RAS HLW-PAPO-000218

Yucca Mountain Repository Assessment Office

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Matt Gaffney
Project Associate

County of Inyo

DOCKETED
USNRC

November 23, 2006 (10:00am)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

November 15, 2006

Ms. Annette L. Vietti-Cook, Secretray
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Re: Inyo County's Initial Certification of Compliance with Licensing Support Network (LSN).

Dear Ms. Vietti-Cook,

Enclosed are an original and two copies of the initial LSN certification by Inyo County, with supporting exhibits, pursuant to 10 CFR 2.1009, that procedures have been implemented and documentary material is available in connection with the U.S. Department of Energy's license application for authorization to construct a nuclear repository at Yucca Mountain, Nevada.

The material that Inyo County is making available can be publicly accessed at http://www.inyoyucca.org/TRANSPORTATION_RESEARCH_PROGRAM.htm.

Inyo County hereby designates Matt Gaffney, Project Associate, Yucca Mountain Repository Assessment Office, as the Responsible Official for the LSN asper 10 CFR 2.1009(a)(1). I can be contacted at (760)-873-7423.

Inyo County will continue to add documentary materials to the LSN in accordance with 10 CFR §2.1003.

Thank you for your consideration. If you have any questions regarding the enclosed materials, please feel free to contact me.

TEMPLATE = SECY-049 SECY-02

Sincerely yours,

Matt Gaffney

Matt Gaffney
Project Associate

RESOLUTION 2006-55

A RESOLUTION OF THE INYO COUNTY BOARD OF SUPERVISORS ADOPTING THE COUNTY'S LICENSE SUPPORT NETWORK PROCEDURES, AND ALSO DESIGNATING MATT GAFFNEY, YUCCA MOUNTAIN REPOSITORY ASSESSMENT OFFICE, AS THE RESPONSIBLE OFFICIAL FOR THE SUBMITTAL OF DOCUMENTS TO THE LICENSE SUPPORT NETWORK ON BEHALF OF THE COUNTY OF INYO

WHEREAS, the County of Inyo, California, is an "Affected Unit of Local Government" under the Nuclear Waste Policy Act of 1987, as amended; and

WHEREAS, such designation allows the County to submit documents to the License Support Network (LSN) which the County will rely on as evidence in any proceeding between the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission regarding the construction of a nuclear repository at Yucca Mountain, Nevada; and

WHEREAS, under 10 CFR §2.1009 (Procedures), Inyo County is required to establish procedures to implement the requirements of 10 CFR §2.1003 (Availability of Material); and

WHEREAS, under 10 CFR §2.1009, Inyo County must designate a Responsible Official before submittal of any documents to the LSN may occur; and

WHEREAS the purpose of the Responsible Official is to certify that the proper procedures are in to place to identify, collect and submit documents to the LSN; and

WHEREAS, the Responsible Official must ensure that submittal documents are relevant to any proceeding concerning Yucca Mountain; and

WHEREAS, the Responsible Official must also ensure that all submitted documents are electronically available for review.

NOW, THEREFORE, BE IT RESOLVED, that the Inyo County Board of Supervisors adopts the document entitled "Inyo County LSN Procedures" and also designates Matt Gaffney, Yucca Mountain Repository Assessment Office, as the Responsible Official, as required by 10 CFR §2.1009, for submittal of documents to the LSN on behalf of the County of Inyo.

PASSED AND ADOPTED THIS 17th DAY OF OCTOBER, 2006 BY THE FOLLOWING VOTE:

AYES: Supervisors Arcularius, Cash, Williams, Bilyeu and Cervantes

NOES: -0-

ABSTAIN: -0-

ABSENT: -0-

Susan Cash

Susan Cash, Chairperson
Inyo County Board of Supervisors

ATTEST:
Ron Juliff
Clerk of the Board

By: Patricia Gunsolley
Patricia Gunsolley, Assistant

Inyo County
LSN Procedures

Submitted by:

County of Inyo
Yucca Mountain Repository Assessment Office
October 17, 2006

1. Summary

In 1982, the United States Congress, in accordance with the Nuclear Waste Policy Act (NWPA), made the United States Department of Energy (DOE) responsible for the development of a geologic repository for the safe disposal of high-level radioactive waste and spent nuclear fuel. The DOE then selected nine locations for consideration as potential sites. Congress amended the NWPA in 1987 and directed the DOE to study only Yucca Mountain in Nevada as a potential repository site. In July 2002 Congress approved the development of a repository at Yucca Mountain. Subsequently, President George W. Bush signed House Joint Resolution 87, allowing the DOE to proceed in establishing a safe repository in which to store our nation's nuclear waste.

The Office of Civilian Radioactive Waste Management (OCRWM) is currently preparing a license application (LA) that it estimates will be submitted to the United States Nuclear Regulatory Commission (NRC) on June 30, 2008. Under the NWPA, as amended, Inyo County, California, has been designated as an Affected Unit of Local Government (AULG). This designation allows Inyo County to receive annual appropriations from the DOE to study potential impacts to the County from the proposed repository at Yucca Mountain. This designation will also allow Inyo County to participate in any proceeding between the NRC and the DOE to grant a license to construct a repository at Yucca Mountain.

2. License Support Network

In conjunction with the LA submittal, the NRC has established the Licensing Support Network (LSN). The LSN allows the DOE, AULG's, and other interested parties to submit documents that will be relied on as evidence during the Yucca Mountain proceeding.

The purpose of this document is to establish procedures for the collection and certification of documentation for inclusion in the LSN in accordance with 10 CFR §2.1003, and that, to the best of the official's knowledge, the documentary material specified in 10 CFR §2.1003 has been identified and made electronically available.

3. Identification, Collection and Certification of LSN Documents

The Inyo County Yucca Mountain Repository Assessment Office (RAO) will be responsible for locating, evaluating, and characterizing documents for inclusion in the LSN through the use of County staff and support contractors. Applying criteria contained in 10 CFR §2.1003, 10 CFR §2.1009 and other applicable federal regulations, the RAO, in consultation with the Responsible Official, will screen documents that are appropriate for inclusion in the LSN. Where appropriate, the RAO will consult County Counsel as to form and legality of such material. The RAO will consult with other County staff and support contractors as necessary to evaluate potential material's appropriateness for inclusion in the LSN. The RAO will finally determine the material that is appropriate for inclusion in the LSN and submit that material to the responsible official, who has the discretion to certify material and submit it to the LSN.

STANDARD OPERATING PROCEDURES FOR SUBMITTAL OF DOCUMENTS TO THE LICENSING SUPPORT NETWORK (LSN)

1. Review of document by Yucca Mountain RAO Staff and support contractors for possible submittal to LSN

2. Submit Staff's recommendation and document to Inyo County Counsel for review as to form and legality

3. After review by County Counsel, Responsible Official will present document to Inyo County's LSN Administrator for submittal to the LSN

4. Obtain certification from U.S. Nuclear Regulatory Commission that document has been submitted

4. Basis for Certification of Documents Collected to Date of this Procedure

Currently, the RAO has prepared numerous documents addressing potential impacts to the County from the proposed repository at Yucca Mountain. The documents focus on impacts such as: transportation of high-level radioactive waste through Inyo County, emergency response capabilities, socio-economic impacts, and impacts on groundwater resources in the southeastern portion of the County, including Death Valley National Park.

These documents were screened by the Yucca Mountain RAO and its support contractors according to the standards outlined in 10 CFR §2.1003 and 10 CFR §2.1009, and the procedures contained herein in Section Three of this document. Inyo County created electronic images and searchable full text of submitted documents, as well as bibliographic headers for the documents consistent with LSN regulations.

These activities provide the basis for the County's Responsible Official to certify that Inyo County has implemented procedures required by 10 CFR §2.1009 (a)(2). In addition, to the best of the Responsible Official's knowledge, licensing documents, as well as the those categories of documentary materials specified in 10 CFR §2.1003, have been identified and made electronically available. These procedures create a reasonable basis for the County's initial certification.

5. Procedures for Future Submittals to the LSN by Inyo County

Inyo County's collection, processing, and review efforts will continue for documents identified after October 17, 2006. Any documentary material identified after this date will be made available as required by LSN regulations as per 10 CFR §2.1003.

6. Challenging Integrity, Validity, or Availability of Submitted LSN Documents by Inyo County

Any challenge to Inyo County's LSN documents shall be submitted in writing to the Project Coordinator, Yucca Mountain Repository Assessment Office, County of Inyo, 163 May Street, Bishop, CA 93514. The Responsible Official shall respond to the challenging party within 20 working days of receipt via certified letter, and any decision made thereafter by the Responsible Official regarding the document is final.

INITIAL CERTIFICATION BY INYO COUNTY RESPONSIBLE OFFICIAL

I certify that Inyo County has implemented procedures as required by 10 CFR §2.1009 (a)(2) and to the best of my knowledge, the documentary material specified in 10 CFR §2.1003 has been identified from those documents submitted and made electronically available. Pursuant to LSN regulations, Inyo County will provide additional documentary material that it may hereafter identify.

Signature: ______________________

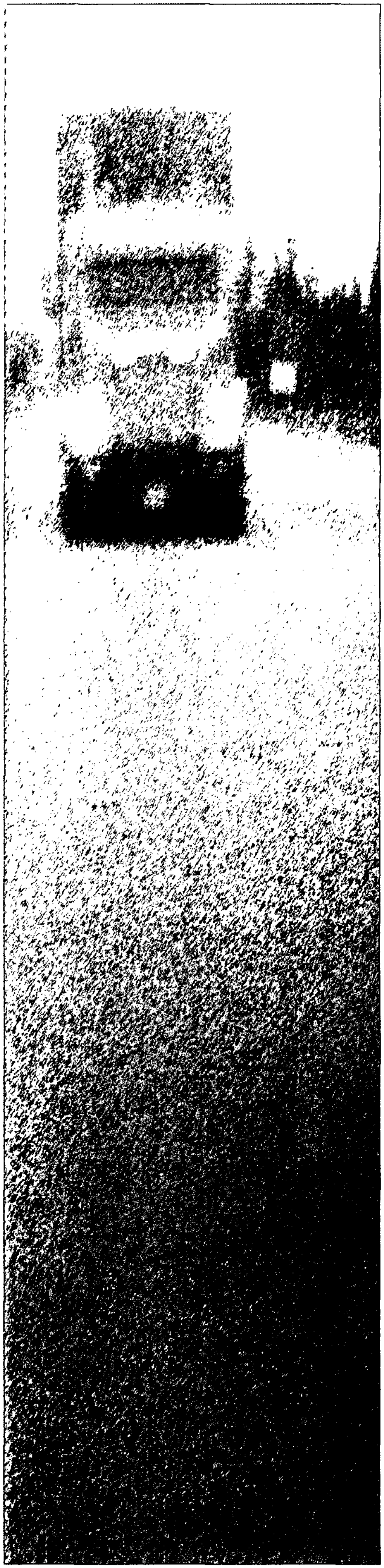
Printed Name: Matt Gaffney

Title: Project Associate

Date: 11-15-06

Inyo County Transportation Risk Assessment Project

Task 2
Transportation Scenario Estimation



Radioactive Waste
Management Associates

526 W. 26th St. Room 517
New York, NY 10001

Table of Contents

List of Abbreviations

ACR	Annual Capacity Report
AUG	Affected Units of Government
AULG	Affected Units of Local Government
BWR	Boiling Water Reactor
CALTRANS	California Department of Transportation
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ESRI	Environmental Research Systems Incorporated
FCR	Full Core Reserve
FEIS	Final Environmental Impact Statement.
HLRW	High-level Radioactive Waste
HMTUSA	Hazardous Materials Transportation Uniform Safety Act
LLW	Low Level Waste
HRCQ	Highway Route Controlled Quantity
MTHM	Metric Tons of Heavy Metals
MTU	Metric Tons Uranium
NEPA	National Environmental Policy Act.
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
NWPAA	Nuclear Waste Police Act Amendments
OFF	Oldest Fuel First
PWR	Pressurized Water Reactor
RFP	Request for Proposal
TRU	Trans Uranic Waste
WEIB	Western States Energy Board
WIPP	Waste Isolation Pilot Project

1. Introduction

This report provides a forecast of potential Spent Nuclear Fuel and High-level radioactive waste (abbreviated as HLW) shipments through Inyo County, California, en route to the proposed repository at Yucca Mountain, Nevada. If this facility is licensed by the NRC and then becomes operational, a large percentage of the waste bound for Yucca Mountain may traverse Inyo County. Depending on the route chosen, Inyo County may be among the most impacted communities in the United States because of its proximity to the destination for the national shipment campaign. This report fills a key need for Inyo County by describing the circumstances under which the county may become an important thoroughfare for these materials.

In order to analyze the local impacts of this program, this report describes the types of waste being shipped to Yucca Mountain and summarizes available information about the DOE's proposed shipping campaign. This includes information about the shipment packages and their radionuclide inventory. A description of the three most reasonable transportation scenarios is provided as a framework to analyze the most probable impacts on Inyo County

The report also describes the types of radioactive materials packages that may be used to ship the waste and the types of carriers that may move the packages.

The report describes how the analytical modeling work was performed and examines the results of these forecasts. During this analysis impacts on Inyo County are compared to other counties nationwide and to other shipping scenarios. The results of the modeling are provided in both printed and electronic formats.

The report concludes that the key determinant of whether or not Inyo County will be impacted by the shipment of these radioactive wastes to Yucca Mountain depends primarily on the choice of routes. There are few routes near Yucca Mountain, so shipments will be constrained to follow one of only a few routes.

2. Shipping Waste to Yucca Mountain

A critical issue for Inyo County will be the routes used to ship waste to Yucca Mountain. Of the original five sites considered for a repository, Yucca Mountain was the least accessible. Route selection has been recognized as a critical issue for a long time because route selection determines where impacts occur. The sites from which waste will be shipped are depicted in Map 1 in Appendix 1.

2.1 Default Routes

In 1987, Congress identified the Interstate highway system as the default route system for moving waste to Yucca Mountain. If routes affect multiple states and those states cannot agree on designating connecting alternate routes that, the interstate highway system will be the route used to ship the waste materials. The DOE's Final Environmental Impact Statement (FEIS) identified the potential interstate routes, despite the subsequent choice of mostly rail as the preferred shipment modality. The discussion of highway routes is critical since:

1. Many shipments may have to be made by truck given the fact that rail routes are not yet under construction and will take a considerable time to build.

2. Truck shipments may be the only way for the program to start. It is shipment modality considered by the study team because it may have an impact on Inyo County.

3. There are few routes near Yucca Mountain and so shipments will be constrained to follow one of only a few routes.

4 Some sites do not have rail access.

The US Department of Transportation (DOT) initially promulgated highway routing regulations for the transport of radioactive materials in 1982. The rulemaking docket that established these regulations is commonly known as HM-164. The rules are specifically set forth in 49 CFR 397.101 and 397.103. In 1992, DOT issued *Guidelines for the Selection of Preferred Highway Routes for of Highway Route Controlled Quantity Shipments of Radioactive Materials* (Guidelines). The Guidelines establish a process for use by a State routing agency for analyzing and comparing safety factors of alternative routes for the shipment of "highway route controlled quantity" packages of radioactive materials waste. "Highway Route Controlled Quantity" (HRCQ) is a term specifically defined in the Federal Hazardous Materials Regulations, and would include the shipments to Yucca Mountain.

Under the DOT routing requirements, an equivalent routing analysis may be used which adequately considers overall risk to the public. Designation of a preferred route for HRCQ shipments must be preceded by consultation with affected local jurisdictions and with any other affected states. Also note that a "preferred route" includes any interstate system highway for which an alternative has not been designated by a State agency.

2.2 Guidelines

The route selection process described in the Guidelines distinguishes between alternate routes by applying three primary route comparison factors to each potential route. They are:

- Normal Radiation Exposure
- Public Health Risk from Accidents
- Economic Risk from Accidents

The first criterion is the radiation exposure caused by the accident-free transportation of the waste containers on highways. None of the containers used to hold the waste can completely shield the truck driver or nearby motorists from some radiation exposure. The Guidelines argue that since the likelihood of an accident is small, normal radiation exposure is the most significant risk associated with the shipments. This criterion seeks the shortest path from the origin of the trip to the destination. The shortest path will minimize the time in transit and, therefore, the radiation exposure for people living adjacent to the route.

The second criterion is the public health risk from accidents. This benchmark measures the health effects of an accident which breeches the container holding the waste. If a container breaks open, radioactive particles can spread in an airborne plume. The Guidelines assume that radioactivity will spread up to ten miles downwind from an accident and will contaminate an area of approximately 25 square miles. Giving consideration to such a large contaminated area, this criterion minimizes the population exposed to radiation by avoiding densely populated regions.

The last criterion used to select routes is the economic risk of transporting the waste. The economic risk is defined as the cost of decontaminating property adjacent to a potential accident location. The factor provides an estimate of the total cost to decontaminate areas affected by radiation. The Guidelines ignore any economic costs beyond decontamination costs. This criterion seeks the route with the lowest cost to decontaminate.

The potential routes are evaluated for each primary comparison factor. Unless all three of the primary factors clearly favor one route, each comparison factor is "normalized" to develop a comparative "overall figure of merit" for each route. In cases where the figures of merit are extremely close, a consideration of secondary comparison factors may assist in the route selection process. The criteria are compared and if no route is significantly better than any other, the criterion are normalized to calculate an index of risk that combines the three factors.

The secondary factors are: emergency response effectiveness, evacuation capabilities, location of special facilities (schools, hospitals), and traffic fatalities and injuries.

The State of Nevada has steadfastly refused to designate a preferred route for shipping High-level nuclear waste and that DOT regulations require that should it do so, it must consult with other affected States. It is possible that Nevada will not prepare a route designation until compelled to do so after all legal challenges to the Yucca Mountain repository have been exhausted.

2.3 Transportation Scenarios

The study examined six scenarios to determine the potential impact of shipments to Yucca Mountain of HLW shipments. Two scenarios forecast the numbers of truck shipments for default interstate truck routes. These routes do not pass through Inyo County. The scenarios are useful for comparative purposes. Other scenarios consider the contingency of using Highway 127 as a HLW shipping route. The first two scenarios are described in the Final EIS.

Because of the unique designs of US nuclear power plants, there are special limitations on moving, loading, and handling waste at many generating sites. As a result, there are limitations on how waste may be transported to Yucca Mountain. These system configuration problems limit our ability to forecast the shipments. Of the 77 potential shipping sites, 24 do not currently have rail access or have significant barriers to the construction of rail access points. In contrast, all 77 potential sites can ship via truck.

Because of uncertainty about shipment timing and schedules, the DOE cannot be certain of the final mix of rail and truck modes. These scenarios were produced by DOE in order to establish the upper and lower limits of the potential alternative modal shipments. The DOE expects that the mostly rail scenario most accurately reflects the actual mix of shipments. However, there is no rail access to Yucca Mountain. Building rail access will be a difficult and lengthy process. The DOE already anticipates shipping waste by truck for six years, while the rail spur to Yucca Mountain is constructed.

This report predicts the numbers of shipments to Yucca Mountain through Inyo County for six alternative scenarios. These routes are consistent with the impacted area described by Inyo County in the Request For Proposal. The scenarios are:

- Mostly truck: Proposed action
- Mostly truck: Modules 1 and 2
- Mostly truck: Southern Route
- Mostly truck: Southern Route Modules 1&2
- Mostly Truck: North South Routing Proposed Action
- Mostly Truck: North South Routing Modules 1 & 2

Two of the scenarios (Mostly Truck: Proposed Action and Mostly Truck: Modules 1&2) precisely follow those described in the FEIS. The numbers of shipments forecasted for these scenarios assume that the waste is not routed away from Las Vegas. The next scenarios (Mostly Truck: Southern Route and Mostly Truck: Modules 1&2) assumes:

1) Either DOE or the State of Nevada takes action to reduce the numbers of shipments through Las Vegas, NV and
2) All waste is shipped via truck.

The North South Routing Scenarios assume DOE uses a routing method similar to the one currently used by the Nevada Test Site for shipments of low level waste. This scenario assumes that all shipments are by truck, they avoid Las Vegas and that they are divided between a northern route through Nevada and a southern route (highway 127).

2.3.1 Mostly Truck: Proposed Action

In the mostly truck scenario, the DOE will ship all of the waste materials to Yucca Mountain using legal-weight trucks (with the exception of naval spent nuclear fuel and possibly some DOE high-level radioactive waste). Naval spent nuclear fuel would be shipped by rail from the Idaho National Laboratory. In this scenario other DOE waste may be shipped to Yucca Mountain in overweight trucks. These shipments would be in excess of the 80,000 lb legal weight truck limit. DOE estimates these shipments may weigh as much as 115,000 pounds. Overweight shipments will require a state operating permit and may entail special highway infrastructure improvements to accommodate such weight limits.

The interstate highway routes considered in the FEIS are depicted in Map 2 in Appendix 1. The DOE described these routes as "representative of routes that DOE could use for truck shipments if the Yucca Mountain site was approved." Any potential highway routing system would have to conform to the requirements listed in 40 CFR 397.101.

This scenario assumes that neither the State of Nevada nor the DOE seek to avoid shipping waste through Las Vegas, Nevada.

2.3.2 Mostly Truck: Modules 1&2

The Mostly Truck Scenario: Modules 1&2 assumes all of the nation's nuclear waste is shipped to Yucca Mountain by truck. The additional shipments described in the FEIS are added to the routes to reflect the increased number of shipments.

These shipments are assumed to use the interstate highway system for the majority of the duration of the trip to Yucca Mountain. Another assumption is that no effort is made to avoid Las Vegas, Nevada.

2.3.3 Mostly Truck: Southern Route

In this scenario, the analysis assumes that the DOE has decided to avoid shipping nuclear waste through Las Vegas, Nevada or that the State of Nevada has designated its "C", "E", or "F" routes as preferred routes for shipping HLW to Yucca Mountain. It is important to note that the State of Nevada has not designated a preferred route for shipping high-level nuclear waste. The use of these routes would make year round shipment of the HLW easier to perform because of the better weather offered on the southern route.

The routes assessed for use as radioactive materials routes through Nevada are depicted in Map 3 in Appendix 1. These potential routes are labeled A through F. The southern routes that affect Inyo County are C, E, and F. These routes are identified in a report authored by Dr. Maria Ardilla-Coulson, *The Statewide Radioactive Materials Transportation Plan (Phase III)* produced by the Nevada Department of Transportation in 1989. Each of these routes is similar insofar as they all use Highway 127 to move the waste to Yucca Mountain. The FEIS volumes of waste shipments are applied to the alternative routes.

2.3.4 Mostly Truck: Southern Modules 1&2

This scenario assumes all of the nation's nuclear waste is shipped to Yucca Mountain by truck. The additional shipments described in the FEIS are added to the routes to reflect the increased number of shipments.

These shipments are assumed to use the interstate highway systems for the majority of the duration of the trip to Yucca Mountain. Another assumption is that a southern alternative route is used.

2.3.5 Mostly Truck: North/South Shipping Proposed Action

Although Scenarios 3, and 4 (southern route) are possible shipment upper bounds, they require all shipments to be funneled to CA 127 from all the interstate gateways. The final scenarios forecast shipments using a combination of the route alternatives.

These routing scenarios somewhat reflect the actual routing developed, and practiced by DOE for all of its LLW, and TRU shipments to/from the NTS. DOE has already established a precedent (and policy) for the diversification of shipments utilizing CA 127. This has been established by discussion between DOE generator sites, NTS, and highway carriers. This policy calls for a "Preferred Low-Level Waste Transportation Routes to the Nevada Test Site". Under this routing strategy the DOE divides shipments between CA 127, and NV 160 during winter months.

