed. If impacts are thought likely to occur, the proposed tree removal must be postponed until the following breeding season (March 1 to August 31).
- No additional habitat will be disturbed within 0.25 mi (0.4 km) of known Mexican spotted owl nesting habitat.
- Construction light sources will be arranged so that light is not directed toward the canyons, or is shielded, during the breeding season (March 1 to August 31).
- Construction noise associated with the facility will be restricted as much as possible at night.
- Noise from construction equipment will be kept as quiet as possible so as not to disturb normal Mexican spotted owl activities and will be directed away from the canyons as much as possible.
- Equipment associated with construction will remain at least 25 ft (8 m) from the surrounding canyon edges during the breeding season (March 1 to August 31).

- Construction personnel will not be allowed beyond the canyon edges.
- Flowchecks will be constructed to slow the rate of any water (e.g. storm water or construction water) released in the canyons originating from the facility; and native vegetation will be planted, as appropriate, to prevent erosion associated with this water release.
- Native trees will be planted, as appropriate, along roads, disturbed canyon edges, and the edges of parking lots.
- A warning siren will be placed on the mesa side of the facility.
- Construction equipment will be well maintained and kept as quiet as reasonably possible.

Each year the LANL ecological studies team would conduct a Mexican spotted owl survey to determine any owl nesting activity in the area. Once a known nest location is determined, this information would be used to evaluate any proposed nighttime shot activity at DARHT.

The following mitigation measures are necessary to ensure no adverse impacts result from operational activities.

- Lights used during shot setup will be directed away or shielded from the canyons.
- Operational and setup noise (e.g., air conditioning cooling fans and electrical generators) will be kept at a minimal level at night, so as not to disturb normal Mexican spotted owl activities, and will be directed away or shielded from the canyons as much as possible.
- Night shots will be conducted during the breeding season (March 1 to August 31), only if the nest is located more than 0.25 (0.4 km) from the proposed facility; a limited number of night shots (no more than one per month) would then be permitted during the breeding season.
- Equipment associated with the facility operations will remain at least 25 ft (8 m) from the surrounding canyon edge.
- Operations personnel will be restricted to the mesa top and will not be allowed beyond the canyon edges, except as allowed by the LANL ecological studies team for specific fragment removal operations.
- Flowchecks will be maintained to slow the rate of the released water in the canyons originating from the facility.
- Water flow from the facility will be monitored to ensure compliance with permitted outfalls.
- Glass plates or other shielding material will be used during large uncontained shots to break up fragments, buffer noise, and limit contaminant release to the Mexican spotted owl habitat.
- Operational equipment will be well maintained and kept as quiet as reasonably possible.
- The LANL ecological studies team must be notified in order to conduct an owl survey, prior to conducting any activities, such as fragment removal in or on the slopes of canyons used by the Mexican spotted owl. If no nesting Mexican spotted owls are found, the activity will be allowed; if a nest is found, the activity will not be allowed until after the breeding season (March 1 to August 31).

K.4.1.2 Northern Goshawk

To preserve goshawk habitat, the following mitigation measures are necessary.

- The LANL ecological studies team must be contacted prior to any new removal of trees (live or snag) to determine impact to the nesting and foraging habitat of the northern goshawk. The vegetation, such as shrubs and grasses, in the canyons and on the mesa top surrounding the facility will be preserved.
- The LANL ecological studies team will provide long-term monitoring of potential goshawk habitat in Potrillo and Valle canyons.

K.4.1.3 Spotted Bat

To protect suitable bat habitat, the following mitigation measure is necessary.

- The ecological studies team must be notified to conduct a survey, prior to any activities that would disturb the slopes of Potrillo, Valle, or Water canyons. If no spotted bats are found, the activity will be allowed; if a spotted bat is found, the activity will not be allowed until after the breeding season.

K.4.1.4. New Mexican Jumping Mouse

To protect the habitat of the New Mexican jumping mouse, the following mitigation measure is necessary.

- The LANL ecological studies team must be notified to conduct a habitat evaluation, prior to any activities that would disturb the canyon bottoms of Potrillo, Valle, or Water canyons. If no meadow jumping mice are found, the activity will be allowed; if a New Mexican jumping mouse is found, the activity will not be allowed until after the time of their highest activity (June to July).

K.4.1.5 Jemez Mountains Salamander

To protect the habitat of the Jemez Mountains salamander, the following mitigation measures are necessary.