A specific reason that has been given by DOE for adopting this route diversification over CA 127 is "to limit the number of shipments that travel along CA 127 due to extremely limited and remote emergency response capabilities." Over the last 5 consecutive years (2000-2004), the annual number of legal weight truck shipments (there have been no overweight shipments) on CA 127 has ranged from 150 to 485 shipments representing from 7 to 14 off-site generators. This is out of annual totals of 520 to 2405 shipments respectively. This represents from 12% to 32% of total shipments over each of the 5 years, or a 5 year average of 21% of total shipments.

To model this scenario, the Nevada B and C routes were used. Although the NTS currently uses State Route 160 for low level waste headed to the NTS, the entry to this route falls completely within the rapidly urbanizing area of Southern Clark County. Use of Nevada Route 160 would not avoid Las Vegas. Therefore 160 would not be a candidate route from the standpoint of the State of Nevada. Additionally, the I 80 is also not a route that has been considered as an acceptable alternative for waste shipments to Yucca Mountain. Therefore, this study examines the Nevada B route as the most likely route used to make truck shipments of waste from eastern reactor sites to Yucca Mountain.

2.3.6 Mostly Truck North South Modules 1 and 2

This scenario modifies the previous scenario by assuming all of the nation's nuclear waste is shipped to Yucca Mountain by truck. The routes used are the northern and southern routes described in the previous scenario. The additional shipments described in the FEIS are added to the routes to reflect the increased number of shipments.

3. Factors Affecting the Scenarios

Very little is known about DOE's plans to ship HLW to Yucca Mountain. The FEIS provides most of the available information, but the operational details that will precisely effect the shipments are unknown. Factors external to the DOE make a precise forecast of shipments difficult.

This report provides a description of the upper boundary of the impacts that can possibly occur in Inyo County. Inyo County may be impacted by truck shipments of HLW to Yucca Mountain. The number of shipments traversing Inyo County vary based on the DOE's shipping program. This forecast suggests the degree to which Inyo County may be impacted.

3.1 The Standard Contract

One extremely important consideration is that the conditions of the "standard contract" which govern the interaction between the DOE and waste generators. The standard contract governs the generators' placement in the shipping queue for wastes destined for Yucca Mountain. As a result of contract language, the generator that owns two nuclear power plants may change the shipping site origin up to six months prior to shipment. This makes DOE's problem of designing a transportation system extremely difficult since the decisions of these utilities may not rest wholly on what is the most efficient and best way to order waste shipments to the Yucca facility. Rather, shipments could be ordered based on differing priorities than would be anticipated if the process was rationalized in some from of oldest fuel first, hottest fuel last (first in first out)..

Under 10 CFR 961 Standard Contract for Disposal of Spent Nuclear Fuel and/ or High Level Radioactive Wastes, starting in April 1991 DOE has issued an Annual Acceptance Priority Ranking system Report. This provides an annual acceptance ranking of the Purchasers (SNF/HLW owners who are contract purchasers) for 10 years following the projected commencement of the DOE facility operation. Based on the Acceptance Ranking Priority, purchasers will submit Delivery Commitment Schedules (DCS) to DOE identifying the range of discharge dates of the SNF/ HLW that the purchaser proposes to deliver to the DOE Waste Management System. The priority for acceptance capacity allocation is based on assigning the highest priority in the acceptance queue to the owners of the oldest fuel on an industry-wide basis. The age of a particular fuel assembly discharged from a specific reactor is the basis for determining the Purchaser's place in the ranking. The age of the SNF is based on the date of final discharge as indicated on the

Purchasers RW-859 submittal form. All SNF qualifies for allocation of acceptance rights based on an OFF (oldest fuel first) priority. In addition all fuel must be at least 5 years cooled prior to acceptance. Since the owner of the fuel may have moved the fuel to another pool in its multi-location system, the original location may not be the pickup location. In addition, purchasers may exercise the trading of their acceptance rights to other purchasers that have lower priority positions in the queue and are at a different location (as long as their fuel is at least 5 years cooled. Logistical simulations have been developed to track the first 10 years of pickup, based on OFF ranking, and location pickup based on OFF, and maintaining FCR (full core reserve) at purchaser reactor locations, but without consideration of location pick-up changes created by trading rights. These simulations have been used to determine maximum pick-up and acceptance rates based on availability of alternative NRC certified cask options. The availability of NRC certified cask packages may be a limiting factor in waste acceptance.

Another variable is the impact of the ongoing litigation between the waste generators and the DOE. The generators have paid DOE a large amount of money to dispose of the waste. Because the DOE has failed to accept the waste in 1998 as required by Congress, the waste generators may be entitled to damages. The amount of the damages may encourage DOE to expedite shipments to Yucca Mountain as soon as possible. This may impact how the DOE approaches the problem.

The impact of these uncertainties on this report is that it the shipment forecasts should be regarded as bounding estimates rather than as an exact forecast. They represent the best possible effort to predict shipments given such uncertainty.

3.2 Road Network in the Vicinity

Inyo County's scope of work for the transportation risk assessment project asked for an assessment of alternative routes State Route 127, State Route 178, and State Route 190. In addition, the RFP identified State Line Road from Death Valley Junction with NV 160 (Pahrump), and SR 178 (Shoshone to its intersection with NR 160) as targets for study.

After examining current and past DOE practice and State of Nevada and California positions on the subject, it is extremely unlikely that State Line Road, California State Route 178, and Nevada State Routes 190 and 160 will be used as shipment routes. Several of these routes are not the shortest route to Yucca Mountain. They do not have the physical capacity to handle these heavy shipments and/or they are within rapidly urbanizing areas.

These routes may materially affect the risks of moving HLW on California State Route 127. They are considered under Task 3 of this project as they may affect risks. The shipping sites and the numbers of shipments are presented below.

Power Plant	FEIS Proposed Action Truck Shipments	FEIS Modules 1&2 Truck Shipments	Power Plant	FEIS Proposed Action Truck Shipments	FEIS Modules 1&2 Truck Shipments
Arkansas 1/2	794	1,550	McGuire 1/2	791	2,001
Beaver Valley 1/2	657	1,121	Millstone 1/2/3	992	2,023
Big Rock Point	110	111	Monticello	257	435
Braidwood 1/2	565	1,142	Nine Mile Point 1/2	813	1,350
Browns Ferry 1/2/3	1,456	1,253	North Anna 1/2	675	1,588
Brunswick 1/2	599	1,435	Oconee 1/2/3	1,294	2,354
Byron 1/2	617	1,136	Oyster Creek	451	658
Callaway	435	701	Palisades	832	660
Calvert Cliffs 1/2	867	1,612	Palo Verde 1/2/3	1,118	2,101
Catawba 1/2	637	1,129	Peach Bottom 1/2/3	1,042	2,058
Clinton	363	636	Perry	293	528
Comanche Peak 1/2	665	1,409	Pilgrim	322	575
Cook 1/2	832	1,759	Point Beach 1/2	409	1,051
Cooper Station	272	621	Prairie Island Station 1/2	665	1,109
Crystal River	277	621	Quad Cities 1/2	979	1,567
Davis-Besse	343	786	Rancho Seco	124	124
Diablo Canyon 1/2	729	2,101	River Bend Station	353	636
Dresden 1/2/3	565	1,969	Robinson	249	470
Duane Arnold	158	576	Salem 1/2	633	1,551
Farley 1/2	693	1,622	San Onofre 1/2/3	853	1,698
Fermi 1/2	377	662	Seabrook	277	590
Fitzpatrick	713	732	St. Lucie 1/2	806	1,768
Fort Calhoun	260	457	Summer	281	1,204
Ginna	320	472	Surry 1/2	863	713
Grand Gulf	592	1,383	Susquehanna 1/2	1,044	1,457
Haddam Neck	255	255	Three Mile Island 1/2	320	2,482
Harris	441	701	Trojan	195	654
Hatch 1/2	272	1,820	Vermont Yankee	380	195
Hope Creek	444	826	Vogtle 1/2	725	1,144
Humboldt Bay	44	44	Waterford 3	374	613
Indian Point 1/2/3	725	1,539	Watts Bar	158	1,379
Kewaunee	653	516	WNP 2	415	607
La Crosse	37	37	Wolf Creek Station	396	552
LaSalle 1/2	769	2,080	Yankee-Rowe	134	134
Limerick 1/2	740	1,354	Zion 1/2	557	557

Figure 1 FEIS truck shipments by generator

	Mostly Truck Shipments: Proposed Action	Mostly Truck Shipments: Modules 1&2
Fort St.Vrain	312	334
Hanford	2,714	15,309
INEEL	1,388	2,759
Savannah River Site	7,371	7,599
West Valley	300	300

Figure 2 Shipments from DOE facilities

3.3 Timing of Shipments

The Federal Government has the responsibility for the disposal of spent nuclear fuel and high-level waste (Nuclear Waste Policy Act of 1982, as amended (the Act). Section 302(a) of that act authorizes the Secretary of Energy to enter into contracts with the owners and generators of commercial spent nuclear fuel and/or high-level waste. The contracts are for the timing and disposal of the waste. When the waste is shipped will be determined by the standard contract.

*The Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste*2 (Standard Contract) is the contractual mechanism for the Department's acceptance and disposal of spent nuclear fuel and high-level waste. The Standard Contract describes the responsibilities of the parties to the Standard Contract in the areas of:

- administrative matters,
- fees,
- terms of
- payment,
- waste acceptance criteria,
- waste acceptance procedures.

The Standard Contract requires the DOE to acquire title to the spent nuclear fuel and/or high-level waste to dispose of the waste. This contract also requires the DOE to issue an annual report that describes the amount of waste at the utilities and the order in which that waste will be shipped for disposal. This report is called the Annual Acceptance Priority Ranking Report and includes the Annual Capacity Report (ACR).

The ACR uses Yucca Mountain's projected waste acceptance to the requirements of the standard contracts to determine the amount of waste individual owners and generators may ship to Yucca Mountain. These volumes are expressed in metric tons of uranium (MTU).

As required by the Standard Contract, the ACR is based on the date the spent nuclear fuel was permanently discharged from the reactor, with the oldest spent nuclear fuel, given the highest priority. The ACR reports 2010 as the opening date of Yucca Mountain. The rate of fuel acceptance for the first ten years of the repository is described below.

Year	SNF (MTU)
1st	400
2nd	600
3rd	1,200
4th	2,000
5th	3,000
6th	3,000
7th	3,000
8th	3,000
9th	3,000
10th	3,000

Figure 3 Rate of fuel acceptance at Yucca Mountain

An important qualifier on the ACR is that it only examines the first ten years of the program. So the shipping schedule for the remaining years is unknown.

4. Modeling alternative scenarios

The purpose of forecasting the shipments of waste to Yucca Mountain is to establish the size of the challenge facing Inyo County. Because so little is readily quantifiable about the transportation program, this kind of modeling requires some simplifying assumptions. In some cases, these assumptions are embedded into the analytical tools used. In other cases, the assumptions must be explicitly stated and then examined as a means to understanding the data provided.

The analysis is performed for the entire 24-38 year period of the proposed action. The analysis further assumes that California Highway 127 is used for legal-weight truck routes.

In this report, the route outputs from Webtragis are accumulated using Caliper Corporation's Maptitude software and converted to ESRI's ARCGIS software. There are some qualifications on the shipments forecasts:

1. HLW routes may modified over the course of the shipping campaign. For example, a significant change in infrastructure may make a different set of routes more attractive for shipments.
2. multiple sets of routes may be needed,
3. The newly licensed Private Fuel Storage facility in Utah may become a national interim storage facility, and
4. The DOE may be successful in constructing a rail line to Yucca Mountain.

Because of these and other issues, this analysis forecasts the shortest distance from the waste generating site to the proposed Yucca Mountain Repository.

4.1 Aggregation of Shipments

The Webtragis software prepared by the Oak Ridge National Laboratory is used to determine the routes for waste shipments to Yucca Mountain. The Webtragis model calculates the paths from an origin to a destination by adding the total impedance of the links on the networks (impedance is a function of travel time and distance) and then finding the shortest path to the destination. A shortcoming of the WEBTRAGIS software reports only a single route at a time. Therefore the tool is of limited value when trying to understand how the accumulation of shipments may impact a locality.

The Appendix to this report (contained on the attached CD) provides both the individual and accumulated numbers of shipments to the Yucca Mountain site on the alternate routes. The files are 1) text outputs describing detailed directions, 2) text outputs describing population characteristics, and 3) ESRI shapefiles which may be used to duplicate the maps.

The WEBTRAGIS software also does not consider capacity constraints on the traffic system itself. In this case, the numbers of shipments will not exceed the capacity of the road network to handle the volume of shipments.

4.2 Time Period of the Analysis

As noted earlier, this forecast covers both the 24 and 38 years of the proposed action in the FEIS. Many analysts of the Yucca Mountain project suggest the current 77,000 MTHM cap on Yucca Mountain waste may have to be lifted in order to accommodate all the nuclear waste the United States will generate in the coming years. Such alterations in the capacity of the Yucca Mountain facility will require updates to the forecasts because the complexities of forecasting the future inventory and location of spent fuel make an exact forecast of that type extremely speculative.

4.3 Sequence of Shipments

As noted earlier in this report, the standard contract provides the owner of spent fuel with a "place in the line" to dispose of the waste. A utility that owns more than one reactor may exchange that place in line between its reactors. Additionally, utilities may buy and sell their place in line to other utilities.

Reactors that cannot ship easily and/or are not planning to ship waste may sell their place in line to others. For example, the Diablo Canyon reactor in California is constructing an Interim Spent Fuel Installation in order to accommodate its waste. This facility has no concern about where in the shipping queue it is and finds little relevance for shipment analysis issues. As a result of these and other complexities, forecasting when the shipments may take place is extremely difficult.

Despite these issues, this report provides a forecast of shipments that is reasonable given the existing uncertainties in the program. These forecasts are the best means to plan for impacts relative to Yucca Mountain since they provide a starting point from which to establish the boundaries of possible impacts on Inyo County.

5. Results of the Modeling

This section reports the results of the modeling. The purpose of the forecast is to establish the boundaries of the possible shipments that could traverse Inyo County en route to Yucca Mountain. Each forecast is expressed in the numbers of shipments, shipment miles and ton-shipment miles moving through the county.

The number of shipments is the number of cask movements through the county over the entire period of the program. "Shipment miles," the product of cask shipments and distance from each origin site, is a measure which adjusts route mileage for the number of cask shipments expected along each segment. "Ton-shipping miles" multiplies the tons of material by the distance transported. This measure provides an even more precise view of the impact of the shipments.

Shipments coming from eastern reactors to Yucca Mountain will essentially travel on one of two interstate corridors: Interstate 80 in the north or Interstate 40 in the south. The effect of using a southern route is to shift the waste from the north to the south.

For DOE, a southern route choice makes sense as 1) an alternative to the northern route and 2) and all-weather route. DOE may see a southern route selection as the most practical way to ensure its shipments can operate year-round. Essentially, the entire national waste flow is shifted south to Interstate 40. In a southern route selection, Las Vegas is only slightly impacted by the shipments and Inyo County becomes heavily impacted. The first scenario examined is the mostly truck scenario.

5.1 Scenario 1 Mostly truck: Proposed Action Shipments

This scenario shows the proposed action in the FEIS. In this scenario, the waste travels on the interstate highway system to Yucca Mountain. It also travels through Las Vegas, Nevada. This scenario assumes that the Congress' mandated limit on the waste stored in Yucca Mountain remains intact at 77,000 MTHM. In this scenario, Inyo County is not directly affected. However, San Bernardino County California will have approximately 7,000 shipments through it en route to Yucca Mountain. This scenario lasts 24 years. This shipping scenario is depicted in Map 4 in Appendix 1.

5.2 Scenario 2 Mostly Truck: Modules 1 and 2

This scenario shows Modules 1 and 2 in the FEIS. In this scenario, all of the nation's nuclear waste is stored in Yucca

Mountain. The waste travels on the interstate highway system to Yucca Mountain. It also travels through Las Vegas, Nevada. In this scenario, no truck shipments traverse Inyo County. This scenario lasts for up to 38 years.
No impacts occur in Inyo County. Approximately 13,000 shipments traverse San Bernardino County.

5.3 Scenario 3 Southern Routes Proposed Action

In this scenario, the southern route is chosen and it avoids Las Vegas, Nevada but travels through Inyo County. This scenario lasts for 24 years and all of the waste shipped travels through Inyo County.

In this scenario, 52,367 shipments travel on 48.92 miles of Inyo County roads. The shipment miles through Inyo County in this scenario is 2,561,793 over a twenty four year period. Assuming a 200 day per year shipping cycle and no time of day restrictions on shipments, then it is possible to assume that on each shipping day, there will be approximately 11 shipments per day on Highway 127.[1]

A common measure of impact - shipment-miles-are higher in Inyo County than many other counties nationwide. When compared to other counties nationwide, this scenario makes Inyo the 15th most affected county in the nation.

So many shipments traverse Inyo County under this scenario that it becomes more affected than all but 13 other states. Stated another way, if Inyo County were a state, under this scenario it would be the 14th most affected state in terms of shipment miles.
In terms of ton shipment miles, this scenario shows 5,123,586 ton shipment miles in Inyo County.[2]

Although there is no way to definitively assess the likelihood of any of the scenarios, it is possible to examine some of the events that could make the scenario more likely. Some of these are:

1. If the State of Nevada successfully blocks construction of a rail line to Yucca Mountain. Congress may decide to move forward with an all truck shipping campaign in order to make some progress.
2. If the State of Nevada were to change it's position to be more supportive of the repository, it may be in a position to ask for the shortest routes through the state as the quid pro quo.

The national routes in this routing system are depicted in Map 5 in Appendix 1.

5.4 Scenario 4 Southern Routes; Modules 1&2

In this scenario, all of the nation's nuclear waste is stored in Yucca Mountain. The waste travels on the interstate highway system to Yucca Mountain. However, as with Scenario 3, the waste avoids Las Vegas, Nevada and travels up Highway 127 to reach Yucca Mountain. In this scenario, all of the truck shipments traverse Inyo County. The FEIS suggests this scenario may last for up to 38 years.

[1] The same number of days as current Nevada Test Site waste operations.

[2] This assumes 2 MTU per cask.

In this scenario, 105,985 shipments will cross Inyo County roads over a 38 year period. The shipment miles through Inyo County in this scenario is 5,184,786 over a 38 year period. Assuming a 200 day per year shipping cycle and no time of day restrictions on shipments, then it is possible to assume that on each shipping day, there will be up to 14 shipments day on Highway 127.

Because this scenario represents a change in magnitude rather than a change in direction, the degree of impact on Inyo County is the same as for Scenario 3. Therefore in this scenario Inyo remains the 15th most affected county in the nation.

In terms of ton shipping miles, this routing shows 10,369,572 ton shipment miles over a 38 year period.

5.6 Scenario 5 Mostly Truck North South Routing Proposed Action

In this scenario, the Congressional limit of 77,000 MTHM waste in Yucca Mountain is maintained, and all waste is shipped by truck. In this scenario, the DOE adopts a routing approach that utilizes the Nevada B Route for some shipments and the Nevada C Route for other shipments. The shipments were optimized to minimize the distance from the shipping sites to the destination using the interstate highway routes.

In this scenario, 27,750 shipments traverse Inyo County. This results in 1,357,530 shipment miles. Assuming a 200 day per year shipping cycle and no time of day restrictions on shipments, then it is possible to assume that on each shipping day, there will be up to 6 shipments day on Highway 127.

In terms of per ton shipment miles, this scenario results in 2,715,060 ton shipment miles. This scenario is unusual in that the shipments are very evenly divided between the north and south based on their geographic proximity to the site.
While the previous scenarios represent the upper and lower bounds of the shipping campaign, this scenario can be regarded as a medium estimate of the impacts. The national routes for this routing system are depicted in Map 6 in Appendix 1.

5.7 Scenario 6 Mostly Truck North South Routing Modules 1 and 2

In this scenario, all of the nation's nuclear waste is stored in Yucca Mountain. The waste travels on the interstate highway system to Yucca Mountain. However, as with Scenario 5, the waste avoids Las Vegas, Nevada and uses either the Nevada B Route or travels up Highway 127 to reach Yucca Mountain.

In this scenario, 55,112 shipments will cross Inyo County roads over a 38 year period. The shipment miles through Inyo County in this scenario is 2,696,079 over a 38 year period. Assuming a 200 day per year shipping cycle and no time of day restrictions on shipments, then it is possible to assume that on each shipping day, there will be up to 7 shipments day on Highway 127.

Because this scenario represents a change in magnitude rather than a change in direction, the degree of impact on Inyo County is the same as for Scenario 5.

In terms of ton shipping miles, this routing shows 5,392,158 ton shipment miles over a 38 year period.

5.8 Scenario Comparison

The scenarios are compared below.

Scenario / **Impact On Inyo**	**Scenario 1** Mostly Truck Proposed Action	**Scenario 2** Mostly Truck Modules 1 and 2	**Scenario 3** Mostly Truck Southern Routing Proposed Action	**Scenario 4** Mostly Truck Southern Routing Modules 1 and 2	**Scenario 5** Mostly Truck North/ South Routing Proposed Action	**Scenario 6** Mostly Truck North/ South Routing Modules 1 and 2
Duration	24 years	38 years	24 years	38 years	24 years	38 years
Shipments	0	0	52,367	105,985	27,750	55,112
Shipment Miles	0	0	2,561,793	5,184,786	1,357,530	2,696,079
Ton Shipment Miles	0	0	5,123,586	10,369,572	2,715,060	5,392,158
Shipments per day	0	0	11	14	6	7

Figure 4 Shipping Scenarios Compared

6. Conclusion

Depending on the route(s) chosen, Inyo County may be among the places most affected by the shipment of HLW to Yucca Mountain. This report describes how the shipment routes were modeled to determine the upper boundary of impacts potentially attributable to the shipments of waste from Yucca Mountain. In order to effectively protect Inyo County, it is necessary to understand the potential volume of shipments.

Appendix 1 Maps of Alternative Scenarios

Albers Projection

Central Meridian: -96
1st Std Parallel: 20
2nd Std Parallel: 60
Latitude of Origin: 40

Legend

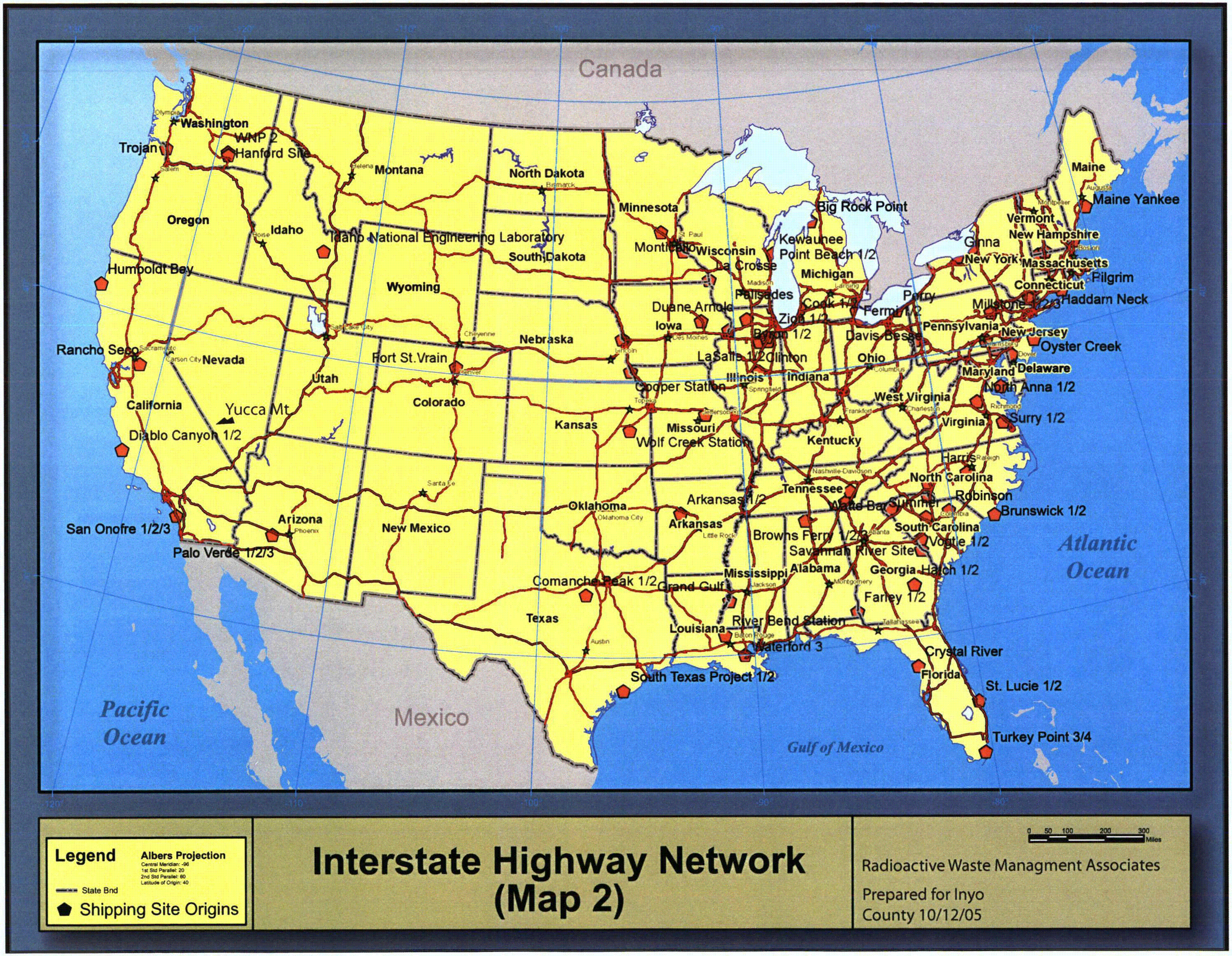
⬟ Shipping Site Origins

Nuclear Waste and Spent Nuclear Shipping Sites (Map 1)

0 50 100 200 300 Miles

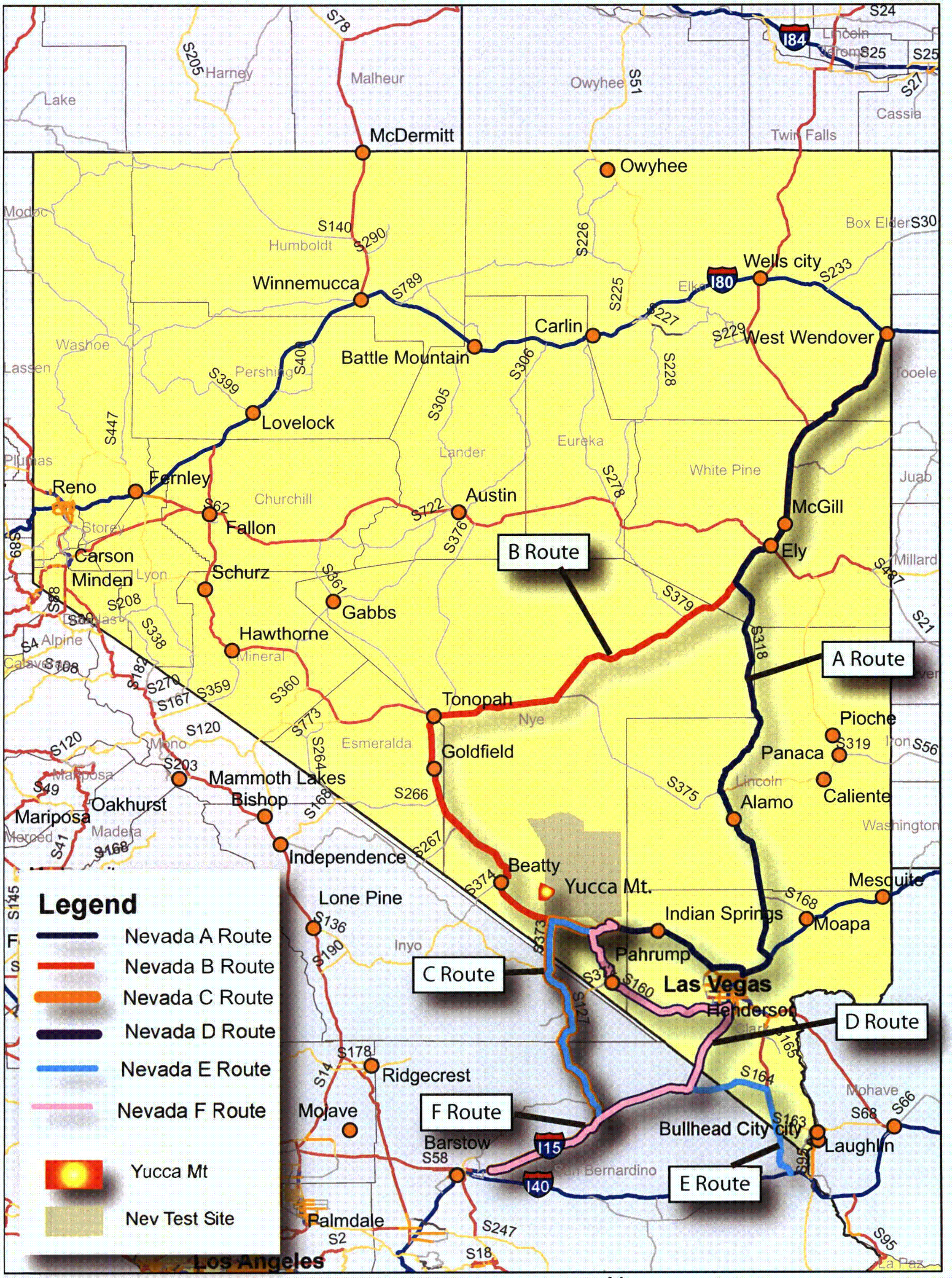
Radioactive Waste Managment Associates

Prepared for Inyo County 10/12/05

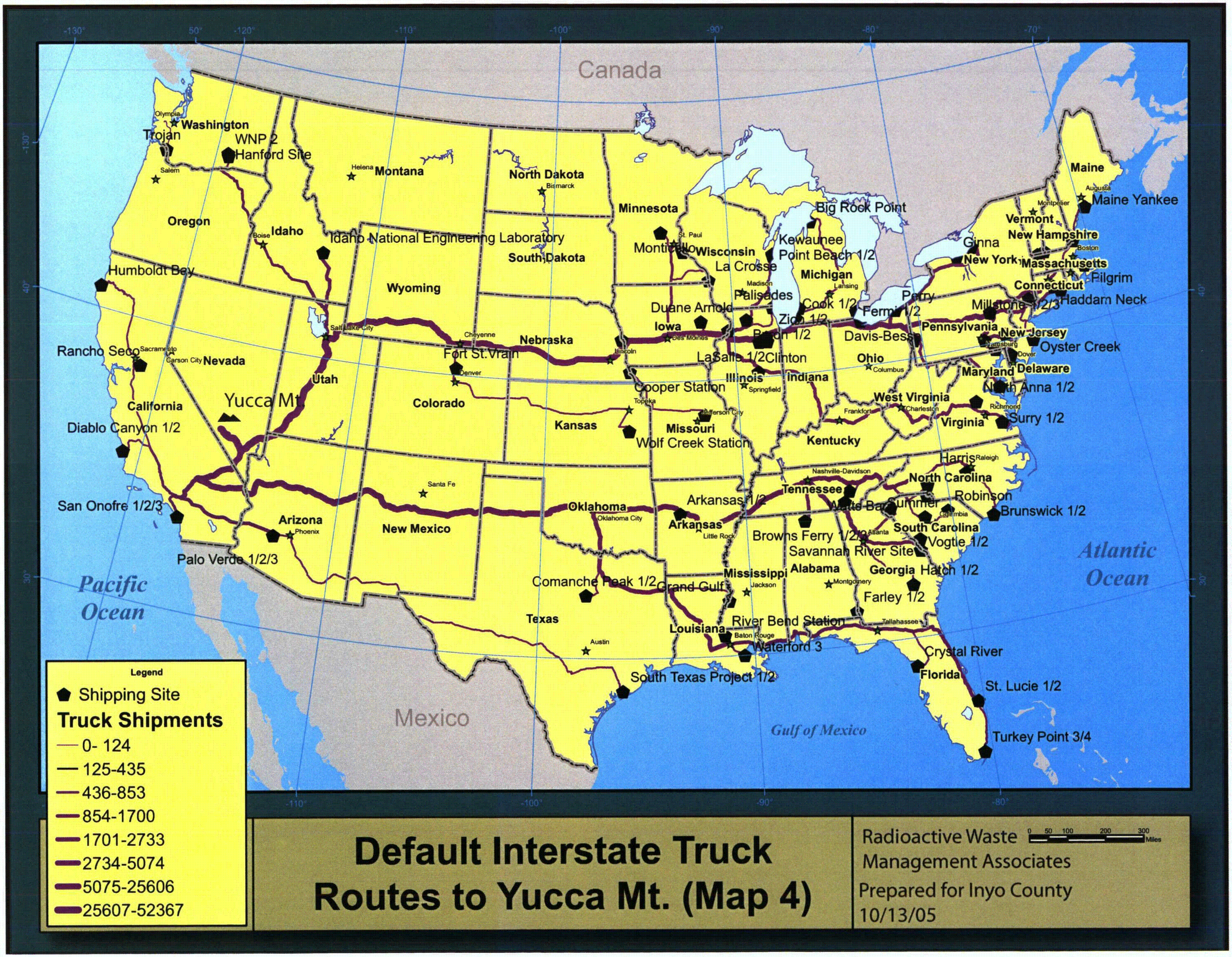


Interstate Highway Network (Map 2)

Potential Nevada Radioactive Materials Routes (Map 3)



Source:
The Statewide Radioactive Materials Transportation Plan (Phase III)
Nevada Department of Transportation 1989

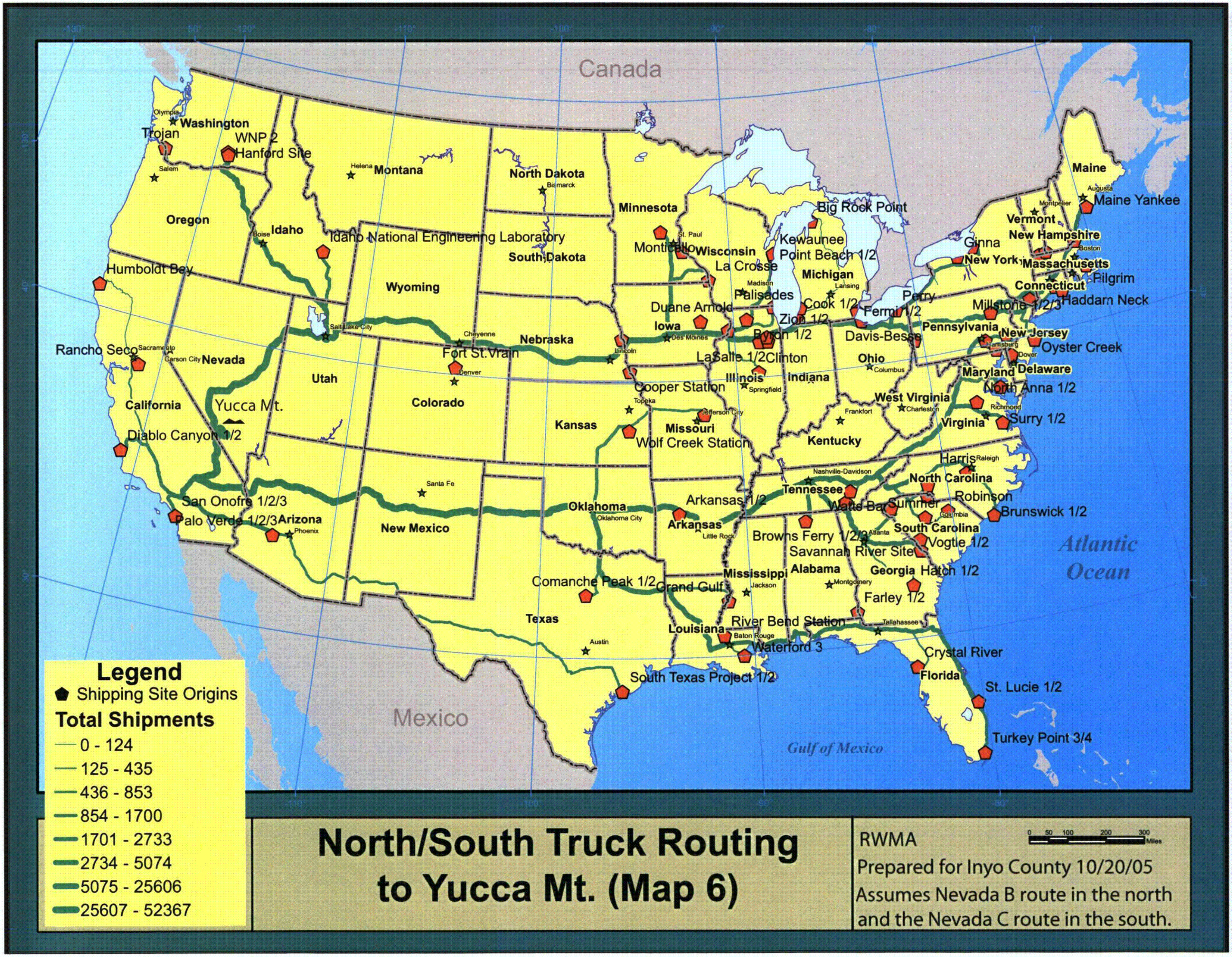


Default Interstate Truck Routes to Yucca Mt. (Map 4)

Southern Interstate Highway Routes to Yucca Mt. (Map 5)

Radioactive Waste Management Associates

Prepared for Inyo County
10/12/05



North/South Truck Routing to Yucca Mt. (Map 6)

RWMA

Prepared for Inyo County 10/20/05
Assumes Nevada B route in the north and the Nevada C route in the south.

Purpose

This report provides a description of the routes that were identified by Inyo County in the request for proposal. Some of the routes may become candidates for the shipment of High-Level Waste (HLW) en route to Yucca Mountain. It is possible that all of these routes will be considered as alternative routes for truck shipment of HLW. The most detailed information is provided for the California routes. Detailed data about both the California and Nevada routes is provided in the attached DVD.

Organization

The report provides technical details that are used for Task 4-the transportation risk assessment. The report is describes three classes of information. The first part describes each route in terms of its: 1) Average Annual Daily Traffic (AADT), 2) trends in AADT, 3) seasonal and hourly traffic peaking and 4) traffic composition. Key roadway design characteristics for each route are also examined. Then the report describes some special events and special traffic generators that contribute to trip making in the area. These are included to assist in understanding what creates seasonal and casual travel in the area.

Contributors to Trip-Making in the Region

Death Valley National Park

The main traffic generator in the region is Death Valley National Park, with approximately one million visitors annually.

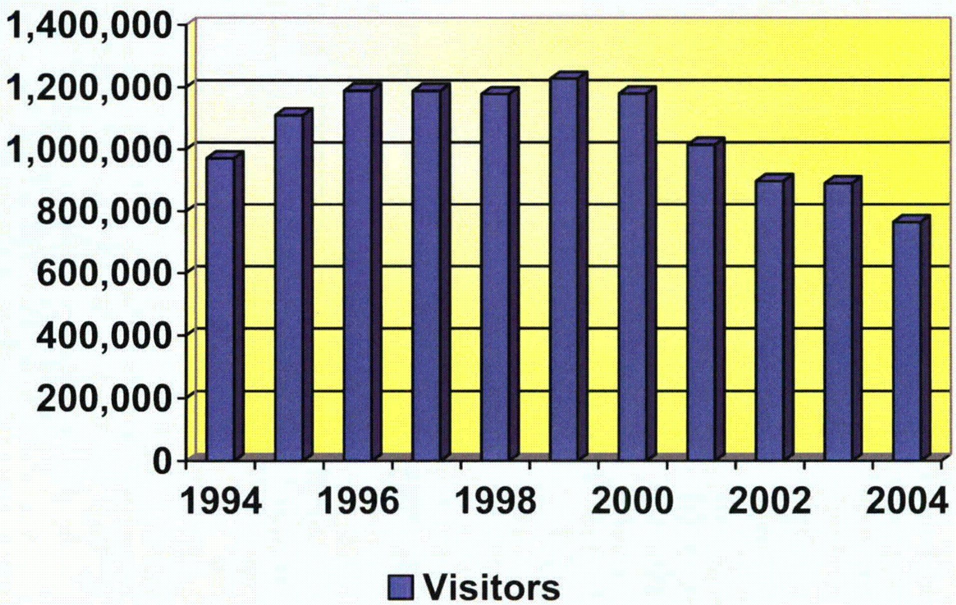


Figure 1 Annual visitation to Death Valley National Park 1994-2004

Since 9/11, park visitation declined dramatically and is only slowing returning to its pre-attack levels. Spring is the primary season for visitors to the park. The most recent data for 2004 shows that the primary month for travel to the park is April. The monthly distribution of visitors is in the table below.

Month	Year	Recreation Visits	Non-Recreational Visits	Total Visits
January	2004	52,401	1,975	54,376
February	2004	64,861	2,546	67,407
March	2004	96,111	3,638	99,749
April	2004	96,662	3,617	100,279
May	2004	77,981	2,930	80,911
June	2004	60,618	2,424	63,042
July	2004	80,405	3,084	83,489
August	2004	50,191	1,862	52,053
September	2004	59,984	2,265	62,249
October	2004	52,428	1,874	54,302
November	2004	46,480	1,731	48,211
December	2004	26,698	964	27,662
Totals:		764,820	28,910	793,730

Figure 2 Monthly visitation to Death Valley National Park (2004)

The monthly trends in Death Valley Park visitation is depicted graphically below.

Figure 3 Monthly visitation to Death Valley National Park (2004)

The primary mode of travel to the park is passenger car and these trips represent the vast majority of travel into and out of the park. The primary point of origin for travel is Las Vegas.

Nevada Test Site

The Nevada Test Site (NTS) is a major facility for storing the low-level radioactive wastes originating from the cleanup of the nation's nuclear weapons facilities. The consequence of this cleanup is that waste is transported to Mercury, Nevada for disposal in Area 3 or 5 at the NTS. Shipments to the NTS represent the closest actual routing developed, and practiced, by the Department of Energy (DOE) for all of its LLW, and TRU shipments to/from the NTS. DOE has already established a precedent for the diversification of shipments utilizing CA 127. This has been established by discussion between DOE generator sites, NTS, and highway carriers. Under this routing strategy the DOE divides shipments between CA 127, and NV 160 during winter months.

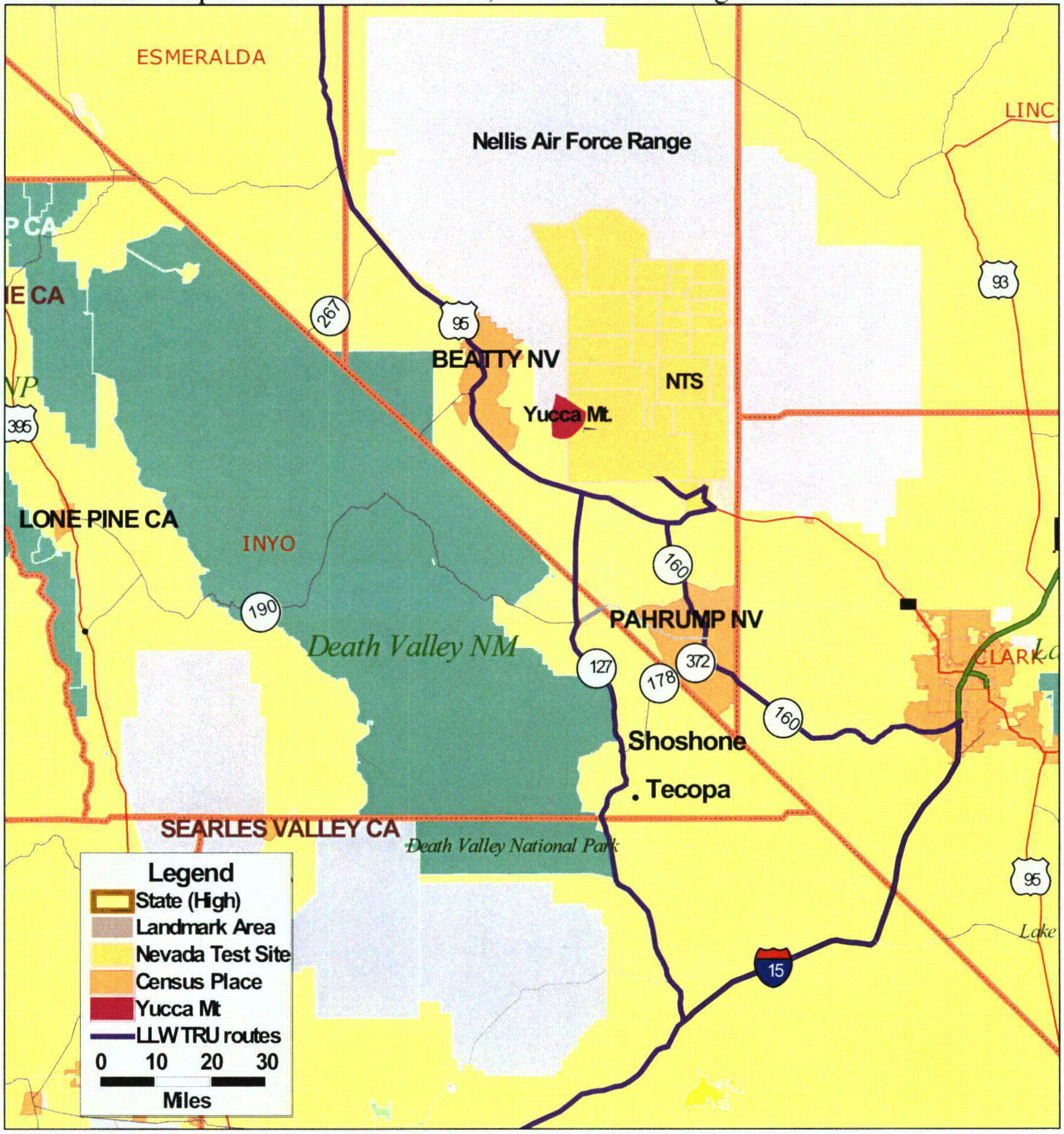


Figure 4 Current routes to the Nevada Test Site used for LLW and TRU shipments

In FY 2005, disposal of Low Level Waste (LLW) and Mixed Low Level Waste (MLLW) at the NTS consisted of 1,390 inbound offsite shipments, from 25 approved generators. These shipments were transported on 19 different approved motor carriers. A total of 2,066,827 cubic feet of LLW from offsite generators was disposed of at the NTS in FY 2005. Three outbound shipments of MLLW were made from the NTS to Envirocare in Utah. Twenty-nine shipments of TRU waste were made from the NTS to Waste Isolation Pilot Plant (WIPP) in FY 2005.

As a result of obligations made by former DOE Secretary Richardson, the transportation of inbound LLW shipments through the Las Vegas I-15 and US-95 Interchange ("Spaghetti Bowl") and across Hoover Dam have substantially decreased since FY 2000. Due to the events of September 11, 2001, tractor trailers are no longer allowed to travel across Hoover Dam. Therefore routes from the north and south have been used.