- The LANL ecological studies team must be notified to conduct a survey, prior to any activities that would disturb the slopes of Potrillo, Valle, or Water canyons. If no Jemez Mountains salamanders are found, the activity will be allowed; if a Jemez Mountains salamander is found, the activity will not be allowed during the time of their highest activity (June to September).
- The LANL ecological studies team must be contacted prior to any removal of trees (live, snag, or downed log) at the DARHT site to determine the impact to Jemez Mountains salamander habitat. If no Jemez Mountains salamander habitat is found, the activity will be allowed; if a Jemez Mountains salamander is found, the activity will not be allowed during the time of their highest activity (June to September).

K.4.1.6 Peregrine Falcon

To protect the habitat of the peregrine falcon, the following mitigation measures are necessary.

- The LANL ecological studies team must be contacted prior to any removal of trees (live or snag) at the DARHT site to determine impact to peregrine falcon foraging habitat. If no peregrine falcons are found, the activity will be allowed; if a peregrine falcon is found, the activity will not be allowed until after the breeding season (March to September).
- The ecological studies team must be notified to conduct a survey, prior to any activities that would disturb the slopes of Potrillo, Valle, or Water canyons. If no peregrine falcons are found nesting, the activity will be allowed; if a peregrine falcon nest is found, the activity will not be allowed until after the breeding season (March to September).

K.4.2 Nonprotected Species

The following sections describe mitigation measures that would be used to minimize adverse impacts to nonprotected plants and wildlife.

K.4.2.1 Plants

Because most groundbreaking and tree removal at the DARHT site is already complete, additional damage to plants would be minimal. Measures have been taken and will continue to be implemented to minimize future erosion. In general, workers must avoid off-road activity and stay within approved right-of-ways except during cleanup procedures. Any proposed activities requiring the disturbance of mature trees and shrubs or new groundbreaking must first be approved by the LANL ecological studies team. The ecological studies team will review all new sites, evaluate any proposed impacts associated with the action, and provide mitigation measures to minimize potential impacts. Revegetation, as addressed in the SWPPP, would be required so that the loss of vegetation would not initiate or increase erosion.

In addition to the mitigation measures, the size of a vegetation buffer zone between the facilities and the edges of the mesa tops will be determined by the LANL ecological studies team based on topographic aspects and vegetation composition; this is to prevent runoff from eroding adjacent canyons.

K.4.2.2 Wildlife

Temporary fencing is currently in place surrounding the DARHT Facility. Any future installation of impenetrable security fencing could possibly affect wildlife movements; project managers must consult with the LANL ecological studies team to minimize effects on large mammal and predator species movements. The ecological studies team will provide site-specific measures regarding the construction of fences and other barriers to facilitate the movement of wildlife, as appropriate.

In addition to the committed SWPPP mitigation measures, personnel would avoid cutting any standing tree (live or snag) unless the LANL ecological studies team has given approval.

K.4.3 Contaminants

To monitor for expected contaminant releases, the LANL ecological studies team will perform the following activities.

- During the construction phase of the facility, baseline data will be collected on any contaminants present at the facility and in the surrounding areas from soils, plants, mammals, birds, and roadkill, as well as at a control site away from the DARHT Facility.
- Once the facility is operational, the ecological studies team will monitor contaminants by sampling soils, plants, mammals, birds, and roadkill at the above mentioned locations once per year, or as appropriate.

K.5 REFERENCE CITED IN APPENDIX K

Keller, D.C., and D. Risberg, 1995, Draft Biological and Floodplain/Wetland Assessment for the Dual-Axis Radiographic Hydrodynamic Test (DARHT) Facility, July, LAUR-95-647, Los Alamos National Laboratory, Los Alamos, New Mexico.

Exhibit 1, page 1 of 2

Department of Energy
Field Office, Albuquerque
Los Alamos Area Office
Los Alamos, New Mexico 87544

JUL 21 1995

Jennifer Fowler-Propst
U. S. Fish and Wildlife Service
Ecological Services
2105 Osuna Road NE
Albuquerque, New Mexico 87113

Dear Ms. Fowler-Propst:

This letter concerns the Department of Energy's (DOE) Biological Assessment and Floodplain/Wetland Assessment for the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility at the Los Alamos National Laboratory (LANL). As we discussed on June 30, 1995, DOE has been collecting additional biological survey data concerning the federally threatened Mexican spotted owl (Strix occidentalis lucida) that has recently been sighted in the vicinity of the DARHT facility site during a field survey investigation conducted for another nearby proposed LANL project site.

The additional biological survey information collected on the Mexican spotted owl has now been incorporated into the enclosed Final Biological Assessment and Floodplain/Wetland Assessment for the DARHT Facility. We would now like to continue with the informal consultation procedure that started with our May 16, 1995 letter that transmitted the initial report. The additional owl survey data provides significant new information on the presence of the species at LANL. It also contains specific details on mitigation and conservation measures that will be incorporated into the construction and proposed operation of the DARHT facility. We feel that these measures will either eliminate or greatly reduce any potential for adverse impacts to birds present in the general vicinity of the facility.