A specific reason that has been given by DOE for adopting route diversification over CA 127 is "to limit the number of shipments that travel along CA 127 due to extremely limited and remote emergency response capabilities." Over the last 5 consecutive years (2000-2004), the annual number of legal weight truck shipments (there have been no overweight shipments) on CA 127 has ranged from 150 to 485 for an average of 21% of total shipments.

Pahrump

Pahrump's population has grown from approximately 18,000 to 33,000 in 2000. It is currently growing at the rate of 4% annually. This growth has naturally attracted considerable business to the area and Pahrump businesses are major employers. This growth has created an increased demand for transportation in the area. For example, the number of vehicular trips on Highway 160 has increased significantly. Additionally, Pahrump's amenities have made it an attractive place for some of the first responders in the region to live.

The potential for development seems substantial. Pahrump itself is one of Nevada's largest cities in terms of land area. The valley is 26 miles long and 8-12 miles wide. Additionally, it sits on a major aquifer that may be able to furnish water to sustain the growth. In planning for this growth pattern, Pahrump has adopted a Regional Master Plan and is developing its first zoning plan.

Description of Routes

Each state maintained highway in the study area is described in this report. State Line Road is mentioned, however, there is no data available for this route (which becomes Ash Meadows Road when it enters Nye County). Each California route is described on four criteria: 1) AADT, 2) trends in AADT, 3) seasonal and hourly traffic peaking and 4) traffic composition. Summaries of the available data are presented below. Less data has been collected for the Nevada Routes. A summary description of the Nevada data is presented at the beginning of the specific Nevada section. Statewide averages are reported where available. The attached DVD contains the associated GIS data and files for this data.

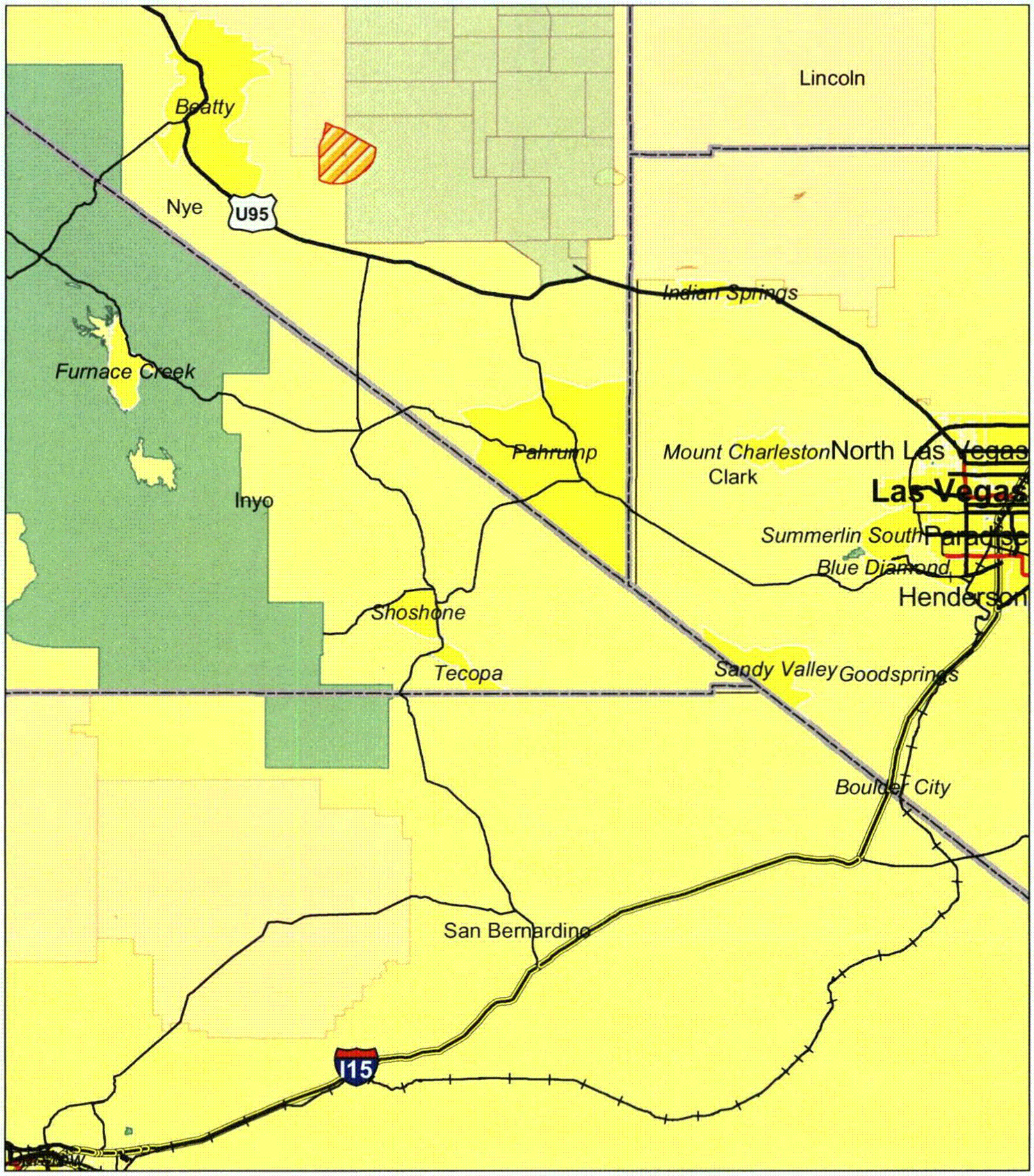


Figure 5 Study Area Roads

Definitions

Average Annual Daily Traffic

AADT is the total volume for the year divided by 365 days. The traffic count year is from October 1st through September 30th. Traffic counting is generally performed by electronic counting instruments moved from location in a program of continuous traffic count sampling. The resulting counts are adjusted to an estimate of annual average daily traffic by compensating for seasonal influence, weekly variation and other variables which may be present.

Peak Hour

An estimate of the "peak hour" traffic at all points on the state highway system is included. Peak Hour is an estimate of the time of day most of the traffic uses the roadway. Peak hour values in the tables below indicate the volume in both directions.

Post Mile/Milepost

A post mile is a mile marker identifying each mile on the road. These markers are referred to in California as “post miles” and in Nevada as “Mileposts.” The postmile values increase from the beginning of a route within a count to the next county line. The milepost values start over again at each county line. Postmile values usually increase from south to north or west to east depending upon the **general direction** the route follows within the state. The postmile at a given location will remain the same year after year.

Peak Month ADT

The peak month ADT is the average daily traffic for the month of heaviest traffic flow. This data is obtained because on many routes, high traffic volumes which occur during a certain season of the year are more representative of traffic conditions than the annual ADT. Back AADT, Peak Month, and Peak Hour usually represents traffic South or West of the count location. Ahead AADT, Peak Month, and Peak Hour usually represent traffic North or East of the count location.

California State Route 127

Highway 127 is the most direct route from Interstate 15 to Yucca Mountain. The highway was originally added to the California State highway system in 1933. The AADT on the route varies from 7,400 in Baker in San Bernardino County to 700 AADT near Death Valley Junction.

Postmile	2000	2001	2002	2003	2004
0	700	700	700	700	700
14.749	900	900	900	950	1020
42.149	740	740	850	750	700
49.42	730	730	700	700	700

Figure 6 Highway 127 traffic 2002-2004

The volume of daily traffic on Highway 127 remains very stable. The peak hour data is the relationship between the percentage of AADT during the peak hour for both directions of travel and the percentage of traffic in the peak direction.

Postmile	End of the Morning Peak Hour	Morning Peak Hour Direction	Morning Peak Hour Day	Morning Peak Hour Month	End of the Evening Peak Hour	Evening Peak Hour Direction	Evening Peak Hour Day	Evening Peak Hour Month
0	Noon	S	Sunday	March	1 PM	South	Sunday	June
14.749	Noon	N	Sunday	February	1 PM	North	Friday	February
42.149	10 AM	N	Monday	February	1 PM	North	Monday	April

Figure 7 Morning and Evening traffic peak periods

The peak hour data are relatively stable throughout Highway 127. The same consistency applies to the peak hour traffic volumes. For morning hours, the percentage of the total daily traffic that occurs during the peak hour is approximately ten percent of the total daily traffic on the roadway. The evening peak hour traffic is approximately seven percent of the total daily traffic.

The number of trucks using Highway 127 is described below. There is no consistent trend in the truck volumes over the time period for which data is available.

Postmile	2000	2001	2002	2003	2004
0.1	91	85	91	114	114
14.70	95	106	95	101	108
42.10	68	68	182	92	220
49.10	219	249	210	210	210

Figure 8 Daily number of trucks on Highway 127

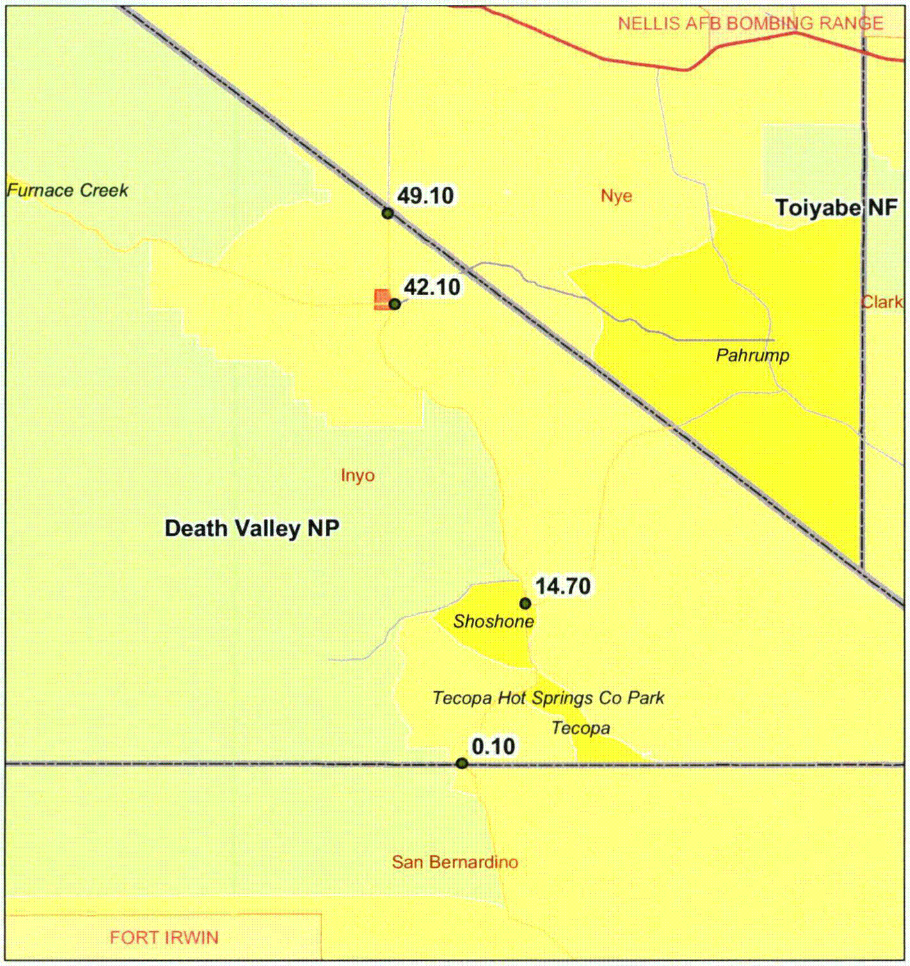


Figure 9 Detail Map of Highway 127 Mileposts

California State Route 178

Highway 178 connects Shoshone with Nevada State Route 372, which intersects Nevada State Route 160, the main route between Pahrump and Las Vegas. The AADT on Route 178 has not changed substantially over time. The numbers of vehicles using the roadway is also consistent.

	Postmile	2000	2001	2002	2003	2004
178	28	190	190	190	120	120
178	42.93	800	800	900	850	900
178	62.186	950	800	800	850	900

Figure 10 Daily AADT on Route 178

The peak hour traffic on the roadway is below.

Postmile	End of the Morning Peak Hour	Morning Peak Hour Direction	Morning Peak Hour Day	Morning Peak Hour Month	End of the Evening Peak Hour	Evening Peak Hour Direction	Evening Peak Hour Day	Evening Peak Hour Month
42.92	Noon	E	Sun	Dec	5 PM	E	Saturday	March

Figure 11 Peak hour traffic on Route 178

The peak hour data are relatively stable throughout Highway 178. The same consistency applies to the peak hour traffic volumes. For morning hours, the percentage of the total daily traffic that occurs during the peak hour is approximately ten percent of the total daily traffic on the roadway. The evening peak hour traffic is approximately seven percent of the total daily traffic.

The number of trucks using Highway 178 is described below. There is no consistent trend in the truck volumes over the time period for which data is available. The number of trucks using California State Route 178 is described below. There is no consistent trend in the truck volumes over the time period for which data is available.

	Postmile	2000	2001	2002	2003	2004
178	42.92	7	7	7	7	7
178	62.186	85	71	71	76	80

Figure 12 Truck volume on Route 178

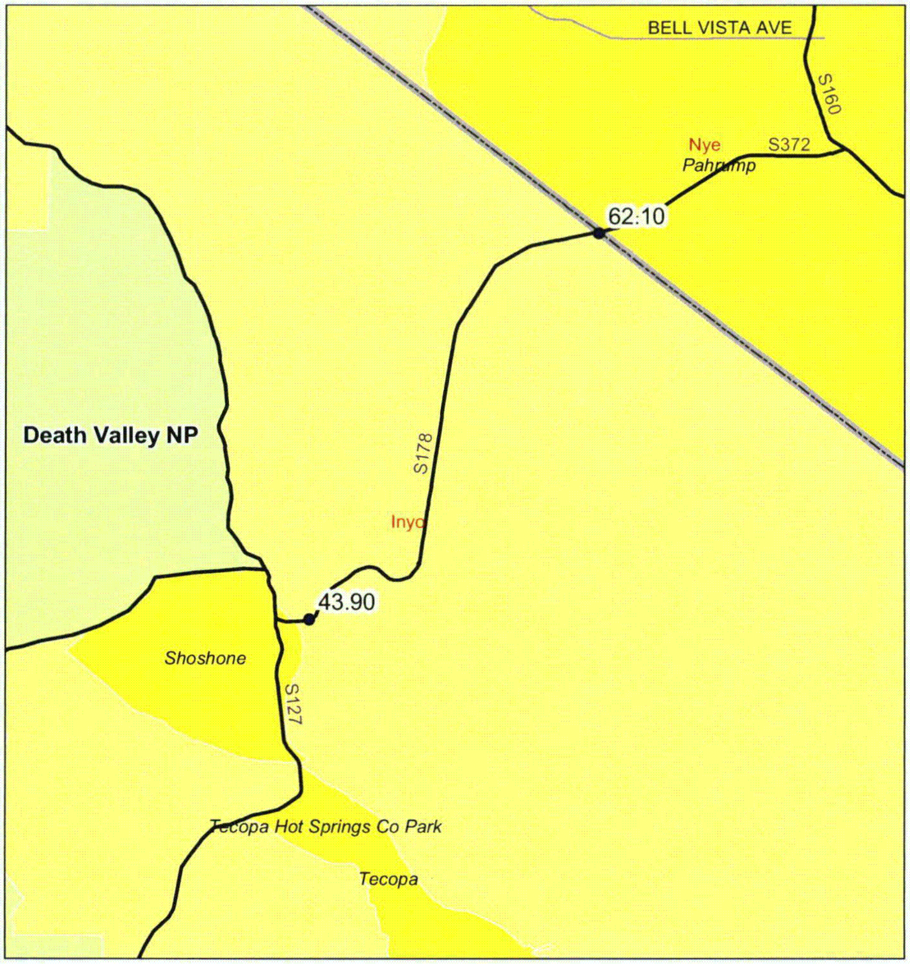


Figure 13 Detail Map of California 178

California State Route 190

State Route 190 is functionally classified as an interregional Two-Lane Minor Arterial, which provides access from US 395 at the eastern flank of the Sierra Nevada Mountains to SR 127 at Death Valley Junction near the California/Nevada border. Elevations along SR 190 varies considerably from 3,648 feet (1,112 meters) at the junction of US 395 to over 5,200 feet (1,585 meters) near Darwin Road, down to 245 feet (67.67 meters) below sea level in Death Valley, and back up to 2,070 feet (630.94 meters) at the junction of SR 127. Due to the combined effects of extreme summer temperatures, steep grades, and high passes, the potential exists for vehicles to overheat on the route. The segment of SR 190 from PM 42.7 (KP 68.7) to PM 128.3 (KP 206.4) is officially designated as both a California Scenic Highway and a National Scenic Byway. State Route 190 is the only State Highway that provides access from the west to Death Valley National Park, which is a globally significant area.

The AADT on Route 190 has not changed substantially over time. The numbers of vehicles using the roadway is also consistent.

	Postmile	2000	2001	2002	2003	2004
190	9.85	330	330	330	170	200

190	24.55	220	220	200	400	400
190	110.72	1350	1350	1350	1350	1050
190	140.69	840	840	840	700	650

Figure 14 Daily AADT on Route 190

The 2004 peak hour traffic on the roadway is below.

Postmile	End of the Morning Peak Hour	Morning Peak Hour Direction	Morning Peak Hour Day	Morning Peak Hour Month	End of the Evening Peak Hour	Evening Peak Hour Direction	Evening Peak Hour Day	Evening Peak Hour Month
24.55	11:00 AM	East	Saturday	June	2:00 Pm	East	Tuesday	April

Figure 15 Peak hour traffic on Route 190

The number of trucks using California State Route 190 is described below. There is no consistent trend in the truck volumes over the time period for which data is available.

	Postmile	2000	2001	2002	2003	2004
190	9.85	3	3	3	1	1
190	24.55	1	1	1	22	22
190	110.72	47	47	47	47	37
190	140.69	33	33	33	49	45

Figure 16 Truck volume on Route 190

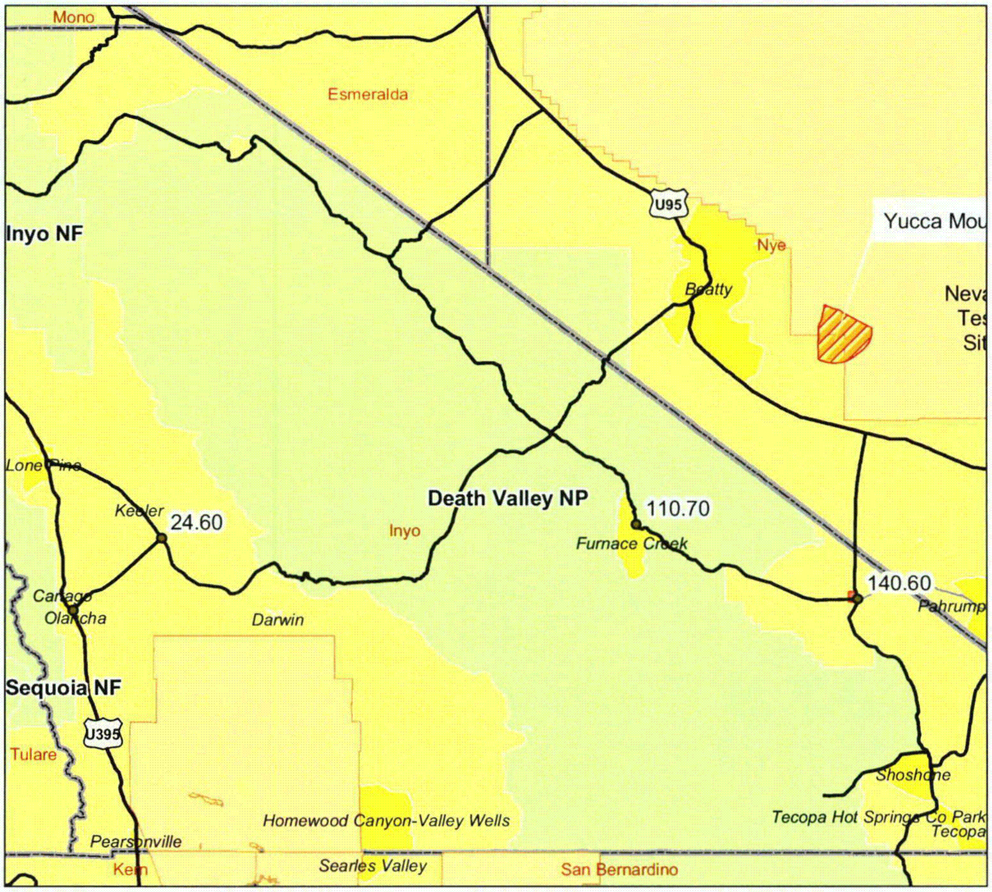


Figure 17 Detail Map of State Route 190

Summary of Nevada Data

The most recent data available for Nevada is for 2002. In terms of risk assessment the statewide averages are the only ones currently available. The standard passenger car was involved in more crashes than any other type of vehicle. Pick-up trucks and small passenger cars ranked number 2 and 3 respectively. Single unit trucks ranked number 4. The number of motorcycle fatal crashes increased in 2002 to 34 from 20 crashes in 2001. There were 20 in 2000, (these numbers do not include "moped" fatal crashes).

Total number of large trucks involved in crashes has decreased from 3,339 in 2000 to 3,101 in 2002. This reflects a 7.1% decrease. Most crashes occurred during daylight hours. The highest number of crashes occurred in clear weather conditions. The majority of crashes occurred in areas where the speed limit is posted at 35 mph. Friday followed by Thursday had the most crashes by day of week. Most fatal crashes occurred on Fridays and Sundays. The most deadly 6 hours of the day were 4:00pm to 10:00pm; 87 of the 330 fatal crashes occurred during that time period. 76 occurred from 10:00pm to 5:00am, 73 from 5:00am to 11:00am and 62 from 11:00am to 4:00pm. The most deadly hour was from 9:00pm to 10:00pm with 22 fatal crashes.

The deadliest holiday period was 4th of July with 16 fatalities. The next deadliest was Nevada Day, with 15 fatalities recorded. The month of October had the most injury and fatal crashes combined, while February had the least injury and fatal crashes.
The Nevada Day holiday period recorded the most fatal crashes involving alcohol with 8. Most fatal crashes occurred in areas where the posted speed limit was 45 mph. Most injury crashes occurred in areas with a posted speed limit of 35 mph.
There were a total of 62,237 traffic crashes in 2002; 41,432 (66.6%) of the crashes resulted in property damage only, 20,475 (32.9%) of the crashes resulted in injuries, 330 (.53%) of the crashes resulted in one or more fatalities.

The top ten crash types by severity were:

1. Ran off Roadway & Overturned
2. Pedestrian
3. Ran off Roadway & Other Combo.
4. Rear End Collision
5. Angle Collision
6. Left Turn Collision
7. Rear End Collision
8. Sideswipe-Same Direction
9. Angle Collision

The top contributing factors by severity were:

1. D.U.I. Alcohol
2. Failure to Yield
3. Inattentive Driving
4. Failure to Yield

5. Failure to Reduce Speed
6. Inattentive Driving
7. Failure to Yield
8. Failure to Reduce Speed
9. Inattentive Driving.

The most frequently struck fixed objects along Nevada's highways were concrete barrier rails. There were 1,858 construction zone crashes that resulted in 9 people killed and 883 injured. Male and Female drivers between the ages of 24 and 35 show the highest crash totals.