I request that the Fish & Wildlife Service concur with our determination that the proposed action is not likely to adversely affect any endangered or threatened species or modify their critical habitat, as provided for under 50 CFR 402.14b. We would appreciate your review of the Biological Assessment and hope to hear from you regarding your concurrence under 50 CFR 402.14b before August 7, 1995.

My staff and the LANL biological staff will continue to be available to work with your staff to address any questions or concerns you may have regarding the potential for effects on the Mexican spotted owl and its habitat from the DARHT Facility.

Exhibit 1, page 2 of 2

JUL 2 1 1995

Jennifer Fowler-Propst 2

If you have any questions, please contact me at (505) 667-5105, or Elizabeth Withers of my staff at (505) 667-8690.

Sincerely,

Larry Kirkman, P.E.
Acting Area Manager

LAAMEP:6EW-011

Enclosure

cc w/enclosure:
Ms. Karen Lightfoot
Endangered Species Botanist
Forestry & Resources
Conservation Division
Energy, Mineral, and Natural
Resources Dept.
P. O. Box 1948
Santa Fe, New Mexico 87504
Mr. Bill Montoya, Director
Game and Fish Department
State of New Mexico
P. O. Box 25112
Santa Fe, New Mexico 87504

cc w/o enclosure:
H. Haynes, Counsel, LAAO
J. Vozella, AAMEP, LAAO
D. Webb, AAMEP, LAAO
E. Withers, AAMEP, LAAO
A. Ladino, Scientech, LAAO
D. Keller, ESH-20, LANL,
MS-M887
T. Foxx, ESH-20, LANL,
MS-M887

Exhibit 2, page 1 of 2

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services State Office
2105 Osuna NE
Albuquerque, New Mexico 87113
Phone: (505) 761-4525 Fax: (505) 761-4542

August 3, 1995

Cons. #2-22-95-I-108

Mr. Larry Kirkman, P.E.
Department of Energy
Los Alamos Area Office
Los Alamos, New Mexico 87544

Dear Mr. Kirkman:

This responds to a letter dated July 21, 1995, requesting concurrence with a Department of Energy (DOE) determination that a project may affect, but is not likely to adversely affect the Mexican spotted owl. The proposed project includes the completion of construction and operation of the Dual Axis Radiographic Hydrodynamic Test (DAHRT) Facility located on site TA-15, Building R312 at Los Alamos National Laboratory (LANL).

During surveys conducted in July 1995, LANL biologist detected the presence of the threatened Mexican spotted owl in canyons located west of the DAHRT site. During a resulting visit to the DAHRT site, representatives of the U.S. Fish and Wildlife Service (Service) made a visual inspection and indicated that potential habitat for the Mexican spotted owl could also exist in the canyon below the site. Subsequent surveys conducted for the Mexican spotted owl revealed the species was indeed nesting in the canyons near the DAHRT site, but that the nest was greater than 1/4 mile from the DAHRT blast site.

The Mexican spotted owl is highly sensitive to human disturbance during its breeding period. Visual inspection of the potential habitat closest to the DAHRT site indicates that the quality of the habitat is considerably lower than that found up canyon. While the owls nesting up canyon of the DAHRT site may occasionally use the canyon below the site for foraging, the birds are less likely to remain in the habitat for extended periods of time. Evaluations regarding noise from the operation of the facility indicate that while owls nesting in the habitat up canyon from the facility would be aware of activities occurring on the site, the topography and distance involved would decrease noise levels to the extent that owls would not be disturbed. In addition, because LANL has committed to restricting tests conducted during the owl's breeding season to daytime periods if an owl nest is located within 1/4 mile of the blast site, and only 1 night shot per night if no nests are located within 1/4 mile, it is unlikely any owls using the habitat in the canyon adjacent to the DAHRT site will be adversely impacted by blast activities. Therefore, the Service concurs with the DOE's determination that the operation of the DAHRT facility is not likely to adversely affect the Mexican spotted owl. Should blast schedules necessitate additional night-time blasts in the future, LANL should reinitiate coordination with the Service to determine if formal consultation is necessary.

Exhibit 2, page 2 of 2

Mr. Larry Kirkman, P.E. 2

We appreciate the DOE efforts to address all Service concerns in a prompt and proficient manner and we look forward to working with your agency on the future site-wide Environmental Impact Statement currently being organized. If you have any questions or comments regarding the above concurrence with DOE's determination, please contact Ms. Karen Cathey at (505) 761-4525.