US Highway 95

Nevada Department of Transportation classifies US 95 north of the NTS as a principal arterial. Traffic on US 95 between the intersection of Nevada Route 160 and the Mercury interchange.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
US 95	2550	2780	2855	2940	2960	2980	3110	2800	2,800	3000

Figure 18 Sample AADT on US 95

The average speed at this location has varied between 70 miles per hour and 71 miles per hour between 2000 and 2002. The composition of trucks on roads of this type in Nevada in 2004 was: 19.60% truck, 80.40% passenger cars and 0.58% buses.

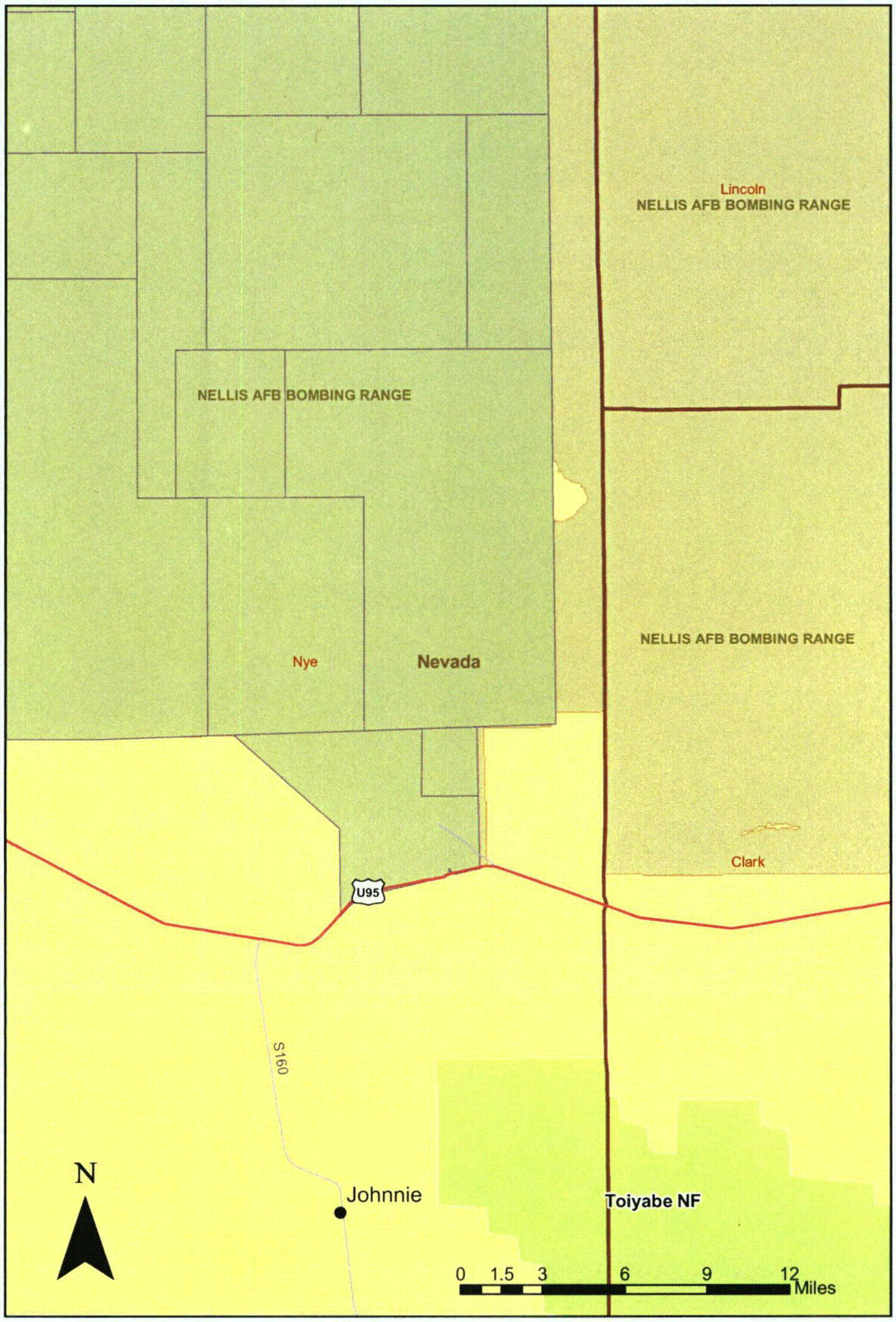


Figure 19 Detail map of US Highway 95

Nevada State Route 160

Nevada State Route 160 is the primary route connecting Pahrump with Las Vegas, Nevada. It has been heavily improved in recent years, but continued development in the southwestern part of the Las Vegas valley continues to grow. It is classified as a rural major collector by the NDOT. The composition of trucks on roads of this type in Nevada in 2004 was: 12.94% truck, 87.06% passenger cars and 0.28% buses.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
SR 160	1140	1100	1050	1200	1350	1300	1400	1400	1400	1450

Figure 20 AADT on SR 160 between Pahrump Valley Road and SR 372

NDOT does not collect speed data for SR 160.

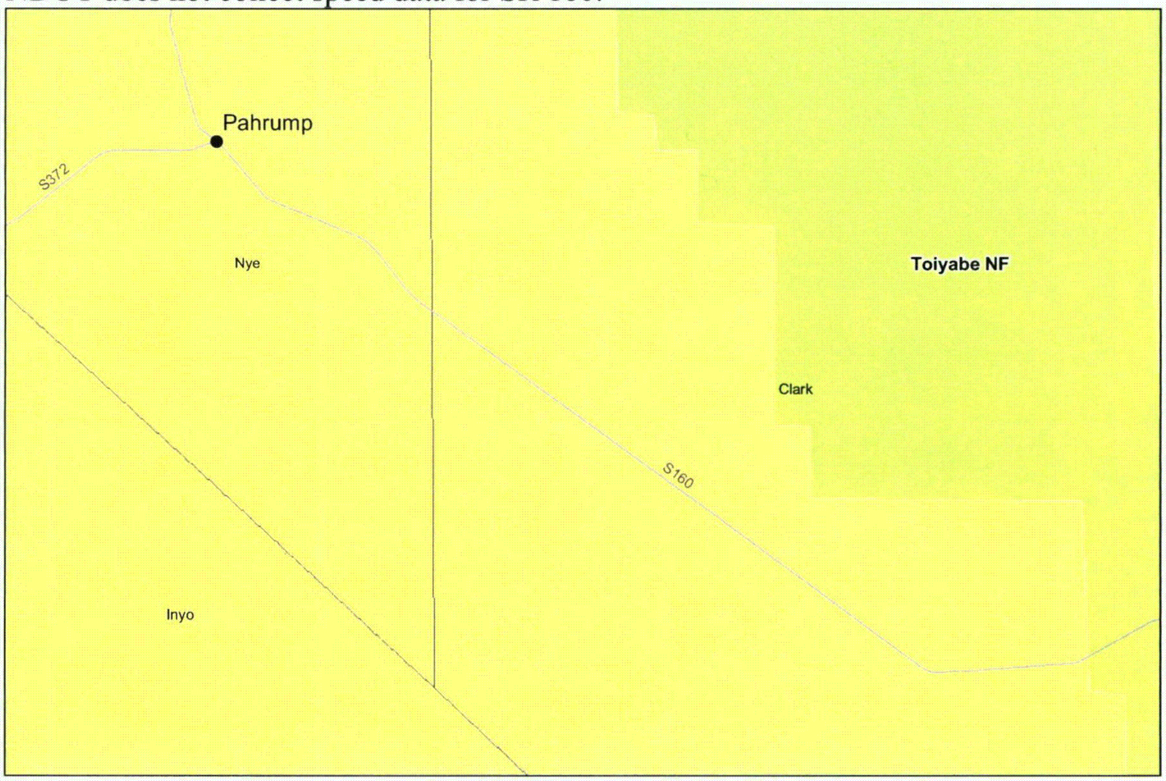


Figure 21 Detail map of Nevada State Route 160

Nevada State Route 372

This road is also referred to as the Charles Brown Highway. This AADT station is .1 mile east of Nevada/California stateline. State Route 372 connects California Route 178 with Nevada State Route 160. It is classified as a rural major collector by the NDOT. The composition of trucks on roads of this type in Nevada in 2004 was: 12.94% truck, 87.06% passenger cars and 0.28% buses.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
SR 372	700	670	640	600	830	780	1000	800	810	860

Figure 22 AADT on SR 372

NDOT does not collect speed data for SR 372.

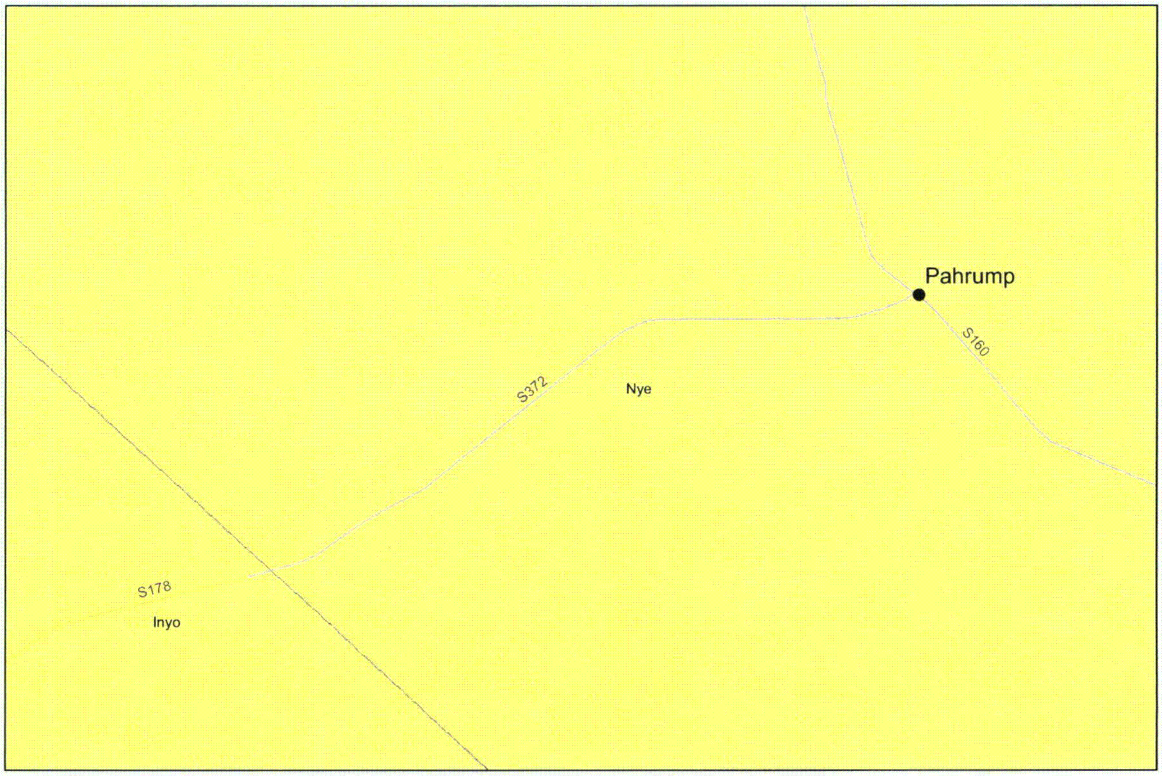


Figure 23 Detail map of Nevada State route 372

Nevada State Route 373

SR 373 is classified as a rural major collector by the NDOT. It connects California Highway 127 in the south with US 95 in the north. The composition of trucks on roads of this type in Nevada in 2004 was: 12.94% truck, 87.06% passenger cars and 0.28% buses.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
SR 373	835	720	610	700	660	650	650	570	570	760

Figure 24 AADT on SR 373 en route to Death Valley Junction .5 mile south of US95

NDOT does not collect speed data for SR 373.

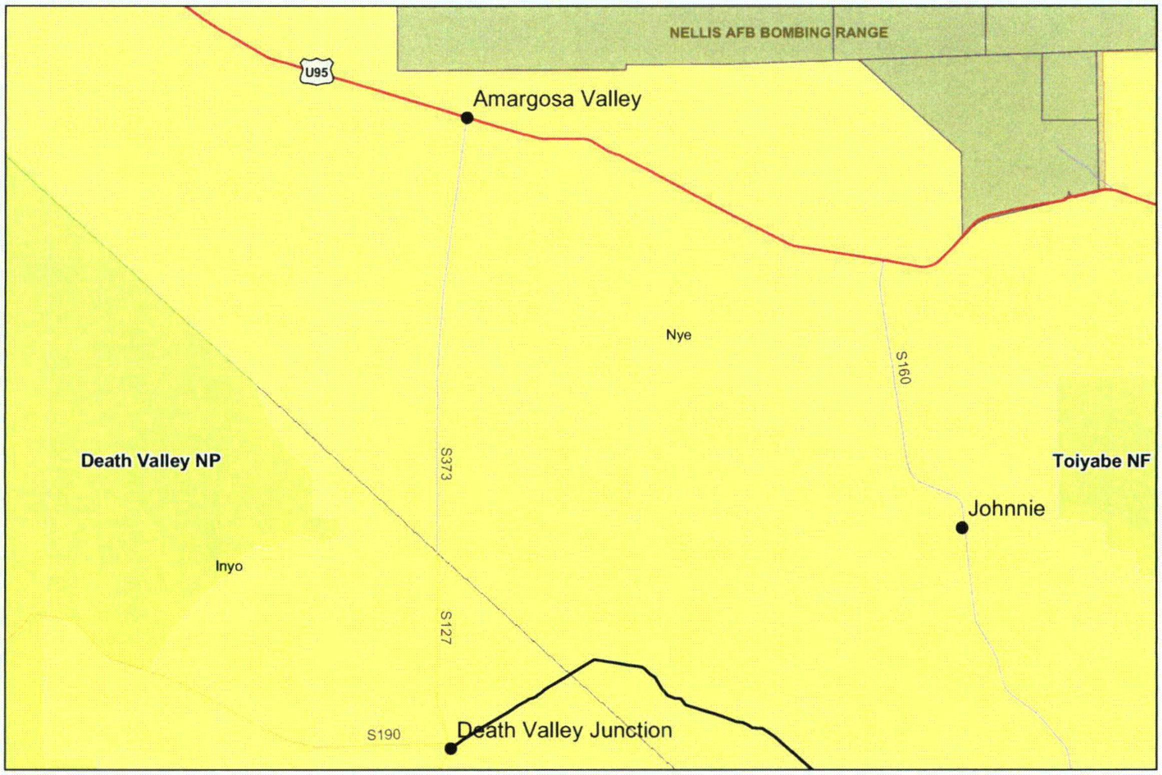


Figure 25 Detail map of Nevada State Route 373

State Line Road/Ash Meadows Road

There is no data for traffic counts or traffic composition data for State Line/Ash Meadows Road. CALTRANS plans to add a classification station on State Line Road.

Flooding and other natural hazards

Highway 127 is subject to frequent floods which interrupt use of the highway. The highway is often interrupted in multiple places. In 2004, the highway was flooded in 13 locations and closed.

Weather Data for Furnace Creek, CA (Elev. 178 feet below sea level - Degrees F.)			
Month	Avg. Max. Temp.	Avg. Min. Temp.	Avg. Precipitation
January	64.6	39.1	0.24"
February	72.3	45.6	0.33"
March	80.4	52.8	0.24"
April	89.8	61.9	0.12"
May	99.3	70.7	0.07"
June	109.0	80.3	0.03"
July	115.3	87.8	0.11"
August	113.2	85.0	0.12"

September	105.8	74.9	0.11"
October	92.0	61.6	0.09"
November	75.7	48.1	0.19"
December	65.1	39.4	0.19"
ANNUAL	90.1	62.2	1.84"

Figure 26 Precipitation in Death Valley

Areas where floods typically occur are where the Amargosa River crosses Highway 127. Potential flooding on 127 is significant, because it could delay shipments and cause multiple shipments to seek a safe haven while the flooding subsides and the road is reopened. Such an event would present security problems and could create high routine doses of radiation.

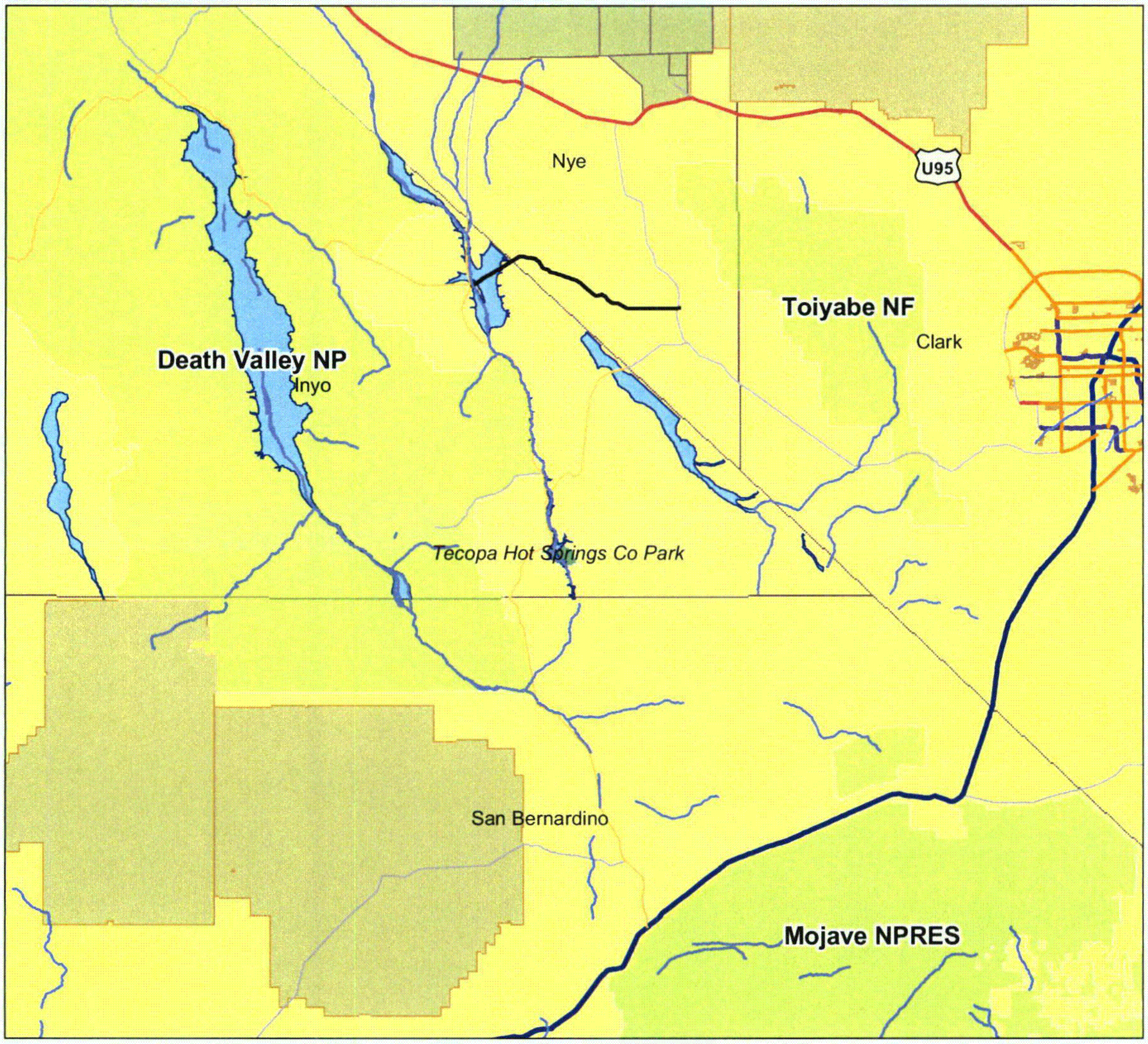


Figure 27 Flooding locations on Highway 127

Dumont Dunes

The Dumont Dunes Off-Highway Vehicle Area is located in San Bernardino County, however, visitors arriving from Las Vegas seeking to use the area typically travel on either 127 from I15 at Baker or from 160 in Nevada. Bordered by steep volcanic hills and the slow running Armargosa River, the region is easily recognized from a distance by its distinctive sand dunes.

The Bureau of Land Management (BLM) estimates that over 130,000 people visit the area each year. Many of these people arrived there from Las Vegas.

Estimates are that 50% arrive from California and 50% from Nevada. Because of this high level of visitation, the San Bernardino County Sheriff's office has had to deploy a mobile jail facility and on-site helicopter pad and deputies. The peak months of visitation at the Dunes are on major holiday weekends between November and March.

Appendix 1 Data

The hard drive enclosed with this report contains the data used herein. The data falls into five broad categories:

Elevation and Land cover

- Digital Elevation Models
- Digital Raster Graphics
- Aerial Photos

Transportation Data

- Roads and Highways (including State Line Road)
- Highways by classification
- Accidents/Incidents
- Line layer with truck composition, AADT, and accident data

Hydrographic Data

- Named streams and rivers
- Flood history in Inyo County
- Water bodies

Demographic Data

- Counties
- States
- Populated Places (points)
- Populated Places (areas)
- Census tract
- Census Block
- Census Block Group
- Parks
- Landmarks
- Private Property
- Federally Owned Property

Yucca Mountain Specific Data

- Nevada Test Site
- Nellis Air Force Range
- Yucca Mountain Controlled Area Boundary
- DOE data sets for Yucca Mountain (e.g. Hydrology, Geology, Groundwater, etc…)

Inyo County Transportation Risk Assessment Project

Task 4
Risk Estimates for Inyo County

May 2006

Radioactive Waste Management Associates
526 W. 26th Street #517
New York, NY 10001

Table of Contents

1. Glossary of Terminology and Acronyms

AADT – Average Annual Daily Traffic

Acute Dose – a single, fairly large dose that persists for a very short time yet produces adverse effects

Accident Probability – measure of how likely it is that an accident will occur

Accident Rate – the amount of accidents occurring over a specific distance of the study road (accidents/veh-km)

Cask – A container designed for the safe transport of spent fuel or high level nuclear waste

CRUD – an acronym for 'Chalk River Unidentified Deposits.' The standard industry term referring to minute, solid, corrosion products that travel into the reactor core, become highly radioactive, and then flow out of the reactor into other systems in the plant

Curie (Ci) – unit used to measure a radioactivity. One curie is that quantity of a radioactive material that will have 37,000,000,000 transformations in one second

Exposure Pathway – the route that links radioactive contamination from a specific source point to a receptor population in a specific ecosystem

FEIS – Final Environmental Impact Statement

Fuel Matrix – the area within a cask that contains the fissionable material and is surrounded by the rod cladding

GIS – Geographic Information Systems

Incident-Free Dose – the radiation dose to the public under routine shipping conditions (no accidents), due to the fact that no shielding material can reduce direct gamma radiation by 100%. The dose depends on the recipient's proximity and duration to the passing radiation source

Ionizing Radiation – radiation with enough energy so that during an interaction with an atom, it can remove tightly bound electrons from their orbits, causing the atom to become charged or ionized

LCF – Latent Cancer Fatality

MEI – Maximally Exposed Individual

NRC – Nuclear Regulatory Commission. A U.S. agency chartered to develop and administer rules for regulating commercial nuclear applications (including nuclear power plants, medical and industrial uses).

On-Link Population – average number of people in the street that is exposed to radiation from transportation casks

Plume – the concentration profile of an airborne or waterborne release of material as it spreads from its source

Radiation – energy in transit in the form of high speed particles and electromagnetic waves

Radioactivity – spontaneous transformation of an unstable atom and often results in the emission of radiation

Radionuclide – a radioactive nuclide (An atom or a collection of atoms whose nuclei have a specified number of protons and neutrons)

Release Fraction – the fraction of the nuclide inventory in a cask that is rapidly released

Rem – a unit used in radiation protection to measure the amount of damage to human tissue from a dose of ionizing radiation

Rod Cladding – the area within a cask that surrounds the fuel matrix and serves to confine and protect the fuel from being released

SNF – Spent Nuclear Fuel. Fuel rods which no longer have enough fissionable uranium in them to be efficiently used to produce power.

2. Introduction

This report provides estimates of radiological and non-radiological risks associated with the forecasted shipment scenarios for each of the three routes identified by Inyo County. The general methodology is given as follows:

1. Estimate the radiological risk for each of the two different campaigns: routine radiological risk (incident-free shipments), and risk arising from accidents involving release of radioactive materials (accident case).
2. Measure the incident-free radiological risk by two indices: a maximum exposed individual (MEI) along the route, and total population exposed along the route.
3. Measure the accident-related radiological risk to maximum exposed individuals (e.g. first responders) and total population from a severe accident occurring in Shoshone, California.
4. Estimate the economic consequences of such an accident.
5. Evaluate the range of possible accident scenarios from high probability and low consequence to low probability and high consequence.
6. Identify and estimate the transportation non-radiological risk associated with the spent nuclear fuel and high-level waste shipments.

If a high-level waste repository opens at Yucca Mountain, a number of truck shipments of nuclear waste are expected to pass through Inyo County. These shipments of nuclear waste would lead to a radiation dose to the public even if the transport is incident-free, because no shielding material can reduce direct gamma radiation by 100%. As a result, residents, drivers, pedestrians and workers will get a radiation dose, which depends on the recipient's proximity and duration to the passing radiation source. Incident-free radiological risk is measured using a MEI along the route as well as the total population exposed along the routes.

This nuclear waste shipment campaign will also increase the associated accident risk on the study roads. Possible accident scenarios range from high probability and low consequence to low probability and high consequence. In case of a severe accident involving a nuclear shipment, the dose to individuals and the population would be much higher. In contrast to incident-free transportation, such an accident would cause both acute and long-term exposures, because radioactive particulates would be dispersed in the environment and continue to lead to radiation exposures. A severe transportation accident leading to a release of radioactive particulates is possible and credible. It could be caused by high impact, long duration fire or sabotage. Such an accident would lead to high radiation exposures due to inhalation of particulates (acute dose) and ground shine, i.e. direct gamma radiation from deposited radionuclides (long-term dose). Additional exposure to radiation would arise from ingestion of contaminated food, water and soil, even though the dose due from the ingestion pathway is very small in comparison to the inhalation and ground shine pathways.

3. Methodologies

Incident-Free Analysis

Risk to the Maximally Exposed Individual and to the Population

For the calculation of expected doses to the MEI and the population under routine shipping conditions, the RISKIND[1] computer program is used. This program is designed to analyze the potential radiological health consequences to individuals or population groups exposed to radioactive materials. For the dose to the population, each of the likely routes and shipping campaigns through Inyo County is examined. In the Assumptions and Parameters section of this report, the most important inputs are discussed. The unit of measurement used to calculate the incident-free dose is rem. Rem is a unit used in radiation protection to measure the amount of damage to human tissue from a dose of ionizing radiation.

Accident Analysis

Collective Accident Risk

To estimate dose risk from a spectrum of accident scenarios along the study roads, the RADTRAN 5 computer code[2] is used. The program considers a range of possible accident scenarios and their related probabilities, including low-probability accident scenarios that have high consequences and high-probability accident scenarios that have low consequences. The expected number of accidents of various severities along study roads resulting from the shipping campaign is determined. The program also calculates unit-risk factors for the inventory being shipped which is measured in person-rem per person per square kilometer per curie. The most important inputs of this analysis are discussed in the Assumptions and Parameters section.

Accident Locations

Together with Inyo County, CALTRANS, Nevada Department of Transportation (DOT), and the California Highway Patrol, we investigated potentially troublesome areas along the study routes traversing Inyo, San Bernardino, and Nye Counties. A wide-range of data including but not limited to accident history, traffic counts, highway speeds, and road grade were used to determine specific accident 'hotspots'. The chosen locations provide a range of potentially severe accident scenarios, from the higher-density areas in Shoshone or Pahrump to the relatively remote areas along CA 127.

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[1] USDOE, 1995.

[2] Neuhauser, Kanipe, and Weiner, 2000.

Radiological Release from Severe Accident

The decision to perform a consequence assessment for an accident occurring in Shoshone, CA was made in order to provide a hypothetical exercise with which to estimate damages and provide guidance for emergency responders. Obviously, it is impossible to predict the precise location of an accident, its severity, and the meteorological conditions at the time of the accident. However, it is instructive to provide a hypothetical scenario as a representative possibility of what could happen if there were a severe accident in Inyo County.

In this section, we calculate the dose to individuals (in rem) and to the population (in person-rem) due to a severe accident involving a nuclear transportation truck cask, and the expected latent cancer fatalities. Rem is once again used as the unit of measurement to determine the amount of damage to human tissue from a dose of ionizing radiation. In a "severe accident", the cask is breached open upon impact or a long-duration fire, and radionuclides are released to the environment.

In addition to RISKIND, the computer program HotSpot[3] was used to obtain contaminant plumes for later inclusion onto a map. Besides calculating an incident-free dose (see above), RISKIND is also designed to provide risks and consequences of spent fuel shipping accidents. HotSpot was developed at Lawrence Livermore and is used to estimate levels of radioactive contamination following an accident. Both use standard Gaussian plume dispersion equations to estimate airborne concentrations and ground deposition of radionuclides.

We calculate the dose for individuals living at different distances downwind from the accident in the centerline of the contamination plume, and for the population living within the contamination plume with HotSpot. The dose calculation for individuals was carried out exclusively with RISKIND. Also, we used RISKIND to calculate the released radionuclides that served as an input for HotSpot for the population dose calculation.

The population dose was calculated by superimposing acute-dose-isopleths onto a map. With the average dose (rem) between two isopleths, and the respective population density (persons/km^2) and area (km^2), we calculated the population dose in person-rem. Rem is a unit used in radiation protection to measure the amount of damage to human tissue from a dose of ionizing radiation. Population densities and areas were taken from the U.S. Census 2000. Areas and population densities between plumes were calculated using the plume maps.

HotSpot provides estimates of ground deposition and acute dose only. However, because acute and long-term dose are directly proportional, we used correlation factors derived from RISKIND to multiply by the acute population dose in order to obtain the long-term population dose. The methodology of arriving at population dose estimates utilizes the fact that long-term dose estimates are directly proportional to acute dose estimates.

[3] "Hotspot Health Physics Code, Version 1.06." Lawrence Livermore National Laboratory. Steven G. Homann, contact.

Estimating a long-term dose estimate then simply becomes an exercise in finding the correct multiplier.

Also using the contamination plumes developed in HotSpot, we were able to make an estimate of the cleanup, decontamination, and relocation costs associated with the spent fuel shipping accidents hypothesized in this study. In order to do this the dollar/area costs estimated by Chanin and Murfin[4] are multiplied by the area of contamination for each of the three contamination areas: light, moderate, and heavy.

Non-Radiological Risk

There will be an increase in truck traffic on the study roads due to the nuclear waste shipment campaign. This will lead to an increase in non-radiological (non-release) risks associated with the spent nuclear fuel and high-level waste shipments. The RADTRAN 5 program is once again used to calculate the expected number of fatalities to occupational and non-occupational individuals resulting from the shipping campaign. We also calculate the expected latent fatalities due to vehicle emissions for each of the shipping routes through Inyo County.

4. Assumptions and Parameters

Description of Routes

There are three variations on the routes through Inyo County: Route 1, Route 2, and Route 3 (Figure 1). The radiological and non-radiological risks are compared between the three routes. For the purpose of this study the routes are divided into segments. Each route contains the first segment (1 – CA 127) that extends from Interstate 15 in Baker to Shoshone. From this point the routes take different segments to reach Highway 95 in Nevada.

Route 1 (Segments 1 & 2): Highway 127 is the first route, extending from Interstate 15 at Baker, CA to Shoshone, CA (Segment 1). The route continues on CA 127 to the Nevada state border where it becomes NV 373 until it reaches Highway 95 (Segment 2). This is the most direct route from Interstate 15 to Yucca Mountain measuring 173.35 km in length.

Route 2 (Segments 1 & 3): The second route also begins in Baker, CA and travels north on CA 127 to Shoshone, CA (Segment 1). Approximately 27 miles north of Shoshone is Death Valley Junction. This area has been identified as a flood-prone area. If flooding conditions occur here, shipments would be prevented from traveling north on CA 127 to Yucca Mountain. Instead, the shipments would turn east on CA 178 to the Nevada

[4] Chanin, DI and WB Murfin, 1996.

border, travel through the city of Pahrump on NV 372 to NV 160, until they reach Highway 95 (Segment 3). The total distance traveled on Route 2 is 178.95 km.

Route 3 (Segments 1 & 4): The final alternative, like the others, begins by traveling north on CA 127 from Baker, CA to Shoshone, CA (Segment 1). Conditions that prevent trucks from entering Nevada on CA 127, such as flooding, would cause shipments to leave the highway and travel north on CA 190. This route passes through Death Valley National Park and would eventually lead to Highway 95 in Beatty on NV 374 (Segment 3). The total distance traveled is 254.15 km, making it the longest of the study routes.

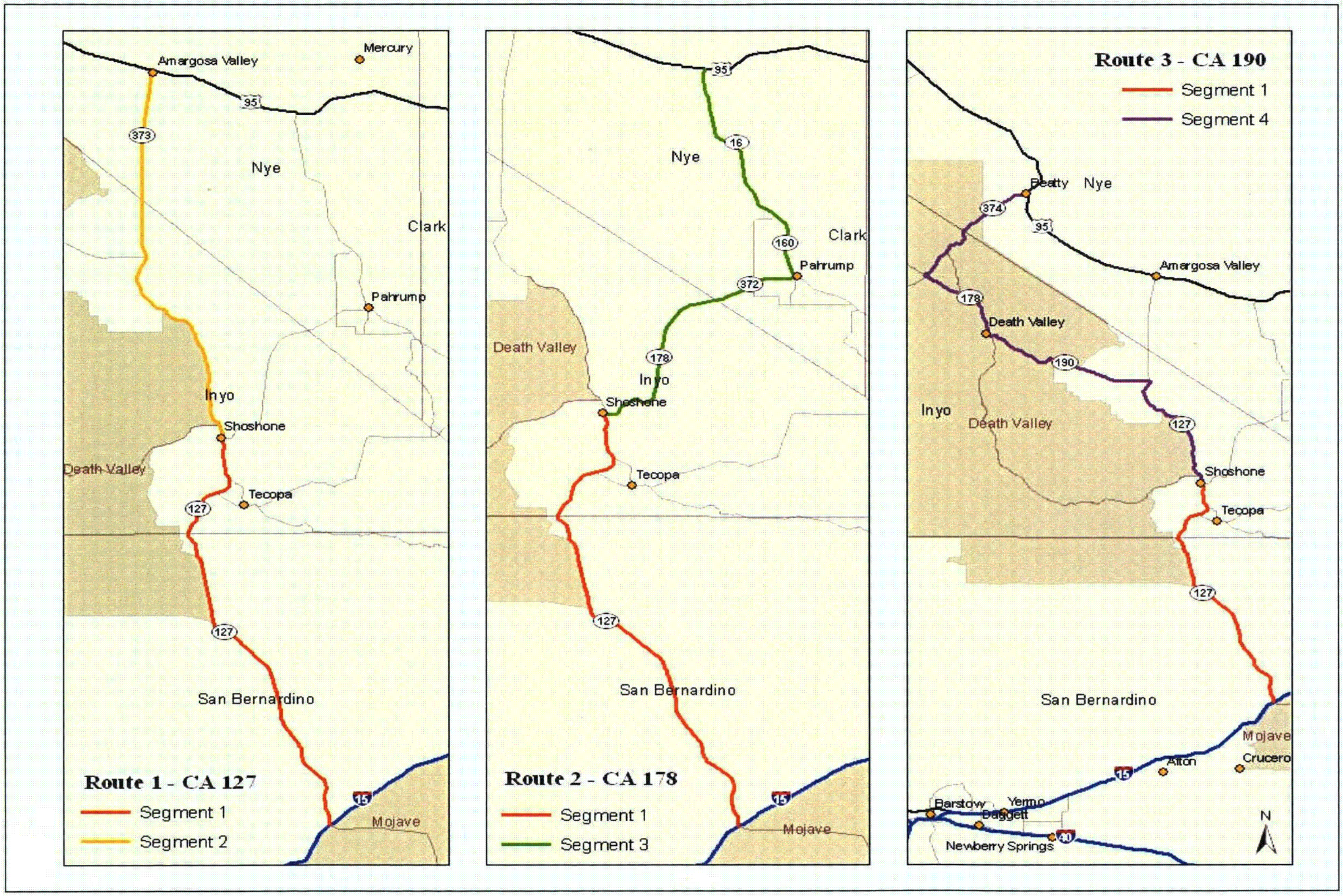

Figure 1. Three shipment variations through Inyo County, California

Incident-Free Analysis

Risk to Population and the Maximally Exposed Individual

The RISKIND computer program is used to calculate the incident-free dose to the MEI and to the population. The inputs used in RISKIND are shown in Table 1. It is assumed that the radiation from the shipment containers is at the regulatory limits, 10 mrem/hour at 6 ft from the cask body. The program has to be run separately to calculate the dose to the MEI in rem/y and total rem, and to the population in person-rem/y, and total person-rem for both truck scenarios. The rem unit of measurement incorporates the health risks from radiation.

Table 1. Input parameters used for RISKIND for incident-free transport

Variable	Value	Comments
Distance from shipping route	4.57 to 800 meters	Exposure at distances greater than 800 meters is not significant
Corridor resident population density (persons/km^2)	*Segment 1* Rural: 3 Suburban: 246.1 *Segment 2* Rural: 3.3 *Segment 3* Rural: 4 Suburban: 287.2 *Segment 4* Rural: 3	Based on a corridor length and corridor population from US Census (WebTRAGIS files) Segments are shown in Figure 1
Distance traveled (km)	*Segment 1* Rural: 90.28 Suburban: 0.97 *Segment 2* Rural: 82.1 *Segment 3* Rural: 74.2 Suburban: 13.5 *Segment 4* Rural: 162.9	WebTRAGIS Segments are shown in Figure 1
Fraction of population indoors	0	Used to obtain upper-bound, no-shielding estimate
1-way traffic density (vehicles/hour)	*Segment 1* Rural: 41.2 Suburban: 54.9 *Segment 2* Rural: 42 *Segment 3* Rural: 48.6 Suburban: 75.2 *Segment 4* Rural: 60.7	Based on 17-hour day, average of traffic density on study roads in both directions Average Annual Daily Traffic (AADT) was available in 2000 – 2004 for CA study roads and 1995 – 2004 for NV study roads Segments are shown in Figure 1
People per vehicle	2	
Number of stops	0	
Average truck speed (mph)	MEI: 35 (56.3 km/h) Population: 45 (72.4 km/h)	Posted speed through Shoshone Average truck speed on study roads
# lanes 1-way	2	
Lane width	3.7 meters	Assumption

Expected Number of Shipments

The Final Environmental Impact Statement (FEIS) estimates that under the Proposed Action for the mostly-truck scenario a total of 53,086 waste shipments would be made to Yucca Mountain, which calls for shipments of 70,000 metric tons of heavy metal (MTHM) including 63,000 MTHM of commercial spent nuclear fuel (CSNF) to the facility from 2010 through 2033. If the expansion of Yucca Mountain (known as Modules I and II) is approved, the FEIS estimates that the number of shipments to increase to 108,844 between the years 2010 and 2048.

It should be noted that the estimates used in this study are the minimal number of shipments that will be necessary to transport all of the SNF from reactor sites. The nation's inventory of CSNF is expected to exceed the 63,000 MTHM estimate used for this analysis. Many of the nuclear reactors have already applied for license renewals and others intend on doing so. License renewals are for an additional 20-year operational period. These renewals would increase the total amount of CSNF, increasing the number of shipments needed, and thus increasing the expected dose.

A previous study estimated the total CSNF inventory that could be generated from existing nuclear power plants including the license renewals[5]. The study developed three scenarios: 1) no granting of any license renewals[6]; 2) granting of all license renewals from reactors expected to apply for renewal over the next six years, according to the NEI[7] and 3) granting of all license renewals. These estimates can be seen in Table 2. In addition, the federal government has generated high-level waste that is expected to lift the total requiring disposal at Yucca Mountain to 210,000 MTHM. Though Yucca Mountain, by law, can only accept 70,000 MTHM, this is a Congressionally-mandated limit and not the physical limit of the proposed Yucca Mountain repository. This legal limit can be changed by Congress.

Table 2. Commercial spent nuclear fuel inventory under three license renewal scenarios

	Spent Fuel Mass (MTHM)			
Scenario	**BWR Fuel**	**PWR Fuel**	**Sum**	**DOE Over Quota**
1: No renewals[8]	29,500	54,800	84,300	21,300
2: 46 renewals	33,482	65,571	99,052	33,052
3: All plants renewed	44,250	82,200	126,450	63,450

The most variable estimate in this study concerns the number of shipments expected to travel through Inyo County en route to Yucca Mountain. Estimates will vary depending

[5] Resnikoff and Lamb, 2001.
[6] Note: there have already been 6 license extensions granted, and 14 applications for renewals have been filed. Scenario 1 ignores these.
[7] Note: includes reactors already granted extensions as well as those that have already filed for renewal.
[8] US NRC, 1996.

on the expected number of truck vs. rail shipments, the number of shipments expected to take one route rather than another alternative, the number of reactor license renewals, etc. For this study, in order to calculate the exposure to individuals and the population from a shipping campaign of nuclear waste, each transportation scenario outlined in Task 2 is used (Table 3). Under the first two scenarios it is assumed that the shipments will use the Interstate Highway System and that none of the truck shipments will pass through Inyo County. Therefore this scenario will not be analyzed in this study. Under the Southern Alternative scenarios, all of the truck shipments pass through Inyo County. Finally, under the North – South routing scenario, 27,750 shipments will traverse Inyo County for the Proposed Action while Modules 1 and 2 calls for 55,112 shipments through the County (Table 3).

Table 3. Expected number of shipments through Inyo County

	N/S Alternative	Southern Alternative
Proposed Action	27,750	52,367
Modules I & II	55,112	105,985

The Maximally Exposed Individual (MEI)

The MEI is assumed to be located just north of Shoshone, CA, at a distance of 15 feet for every shipment. It is assumed that the MEI will be exposed to every passing shipment, as would be the case for a gas attendant at the nearby gas station (Figure 2). Four separate calculations were performed, to consider a person for both shipping scenarios, both indoors and outdoors. For passing shipments, it is assumed that the trucks will travel at 35 mph near the intersection. The speed of trucks passing will vary, however this value is considered the likely speed and will therefore be used for the dose calculations.

Figure 2. Gas station near Shoshone, California

Population and Population Density

Only persons living within 800 meters of the proposed shipment routes were considered in this calculation. We obtain the population density for each route by dividing the corridor population by the route length.

In addition to the corridor population, we include the "on-link" population of motorists. An estimate of the "on link" population (average number of people in the street that is exposed to radiation from transportation casks) is made based on traffic figures given by CALTRANS, Nevada DOT, and by park visitation numbers from the National Park Service. Traffic counts are available between 1995 and 2004 for study roads in Nevada and between 2000 and 2004 for study roads in California. The estimates of annual average daily traffic (AADT) are given in Table 1. Although these numbers represent daily averages for the entire year, we would expect to see more vehicles on the road during the peak tourist months of the summer. According to the National Park Service, 764,820 people visited Death Valley National Park in 2004. The total visitor population is separated by the eight entrances to the park. The numbers of visitors entering Death Valley National Park on Inyo County study roads are included in the "on-link" population.

Accident Analysis

Collective Accident Risk

The dose risk from six accident severity categories is estimated using the RADTRAN program. The analysis calculates unit risk factors for a shipment for each accident severity category. The program uses the study-road specific accident rates and population densities. Populations, according to the 2000 census, within 800 meters of the study roads were used to determine the population density. The unit risk factors are calculated for one person per square kilometer per kilometer of route traveled. These numbers are then multiplied by the appropriate population densities for each route and number of kilometers traveled. Table 4 shows the parameters that were used as inputs to RADTRAN 5. For parameters that we did not specify here, RADTRAN default values are used.

Note: The accident probability fractions in Table 4 and other numbers throughout this report are expressed in scientific notation. Scientific notation is a shorter method to express very small or very large numbers and is based on powers of the base number 10. For example, the accident probability fraction for a Category 3 severity is 0.00382, which can also be expressed as $3.82 * 10^3$ or as expressed throughout this report, 3.82E-03.

Table 4. Input parameters used for RADTRAN for collective accident risk

Variable	Value	Comments
Cask Dimensions (m)	Length: 4.4 Radius: 0.508	YM FEIS
Truck Size (m)	Length: 21	YM FEIS
Crew	Size: 2 Distance: 6 m View: 1.16 m	YM FEIS
Radionuclides (Ci) present in truck cask	480 H-3; 2.64 C-14; 0.022 Cl-36; 4,400 Kr-85; 176 Cs-134; 1.08 Cs-135; 136,000 Cs-137; 880 Co-60; 7,600 Pu-238; 720 Pu-239; 1,120 Pu-240; 96,000 Pu-241; 4 Pu-242; 13.6 Fe-55; 5.2 Ni-59; 760 Ni-63; 92,000 Sr-90; 2.4 Nb-94; 29.2 Tc-99; 0.032 U-235; 0.56 U-236; 0.56 U-238; 2.6 U-234; 0.000124 U-233; 0.084 U-232; 0.96 Np-237; 6,400 Am-241; 44 Am-242M; 56 Am-243; 36.4 Cm-242; 38.8 Cm-243; 3,600 Cm-244; 0.84 Cm-245; 0.188 Cm-246; 4.8 Zr-93; 0.264 Pd-107; 44 Cd-113M; 520 Pm-147; 760 Sm-151; 3,840 Eu-154; 640 Eu-155; 0.0000292 Ac-227; 0.00056 Th-230; 0.000064 Pa-231; 0.132 Ru-106; 0.072 I-129	YM FEIS
Corridor resident population density (persons/km^2)	*See Table 1*	Based on a corridor length and corridor population from US Census (WebTRAGIS files)
Distance traveled (km)	*See Table 1*	WebTRAGIS
1-way traffic density (vehicles/hour)	*See Table 1*	Based on 17-hour day, average of traffic density on study roads in both directions AADT was available in 2000 – 2004 for CA study roads and 1995 – 2004 for NV study roads
People per vehicle	2	
Accident rate (accidents/veh-km)	Segment 1 Rural: 7.43E-07 Suburban: 7.43E-07 Segment 2 Rural: 4.88E-07 Segment 3 Rural: 4.48E-07 Suburban: 1.08E-06 Segment 4 Rural: 4.35E-07	Accident rates obtained from CALTRANS and Nevada DOT Segments are shown in Figure 1
Deposition Velocity	1 cm/sec	
Number of stops	1	Assumed stop for 20 minutes for refueling
Average truck speed (mph)	Rural: 45 (72.4 km/h) Suburban: 25 (40.2 km/h)	Average truck speed on study roads
Accident Probability Fraction	Category 1: 9.94E-01 Category 2: 4.05E-05 Category 3: 3.82E-03 Category 4: 1.80E-03 Category 5: 1.55E-05 Category 6: 9.84E-06	YM FEIS

The following sections discuss the assumptions that were made in this study to perform an accident analysis. These estimates were used to determine the collective accident risk as well as the radiological release from a Category 5 accident.

Spent Fuel Release Fraction Estimates

Below is a more detailed discussion of the various estimates made in determining the release fraction. The release fraction refers to the fraction of the nuclide inventory that is rapidly released.