Sincerely,

Jennifer Fowler-Propst
State Supervisor

cc:
Director, New Mexico Department of Game and Fish, Santa Fe, New Mexico
Director, New Mexico Energy, Minerals, and Natural Resources Department, Forestry and Resources Conservation Division, Santa Fe, New Mexico
Regional Director, U.S. Fish and Wildlife Service, Ecological Services, Albuquerque, New Mexico
Elizabeth Withers, Department of Energy, Los Alamos National Laboratory (AAMEP), Los Alamos, New Mexico
Mark Sifuentes, Department of Energy, Albuquerque Field Office, Albuquerque, New Mexico

About NEPA

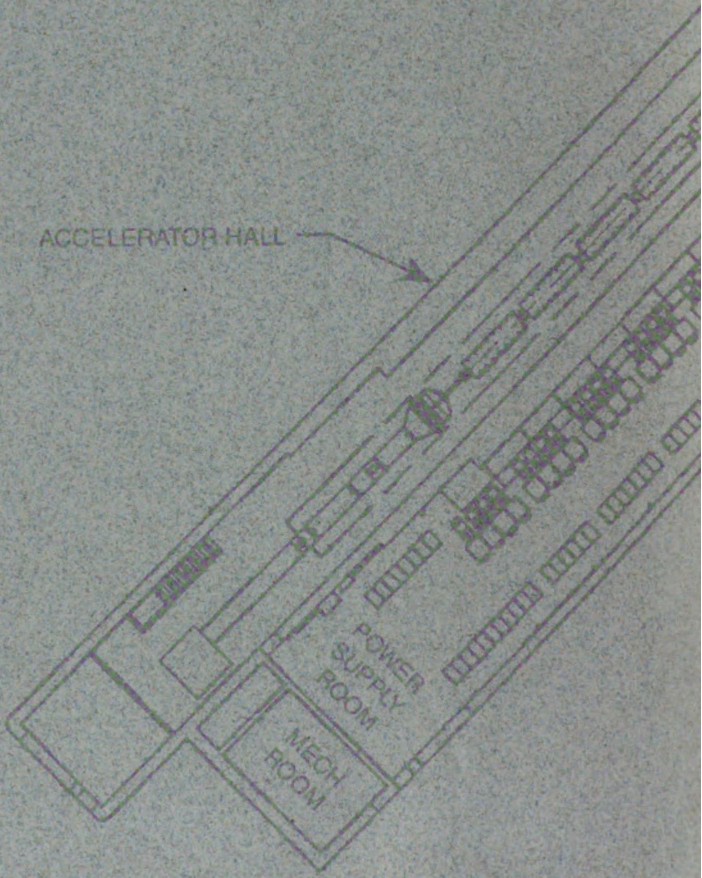
The National Environmental Policy Act (NEPA) was enacted to ensure that Federal decision-makers consider the effects of proposed actions on the human environment and to lay their decision-making process open for public scrutiny. NEPA also created the President's Council on Environmental Quality (CEQ) to establish a NEPA review process. DOE's NEPA regulations (10 CFR 1021) augment the CEQ regulations (40 CFR 1500).

An environmental impact statement (EIS) documents a Federal agency's analysis of the environmental consequences that might be caused by major Federal actions, defined as those proposed actions that might result in a significant impact to the environment. An EIS:

- Explains the purpose and need for the agency to take action
- Describes the proposed action and the reasonable alternative courses of action that the agency could take to meet the need
- Describes what would happen if the proposed action were not implemented – the "No Action" (or Status Quo) Alternative
- Describes what aspects of the human environment would be affected if the proposed action or any alternative were done
- Analyzes the changes, or impacts, to the environment that would be expected to take place if the proposed action or an alternative were implemented, compared to the expected condition of the environment if no action were taken

The DOE EIS process follows these steps:

- Notice of Intent, published in the *Federal Register*, identifies potential EIS issues and alternatives and asks for public comment on the scope of the analysis
- Public scoping period, with at least one public meeting
- Implementation Plan, which gives the results of public scoping and provides a "roadmap" of how the EIS will be prepared
- Draft EIS, issued for public review and comment, with at least one public hearing
- Final EIS, which incorporates the results of the public comment period on the draft EIS
- Record of Decision, which states:
  - The decision
  - The alternatives that were considered in the EIS and the environmentally preferable alternative
  - All decision factors, such as cost and technical considerations, that were considered by the agency along with environmental consequences
  - Mitigation measures designed to alleviate adverse environmental impacts
- Mitigation Action Plan, which explains how the mitigation measures will be implemented and monitored.


ACCELERATOR HALL
POWER SUPPLY ROOM
MECH ROOM