The question of how much radioactivity may be released in an accident of a given severity is a contentious one. Currently, there are no plans to physically test to destruction the transportation casks likely to be used for the transcontinental spent fuel shipping campaign to the proposed facility at Yucca Mountain. Instead, several studies have been conducted by the Nuclear Regulatory Commission (NRC) or its contractors to estimate cask response to accident conditions using computer modeling. Different studies have focused on different criteria for correlating accident severity with cask damage. For example, one NRC-contracted research team correlated cask damage due to impact with strain to the inner cask wall[9], while a more recent study by Sandia National Laboratory primarily focused on the bolts and seal in the lid region of the cask.[10] For cask damage caused by heat, the temperature is measured at the midpoint of the lead shield. The newer generation casks use depleted uranium, rather than lead, as a gamma shield. For this study, we have elected to use the cask response estimates derived by the Modal Study with certain modifications to account for information obtained since its publication. The Sandia study, referred to as NUREG/CR-6672, was not used in this report for reasons discussed below, even though the focus on the bolts is considered an improvement over the Modal Study.

The more recent NRC-sanctioned cask response study, NUREG/CR-6672, contains certain flaws which result in a non-conservative estimation of container response to severe stresses. In its peer review of NUREG/CR-6672, Lawrence Livermore National Laboratory (LLNL), the researchers for the Modal Study, have raised valid criticisms regarding the modeling of the bolt and seal area of the lid which are critical to the size opening during an accident and the amount of radioactivity released. In particular, when predicting strain on the seal regions and the bolts, NUREG/CR-6672 did not explicitly model the grooved region between the cask lid and the lid well. Rather, it estimated the deformation "at a location near where the O-rings would be located."[11] Further, the modeling assumed "that the cask wall and lid are much stiffer than the closure bolts, and the opening displacements are the result of displacement discontinuities between the cask body and lid, and are not greatly affected by bolt clamping force."[12] We agree with LLNL that the model of the bolt region is overconstrained and underpredicts the size of the potential opening under stress. Underpredicting the size of the cask-to-environment leak opening has cascading effects on the estimation of releases in the event of an

[9] Fischer et al, 1987. Referred to as "The Modal Study" in this report.
[10] Sprung et al, 2000.
[11] Sprung et al, 2000. pg. 5-11
[12] *ibid.*

accident. The Modal Study release estimates were therefore used, with important modifications to account for information obtained since its publication (Table 5). These modifications are discussed below, according to the three barriers that must be breached for a radioactive release to the environment to occur.

Table 5. Postulated accident release fractions

Severity Category	Inert Gas	Iodine	Cesium	Ruthenium	Particulates	CRUD
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-01
2	9.90E-03	7.50E-05	1.98E-04	8.10E-07	6.00E-08	1.50E-01
3	3.30E-02	2.50E-04	6.60E-04	2.70E-06	2.00E-07	1.00E+00
4	3.30E-01	2.50E-03	6.60E-03	2.70E-05	2.00E-06	7.17E-01
5	3.90E-01	4.30E-03	6.60E-03	4.80E-05	2.00E-06	1.00E+00
6	6.30E-01	4.30E-02	6.60E-02	4.80E-04	2.00E-05	8.94E-01

Fuel Inventory

We use the assumptions made by DOE in the FEIS for the proposed Yucca Mountain Facility[13]. The total radionuclide activity for an average pressurized-water reactor (PWR) fuel assembly is listed in Table 4.

The FEIS assumes that fuel from a PWR is shipped in GA-4 truck casks, which have a radius of 0.508 m and a length of 4.4 m. There are 4 assemblies of 424 kg each of uranium per cask. The average age of the spent fuel is 15 years, with an assumed burnup of 50,000 MWD/MTU. Burnup refers to the amount of energy produced per kg of fuel.

Fuel Matrix

For a release of radioactive materials from a cask to take place, three barriers must be breached - fuel matrix, rod cladding, and cask. The fuel matrix contains the fissionable material and is surrounded by the rod cladding, which serves to confine and protect the fuel. This combined structure is further contained within a cask. When fuel is heated in reactors, a percentage of volatile radionuclides, such as cesium, will migrate out of the fuel matrix under the influence of temperature gradients and concentrate in the fuel-clad gap, the space between the fuel pellet and the surrounding tube (see PNL-10540, 1995. Gray and Wilson, *Spent Fuel Dissolution Studies, FY1994 to 1994*. Pacific Northwest Laboratories, p vi.). This "gap cesium" inventory is directly related to the release fraction in the event of an accident because it can be released in the event of any cladding breach. Almost all of the cesium released in the event of a spent fuel shipping accident will be this "gap cesium." For the fuel matrix, the Modal Study assumes 0.3% of the cask inventory of cesium will be present between the cladding and the fuel pellet. However, we believe that the estimate made by Gray *et al* (9.9% gap cesium inventory) is on more solid experimental ground. Assuming the cesium release fraction is directly

[13] USDOE, 2002.

proportional to the gap inventory, we intend to increase the release fraction posted in the Modal Study by a factor of 33. For particulates and gases, other release fractions apply, as discussed below.

In addition, the Modal Study does not adequately consider CRUD spallation, or fragmentation, in the event of an accident. CRUD resides on the external surfaces of fuel assemblies and it is more easily dislodged and dispersed in a severe accident. We will assume an independent estimate for this source term, using the average CRUD surface density given for PWR reactors in the RISKIND User's Manual.

Cask Opening

The Modal Study assumes all material within the cavity is released if a leak path exists, and it further assumes a leak path exists for any accident with maximum strain greater than 0.2%. According to the Modal Study, Category 5 accidents produce greater than a 2% strain on the cask inner wall. The Modal Study estimated that a 2% strain on the cask inner wall could occur in an end-on impact with an unyielding target at a velocity of 46 mph. For a truck cask, a 30% strain on the cask inner wall could occur in an end-on impact with an unyielding target at a velocity of 76 mph (Modal Study, p. 7-5). A 2% strain assuming a side impact with a train sill (or similar immovable object such as a bridge abutment or rock wall) could occur at a speed of 20 mph. In our opinion, these accident speeds are plausible at the chosen accident locations.

Rod Cladding Breach

Rod cladding surrounds the fuel matrix and serves to confine and protect the fuel from being released. A breach of the cladding will cause a release of harmful radiation to the atmosphere. This could be caused by an impact or internal rod pressure due to high temperature.

The Modal Study assumes the rods are most susceptible to breach in an end-on impact (p. 8-7). Fig. 8-3 of that study shows that 3% break occurs in an impact resulting in 0.2% strain (at an acceleration < 40g), 10% break in an impact resulting in 2% strain (40-100g), and 100% break in an impact resulting in 30% strain, >100g. However, other studies (in particular, the one relied on by Holtec in its SAR for the HI-STAR 100 cask)[14] show that a sideways impact greater than 63g is sufficient to shatter the cladding. All impact accidents we consider here have a deceleration greater than 63g, so we assume 100% of the cladding is shattered by impact.

A breaching of the cladding can also occur in a severe accident involving a fire. The cask and its spent fuel contents may absorb heat from the fire causing an increase of the fuel rod cladding. This condition is known as thermal creep. This effect coupled with pressures generated within the rods can cause a breaching of the cladding (Modal Study, p. 8-10).

[14] Chun, Witte and Schwartz, 1987.

Radiological Release from Severe Accident

To estimate the release fractions to be used in this study, we take the results from the Modal Study accidents corresponding to severity Category 5 as used in the Yucca Mountain FEIS, correcting for the additional cesium believed to be in the fuel-cladding gap. The release fractions for a Category 5 accident are listed in Table 5.

Although the population densities are similar in Shoshone to that of its rural surroundings, we differentiate between the two. In Figures 8 – 10, the blue outlined area encloses the town boundary of Shoshone. Using population data from the 2000 US Census, we arrive at a population density in Shoshone of 0.7 people per km^2 (Table 6). The city of Bishop and its surroundings contain nearly 63% of Inyo County's population (11,290 people). Therefore, if we exclude the population of Shoshone and the Bishop region, we get a more accurate population density for the area surrounding Shoshone in Inyo County. The population density of Inyo County, excluding Shoshone and the Bishop region, is 0.254 people per km^2.

Table 6. Population density of Shoshone, CA

Region	Pop.2000	Area (km^2)	Dens.2000 (p/km^2)
Inyo County	17,945	26,262.48	0.683
Shoshone	52	74.4	0.7
Bishop Region	11,290	171.82	65.7
Inyo Co. excl. Shoshone and Bishop Region	6,603	26,016.26	0.254

Table 7 shows the parameters that were used as inputs for RISKIND and HotSpot to determine the radiological release from an accident occurring in the town of Shoshone, CA. The specific location chosen for the accident was near the gas station located on CA 127 just north of the CA 127 and CA 178 intersection. Most values were taken from the Yucca Mountain FEIS, Chapter 6 and Appendices A and J and are explained in the following sections. Metrological conditions were taken from the nearest stations with historical records. For parameters that we did not specify here, we used default values.

Table 7. Inputs into RISKIND and HotSpot

Parameter	Value	Comments
RISKIND:		
Acute exposure	24 h	Estimated evacuation time
Long-term exposure	1 and 50 y	Exposure range
Shielding	none	Default
Cask dimensions	length 4.4 m radius 0.508 m	YM FEIS
Burnup	50,000 MWD/MTU	YM FEIS
Cooling time	15 y	YM FEIS
Total uranium in cask	1.696 MT	YM FEIS; 4 assemblies of 424 kg
Cask cavity surface area	39 m2	Default
Crud surface activity	140 micCi/m2	From YM FEIS
Mixing height	400-1600 m	Default
Temperature	283 K	Default
Anemometer height	10 m	Default
Rainfall	none	Default
Release height	1 m	Default
Release fractions:		
Particulates	0.000002	Modal Study
Ru	0.000048	Modal Study
Cs	0.0066	Value form Mod.St., multiplied by 33
I	0.0043	Modal Study
Gas	0.39	Modal Study
Heat release	500 ca/s	Default for accident without heavy fire
Parameter	**Value**	**Comments**
HotSpot:		
Dispersion model	General plume	
Released radionuclides (Ci)	0.016 H-3; 0.0024 Fe-55; 7.82 Co-60; 0.017 Ni-63; 2,780 Kr-85; 2.5 Sr-90; 2.5 Y-90; 0.016 Sb-125; 0.004 Te-125M; 21.8 Cs-134; 1,210 Cs-137; 3.48 Ba-137M; 0.081 Pm-147; 0.017 Sm-151; 0.18 Eu-154; 0.05 Eu-155; 0.22 Pu-238; 0.015 Pu-239; 0.025 Pu-240; 2.68 Pu-241; 0.1 Am-241; 0.15 Cm-244	Output from RISKIND
Deposition velocity	1 cm/s	Output from RISKIND
Wind speed	2.9 m/s	Average wind speed
Wind direction	NW	Dominant direction 1984 – 1992
Stability class	D	Most frequent stability class

Economic Consequences of Decontamination and Cleanup

As has been previously discussed, many of the latent effects of such accidents could be prevented with proper evacuation and decontamination. There is, however, an enormous monetary expense associated with this proper decontamination.

Previous estimates of the duration of decontamination following a plutonium dispersal accident were made by Chanin and Murfin[15]. Their study estimated the activities likely to be involved in the decontamination of an accident involving the dispersal of plutonium. Although the radioactive material they studied is different than the spent fuel accidents discussed in this study, the methodology and conclusions used by Chanin and Murfin to estimate decontamination costs are directly useful. For example, their study estimates the cost of decontamination as a function of the level of cleanup required to achieve an acceptable level. The cleanup level is assigned a decontamination factor (DF) of 1, meaning that no cleanup is needed to meet the criteria. Areas contaminated to up to 5 times the cleanup level are considered to be lightly contaminated, areas with levels between 5 and 10 times the cleanup level are considered to be moderately contaminated, and areas exceeding 10 times the cleanup level are considered to be heavily contaminated. For each level (light, moderate, heavy), certain cleanup assumptions are made and a cost is estimated for both rural and urban environments. Further, the costs associated with cleanup assumed in the Chanin and Murfin study are relatively non-specific with respect to the type of contamination. For example, they estimate the cost involved with scrubbing sidewalks and buildings in order to remove contamination, which would occur in the aftermath of a spent fuel accident involving the release of radioactive particulates. Therefore, we use these criteria to estimate cleanup costs. In addition, we use the estimates made by Chanin and Murfin with regard to the duration of decontamination, applying the contaminated areas estimated here to their values.

In order to estimate the extent of contamination and the required cleanup, an estimate of the acceptable cleanup level is required. While the actual cleanup criteria adopted after a severe accident may ultimately be dictated by local concerns, Price-Anderson insurance and Congressional activity, the Environmental Protection Agency's (EPA) protective action guide (PAG), states that relocation is warranted when the first year dose will exceed 2 rem. Any yearly dose after the first year should not exceed 0.5 rem, and a cumulative total of 5 rem is set as the limit for a 50-year exposure period. The study by Chanin and Murfin estimated that it would cost \$394 million per square kilometer to remediate a heavily contaminated area (greater than 10 times the cleanup criteria), \$182 million per km^2 to remediate a moderately contaminated area (between 5 and 10 times the cleanup criteria), and \$128 million per km^2 to remediate a lightly contaminated area (between 1 and 5 times the cleanup criteria).

It is important to note that the Chanin and Murfin cost estimates are based on assumed urban land use characteristics and population density. However, many of the costs

[15] Chanin, DI and WB Murfin, 1996.

associated with decontamination are "fixed," not influenced by population density. For example, demolition and restoration costs are relatively independent of population density, as are decontamination costs for streets and sidewalks. Using the EPA's PAG and the cost estimates made in the Chanin and Murfin study, we estimate the cleanup cost following the hypothetical accident.

Non-Radiological Risks

Refer to the *Collective Accident Risk Section* (Page 12) for RADTRAN 5 inputs used to determine the non-radiological risks associated with the shipping campaign through Inyo County.

In determining the latent fatalities from exposure to vehicle exhaust, we use the Yucca Mountain FEIS. The FEIS predicts three latent fatalities for every 10 billion kilometers traveled in rural areas, like that of Inyo County. Using this estimate, we predict the number of expected latent fatalities for each study route by multiplying the segment length (Table 1) by twice the number of shipments (round trip). These numbers represent the expected latent fatalities over the entire shipping campaign to the population living near the study roads.

5. Baseline Risk Estimate Results

Incident-Free Analysis

Incident-Free Dose to the Maximally Exposed Individual (MEI)

RISKIND calculates the incident-free dose per truck. We therefore multiply this dose with 52,367 – 105,985 for the Southern Alternative Route and by 27,750 – 55,112 for the North – South Route to obtain the total dose in mrem, and divide this dose by 24 and 39 y to calculate the annual dose in mrem/y for the "Proposed Action" and "Modules I&II" alternatives, respectively. The annual and lifetime dose of the MEI for both transportation scenarios can be seen in Table 8.

Table 8. Dose to the Maximally Exposed Individual (MEI) from incident-free transportation (mrem)

Dose	Scenario	Dose (mrem)			
		Southern Alternative		*North – South Routing*	
		15 ft, outdoors	15 ft, indoors	15 ft, outdoors	15 ft, indoors
Yearly Dose	Proposed Action	1.72	0.70	0.91	0.37
	Modules I&II	2.15	0.87	1.12	0.45
Lifetime Dose	Proposed Action	41.37	16.76	21.92	8.88
	Modules I&II	83.73	33.92	43.54	17.64

Incident-Free Dose to Population

The incident-free dose to the population from the Southern Alternative truck scenario is given in Table 9 and the North – South routing scenario in Table 10. The doses are broken down into categories of persons: residents (off-link) and those sharing the roadway with the shipment (on-link). Unlike the dose to the MEI, which describes a worst-case scenario for a single person, the population dose is the expected average dose that is received by the population along the transportation corridor. This is the reason why the annual population dose is less than the annual dose to the MEI. In addition to the dose in person-rem, we also calculate the number of expected latent cancer fatalities (LCF) due to such a radiation dose.

Table 9. Incident-free dose rate to the population for the Southern Alternative scenario

Receptors	Annual dose (person-rem/y)			Total dose (person-rem)		
	Route 1	Route 2	Route 3	Route 1	Route 2	Route 3
			Proposed Action Scenario			
Off-link residents	0.0158	0.0948	0.0202	0.3786	2.2764	0.4844
On-Link	0.0063	0.0064	0.0064	0.1505	0.1525	0.1531
Total dose	0.0221	0.1012	0.0264	0.5291	2.4289	0.6375
Expected LCF	2.21E-05	1.01E-04	2.64E-05	5.29E-04	2.43E-03	6.38E-04
			Modules I and II scenario			
Off-link residents	0.0196	0.1181	0.0251	0.7663	4.6072	0.9804
On-Link	0.0078	0.0079	0.0079	0.3045	0.3087	0.3098
Total dose	0.0274	0.1260	0.0329	1.0708	4.9159	1.2902
Expected LCF	2.74E-05	1.26E-04	3.29E-05	1.07E-03	4.92E-03	1.29E-03

Table 10. Incident-free dose rate to the population for the North – South routing scenario

Receptors	Annual dose (person-rem/y)			Total dose (person-rem)		
	Route 1	Route 2	Route 3	Route 1	Route 2	Route 3
			Proposed Action Scenario			
Off-link residents	0.0084	0.0503	0.0107	0.2006	1.2063	0.2567
On-Link	0.0033	0.0034	0.0034	0.0797	0.0808	0.0811
Total dose	0.0117	0.0537	0.0141	0.2803	1.2871	0.3378
Expected LCF	1.17E-05	5.37E-05	1.41E-05	2.80E-04	1.29E-03	3.38E-04
			Modules I and II scenario			
Off-link residents	0.0102	0.0614	0.0131	0.3985	2.3957	0.5098
On-Link	0.0041	0.0041	0.0041	0.1584	0.1605	0.1611
Total dose	0.0143	0.0655	0.0172	0.5569	2.5562	0.6709
Expected LCF	1.43E-05	6.55E-05	1.72E-05	5.57E-04	2.56E-03	6.71E-04

Accident Analysis

Collective Routine Risk

There will be an increase in the number of accidents along study roads during the shipping campaign attributable to the increased truck traffic. This involves trucks transporting loaded casks to the repository as well as returning shipments of empty casks. The number of accidents expected on the three study routes under the Southern Alternative shipping scenario is shown in Table 11. The expected numbers of accidents under the North – South routing scenario are listed in Table 12. These two tables divide doses by route but also by accident severity. RADTRAN, like RISKIND calculates the number of expected accidents and fatalities from accidents per truck. We therefore multiply this number with 52,367 – 105,985 for the Southern Alternative Route and by 27,750 – 55,112 for the North – South Route.

Table 11. Number of expected accidents for the Southern Alternative scenario

	Southern Alternative					
	Proposed Action Scenario			*Modules I and II Scenario*		
Severity Category	**Route 1**	**Route 2**	**Route 3**	**Route 1**	**Route 2**	**Route 3**
1	1.12E+01	1.20E+01	1.44E+01	2.27E+01	2.44E+01	2.91E+01
2	4.57E-04	4.90E-04	5.87E-04	9.24E-04	9.92E-04	1.19E-03
3	4.32E-02	4.62E-02	5.55E-02	8.73E-02	9.36E-02	1.12E-01
4	2.04E-02	2.18E-02	2.61E-02	4.12E-02	4.42E-02	5.29E-02
5	1.75E-04	1.88E-04	2.25E-04	3.55E-04	3.80E-04	4.56E-04
6	1.11E-04	1.19E-04	1.42E-04	2.25E-04	2.41E-04	2.88E-04

Table 12. Number of expected accidents for the North – South routing scenario

	North – South Routing					
	Proposed Action Scenario			*Modules I and II Scenario*		
Severity Category	**Route 1**	**Route 2**	**Route 3**	**Route 1**	**Route 2**	**Route 3**
1	5.94E+00	6.38E+00	7.63E+00	1.18E+01	1.27E+01	1.52E+01
2	2.41E-04	2.60E-04	3.11E-04	4.81E-04	5.16E-04	6.17E-04
3	2.29E-02	2.45E-02	2.94E-02	4.54E-02	4.87E-02	5.84E-02
4	1.08E-02	1.16E-02	1.38E-02	2.14E-02	2.30E-02	2.75E-02
5	9.30E-05	9.96E-05	1.19E-04	1.85E-04	1.98E-04	2.37E-04
6	5.88E-05	6.30E-05	7.55E-05	1.17E-04	1.25E-04	1.50E-04

The expected risk value of early fatality and morbidity due to the shipment of nuclear waste on the study roads is also calculated using the RADTRAN software. One again we multiply this number with 52,367 – 105,985 for the Southern Alternative Route and by 27,750 – 55,112 for the North – South Route.

Table 13. Expected fatality and morbidity risk for Southern and North – South Routing scenarios

	Southern Alternative					
	Proposed Action Scenario			*Modules I and II Scenario*		
	Route 1	**Route 2**	**Route 3**	**Route 1**	**Route 2**	**Route 3**
Fatality	1.72E-07	3.24E-06	4.10E-07	7.19E-07	6.55E-06	8.30E-07
Morbidity	8.17E-07	7.44E-06	9.43E-07	1.65E-06	1.50E-05	1.91E-06
	North – South Routing Alternative					
	Modules I and II scenario			*Modules I and II Scenario*		
	Route 1	**Route 2**	**Route 3**	**Route 1**	**Route 2**	**Route 3**
Fatality	1.88E-07	1.71E-06	2.17E-07	3.74E-07	3.41E-06	4.32E-07
Morbidity	4.33E-07	3.94E-06	5.00E-07	8.60E-07	7.83E-06	9.92E-07

RADTRAN calculates the expected values of population risk in person-rem for an individual truck. We therefore multiply this dose with 52,367 – 105,985 for the Southern Alternative Route and by 27,750 – 55,112 for the North – South Route to obtain the total dose in person-rem. The rem unit of measurement incorporates the health risks from radiation. The overall expected values of population risk were determined for each route through Inyo County and can be seen in Table 14.

Table 14. Expected values of population risk for both transportation scenarios (person-rem)

	Proposed Action Scenario			*Modules I and II Scenario*		
	Route 1	**Route 2**	**Route 3**	**Route 1**	**Route 2**	**Route 3**
Southern Alternative	24.30	220.99	28.07	49.18	447.26	56.81
North – South Routing	12.88	117.11	14.87	25.57	232.57	29.54

Accident Locations

Overall accident rates are expected to increase along the study roads due to increased truck traffic of spent nuclear fuel and high-level waste. The majority of these accidents will be non-release incidents, thus increasing the overall non-radiological risk. However, the next section outlines troublesome areas along the study routes traversing Inyo, San Bernardino, and Nye Counties that could potentially lead to a severe accident.

Keeping in mind that the chosen locations are intended to be representative, and that this study is in no way predicting the location of accidents, we investigate the following scenarios which can also be seen in Figure 6:

A. There are a series of curves along CA 127 that are thought to be potential accident areas. The major concern at these locations is severe curves that can cause "curve accidents". Accidents are likely to occur when high speeds and less attentive driving are involved. Due to the relatively remote nature of these locations, trucks can be expected to travel at fairly high speeds, giving the possibility of a severe impact scenario. The average speeds along this roadway are between 55 – 60 miles per hour. However, trucks can approach 70 miles per hour along the barren stretches of CA 127. The short distance and absence of dividers between the north- and southbound lanes creates the possibility for high-speed, head-on collisions. Listed blow are problematic areas along the study roads:

   - The first location is on CA 127 approximately 1.5 – 2 miles north of Shoshone near mile post 16. This area is known as 'The Milky Way' because milk trucks are frequently seen on the route (Figure 6). There is a series of curves along this stretch where a great deal of accidents involving larger trucks has occurred in the past. It is a major concern because the potential threat is to trucks traveling northbound, thus loaded with waste traveling to the Yucca Mountain facility. This area has also been flagged as a 'drop zone' for communication. Cell reception and other forms of communication are limited, thus increasing the response time for a severe accident.

   - There is a sharp curve located on CA 127 in Death Valley Junction. Once again, this area is a potential threat to loaded trucks traveling northbound. This curve is also located in close proximity to people living in the town as well as any tourist activity.

   - One other accident hotspot is located on CA 127 near Eagle Mountain. The exact location can be seen in the first map inset of Figure 6. This area contains two potentially dangerous curves that could lead to a severe accident.

B. There are several low-lying areas along CA 127 that have been designated by the Federal Emergency Management Agency (FEMA) as floodplain boundaries. The floodplain boundaries can be seen in Figure 6 as a gray-hatched area. These areas are prone to flooding or flash flooding which can cause washouts. In the past, flash flooding has caused road closures along CA 127 and CA 190 in Inyo County. One example of this is the town of Death Valley Junction which has been noted as an issue area. This type of natural hazard can leave truck shipments stranded, disrupt service, or in a worse case scenario cause a severe accident.

C. Steep grades along the transportation corridor can pose problems to heavy trucks carrying nuclear waste north to the Yucca Mountain facility. The combination of heavy trucks and severe highway downgrades could cause brake failures and lead to a potentially severe accident. Also, steep grades can pose problems to trucks returning from Yucca Mountain, traveling south on the study roads. A runaway truck, traveling at high speeds, could collide head-on with loaded trucks traveling northbound. Elevation profiles were created along the study roads to determine steep slopes (Figures 3 & 4). It is important to note that in these figures, a drastic, out-of-place spike in elevation is caused by mapping error. However, the larger spikes in elevation occurring over longer distances are representative of road conditions and are discussed in more detail.

- The elevation profile for CA 127 traveling north from Baker to Shoshone can be seen in Figure 3. From this we can see that after a severe rise in elevation from under 500 feet to over 2,000 feet in less than 10 miles, the road descends to nearly 1,250 feet in just a few miles. Also, the slope for trucks returning from Yucca Mountain, traveling south on CA 127 is severe between the 40 and 30 mile mark.

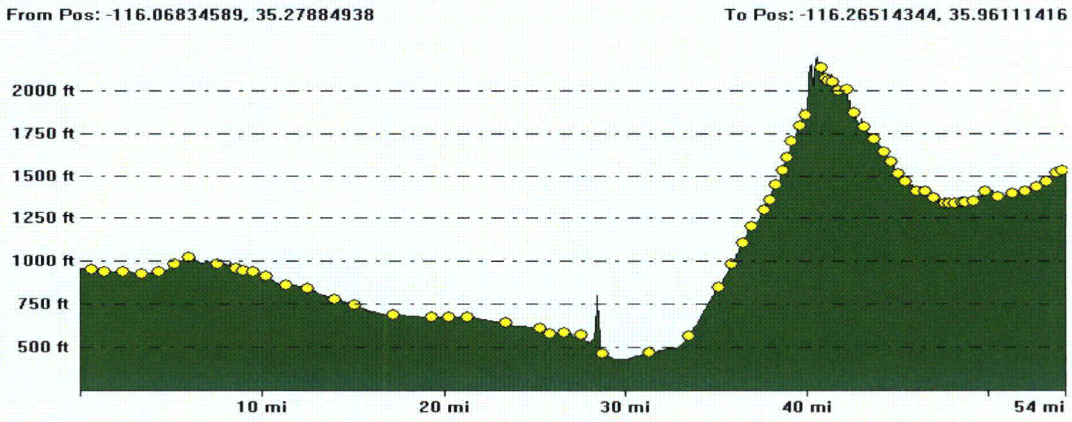

Figure 3. Path CA 127 traveling north from Baker to Shoshone

- A second profile can be seen in Figure 4 for CA 127 traveling south from Death Valley Junction to Shoshone. Once again, areas with steep grade (high slope) can pose a threat to trucks hauling nuclear waste. The areas of concern can be seen just before the 10 and 20 mile mark, and for the last 5 miles into Shoshone.

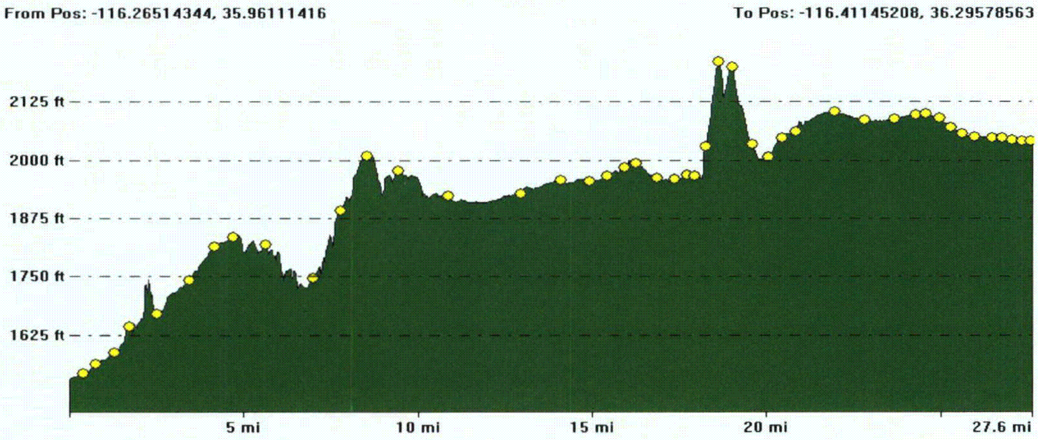

Figure 4. Path CA 127 traveling south from Death Valley Junction to Shoshone

D. Accident locations along the study routes between 1994 and 2005 were obtained from CALTRANS. The locations where accidents occurred were referenced to the study roads by mileage posts and be seen as blue circles in the third map inset of Figure 6. On this map, accidents are categorized by the number of individuals injured per accident. From this information areas with a high frequency of accidents were identified:

- The first example of this is on CA 127 in Inyo County, just north of the San Bernardino County border (Map Inset 3 – Figure 6). There have been numerous accidents recorded at this location.

- Another spot in Inyo County with a high accident rate is on CA 127 near the Nye County, Nevada border. This location has also been identified as a low-lying area within the FEMA designated flood boundary.

E. A long duration fire leading to the release of radioactive material is possible and could be caused by a collision with a truck hauling explosive material or a gas tanker. There have already been a large number of trucks identified on the transportation corridor. Some of these trucks contain hazardous materials including acids, caustics, and explosives. Also possible is an explosion at a gas station located adjacent to the corridor (Figure 2) or with a truck filled with gasoline.

F. There can be a considerable amount of large, slow moving recreational vehicles and trailer combinations on CA 127 near the Dumont Dunes off-road vehicle recreational area (Figure 5, Figure 6). There are two ways of accessing the dunes. The Little Dunes staging and camping area is directly off CA 127. One mile north of this point, just off CA 127, is Dumont Road, a dirt road that leads to the main field of large dunes. The average speeds along this roadway are between 55 – 60 miles per hour. As mentioned before, due to the relatively remote nature of this location, trucks can be expected to travel at fairly high speeds. The risk these slow moving vehicles pose to shipments may be significant.

Figure 5. Dumont Dunes off-road recreational area

G. To compare the first accident locations (A) with that of a more densely populated area along the study roads, an accident in the town of Pahrump, Nevada was chosen (Map Insert 4 – Figure 6). This accident scenario is relevant to Inyo County because the city is situated along the state border. Outer portions of the city are located within Inyo County, leaving the possibility for Pahrump to expand into the County even further. If such an accident were to occur in Pahrump, citizens of Inyo County would be impacted by the direct radioactive release as well as by individuals evacuating from the accident area and the need for an emergency response from California. A severe accident is possible at the interchange of NV 372 and NV 160 in Pahrump, Nevada. More specifically, the scenario will involve a truck traveling on NV 372 going onto NV 160.

H. Lastly, as further discussed in the *Conclusion* section, the threat of a sabotage or terrorist attack is credible. This event could occur at any point along the transportation routes, leading to a radioactive release.

The eight accident scenarios (A-H) described above can also be seen in Figure 6. The specific letters (A-H), representing the different scenarios, are placed in the exact locations where those conditions are present in the far left map of Figure 6. For example, the first map inset identifies a severe curve, labeled A, near Eagle Mountain on CA 127. Steep slopes can be seen in the second inset, labeled C. Accident frequency is labeled as D in the third inset, with blue circles representing where accidents have occurred on CA 127 in the past. Finally, the densely populated city of Pahrump can be seen in the last inset.

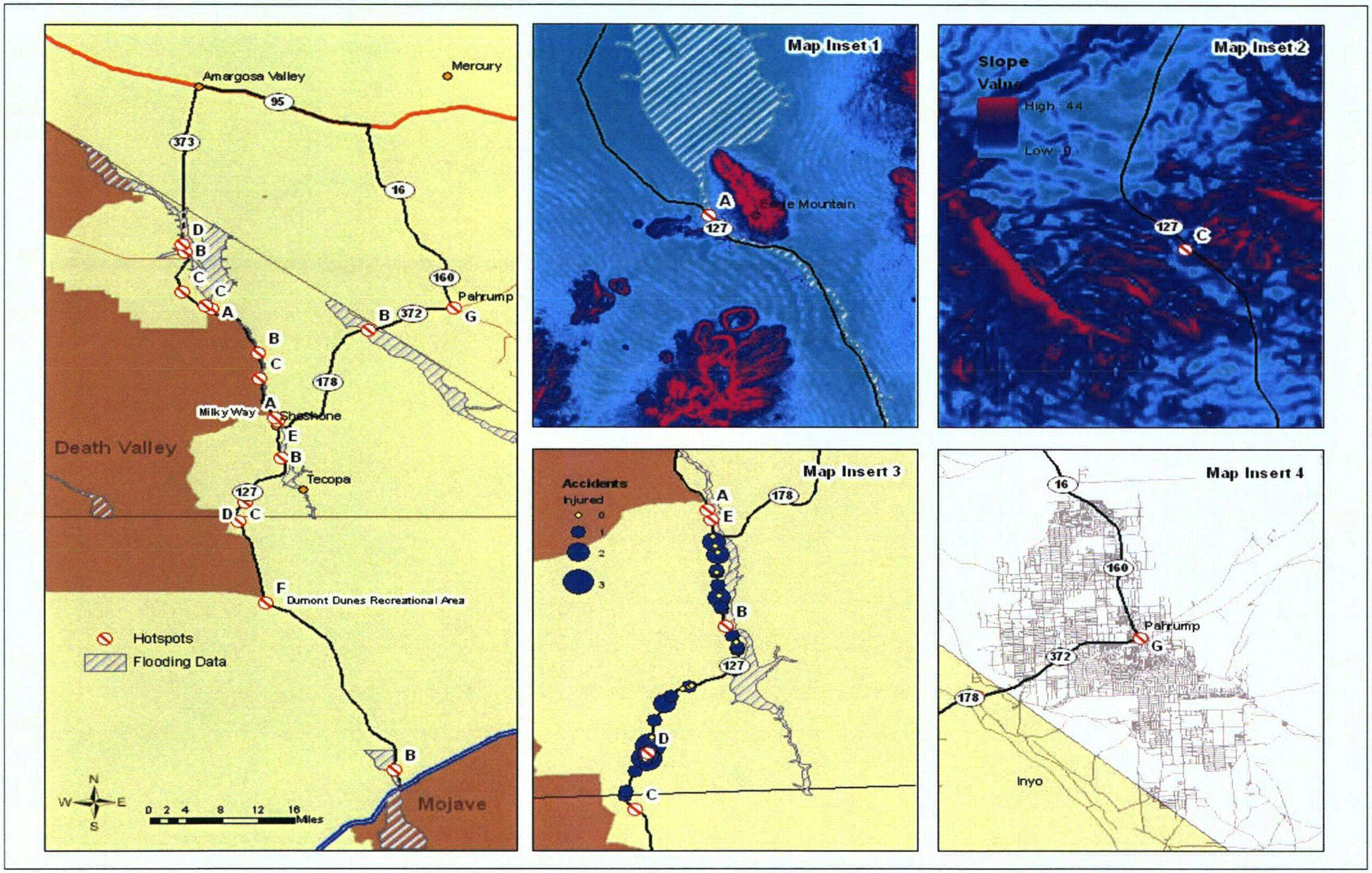

Figure 6. Potential accident scenarios along Inyo County study routes

Dose to Individual from Severe Accident

The acute (24 h) dose in rem to an individual directly downwind from the accident location was calculated for 95% of all weather conditions. This means that there is only a chance of 5% that the dose would even be higher, due to extreme weather. The results are shown in Table 15. The rem unit of measurement incorporates the health risks from radiation. All calculated doses are without any remediation. The very high long-term doses for an accident indicate a cleanup or a permanent evacuation, since they are not acceptable. The question remains as to what area has to be remediated. We discuss this matter below in the section, "population dose".

Table 15. Dose to Individual living downwind from accident

Distance downwind (km)	Acute Dose (rem)	1-y-Dose (rem)	50-y-Dose (rem)
0.05	246	6,490	136,000
0.1	110	2,910	61,200
0.2	34.2	903	19,000
0.5	10.3	272	5,720
1	3.5	93	1,950
2	1.1	28.4	597
5	0.22	5.8	122
10	0.0613	1.6	33.8
20	0.0145	0.38	7.99
50	0.0021	0.0551	1.16

Obviously, the acute dose cannot be avoided by remediation. Therefore, assuming immediate and perfect remediation, this is the minimum dose that individuals living along the center of the contamination plume would receive in case of a Category 5 accident.

Acute Dose to Population from Severe Accident

The next step was to superimpose plume diagrams on the map of Shoshone and its surroundings to estimate the amount and extent of contamination and dose from a severe truck accident. Plumes for acute dose and ground deposition concentration were obtained from the HotSpot computer model and plotted in a Geographic Information System (GIS) which is shown in Figures 7 – 10.

The population dose (person-rem) is calculated by multiplying the average dose (rem) of a dose zone with the respective population (persons). The dose zones are the areas between two neighboring dose isopleths. The dose zone population is calculated from the population density and the surface of each dose zone. The isopleths of the six highest acute doses are completely inside of Shoshone, whereas the ones with acute doses below

1 rem are partially outside. By measuring the plumes on the map and applying basic geometric calculations of ellipse segments, we calculate the area of each dose zone inside and outside of Shoshone (Table 16).

For example, the second dose zone listed in Table 16 is the area between the 100 rem plume and the 50 rem plume (Figure 7). The average dose in this area is calculated as (100 + 50)/2 = 75 rem. We then multiply this number by the plume area (km^2) and the respective population density (persons/km^2) to determine the acute population dose (person-rem), [75 rem*0.002 km^2*0.7 p/km^2 (2000) = 0.105 person-rem]. This number represents the average dose to the population for the area between the 100 rem and 50 rem plumes.

Table 16. Acute dose to the population

Dose zone between isopleths	Av. Dose in dose zone (rem)	Surface of dose zone Total (km^2)	within Shos. (km^2)	outside Shos. (km^2)	Acute population dose[a] 2000 (person-rem)
inside 100	>100	0.002	0.002	0	0.140
100 to 50	75	0.002	0.002	0	0.105
50 to 10	30	0.019	0.019	0	0.399
10 to 5	7.5	0.025	0.025	0	0.131
5 to 3	4	0.036	0.036	0	0.101
3 to 2	2.5	0.046	0.046	0	0.081
2 to 1	1.5	0.16	0.16	0	0.168
1 to 0.5	0.75	0.36	0.15	0.21	0.119
0.5 to 0.4	0.45	0.19	0.03	0.16	0.028
0.4 to 0.3	0.35	0.36	0.07	0.29	0.043
0.3 to 0.2	0.25	0.7	0.03	0.67	0.048
0.2 to 0.1	0.15	2.5	0.1	2.4	0.102
outside 0.1	<0.1	N/A	N/A	N/A	Omitted
Total					1.465

a: Dose calculated with population density estimates from 2000 US Census data

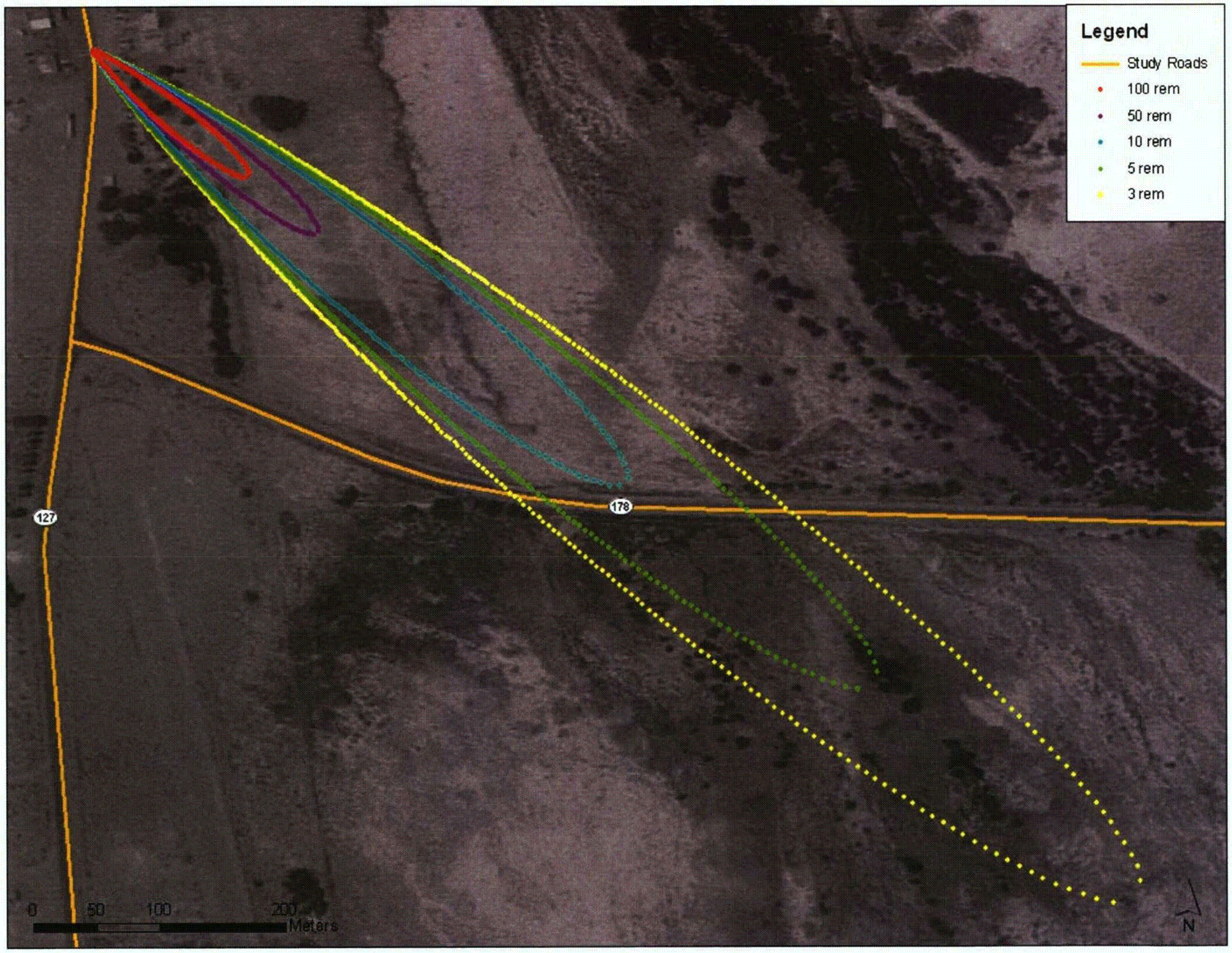

Figure 7. Acute dose isopleths in Shoshone, CA: 100, 50, 10, 5, and 3 rem

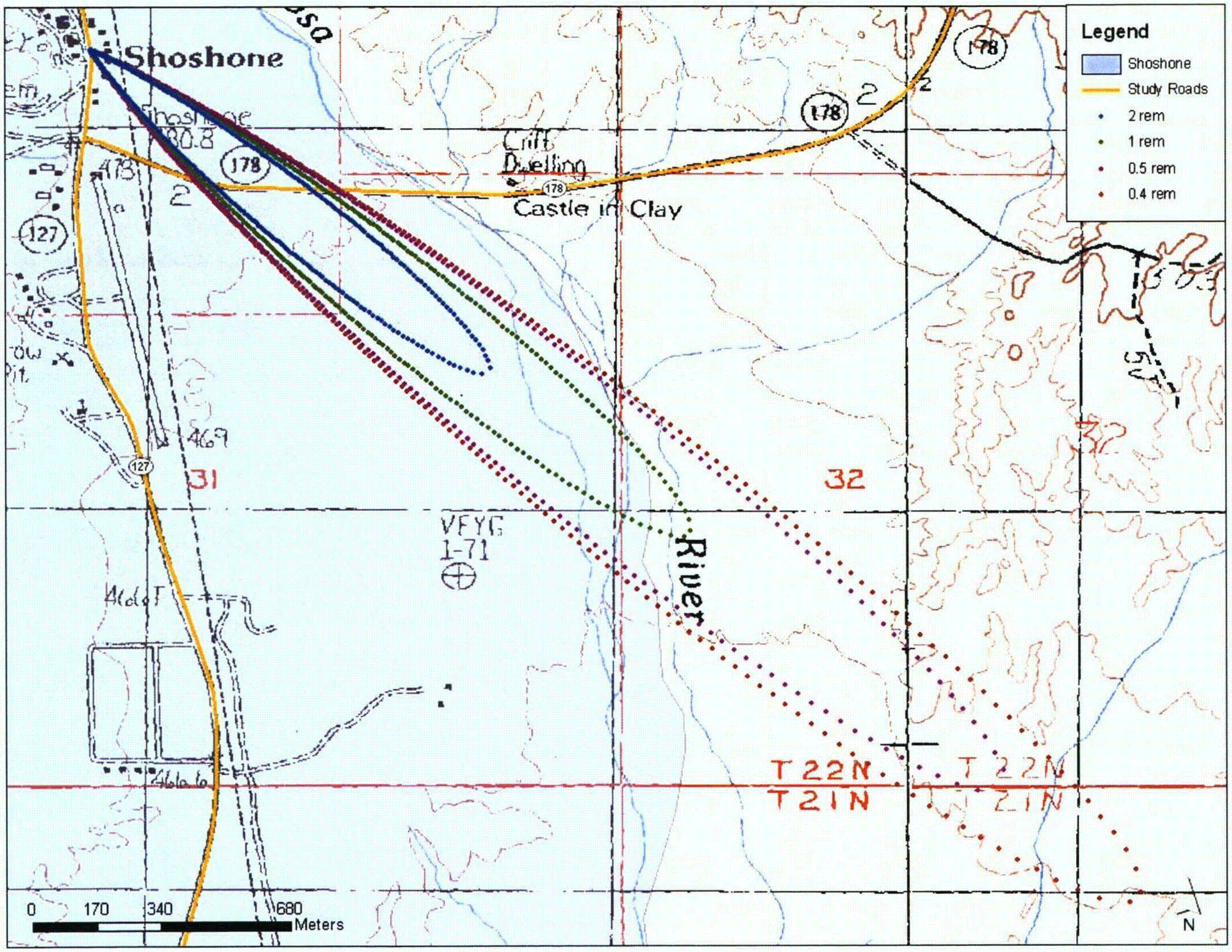

Figure 8. Acute dose isopleths for Shoshone, CA and surroundings: 2, 1, 0.5, and 0.4 rem

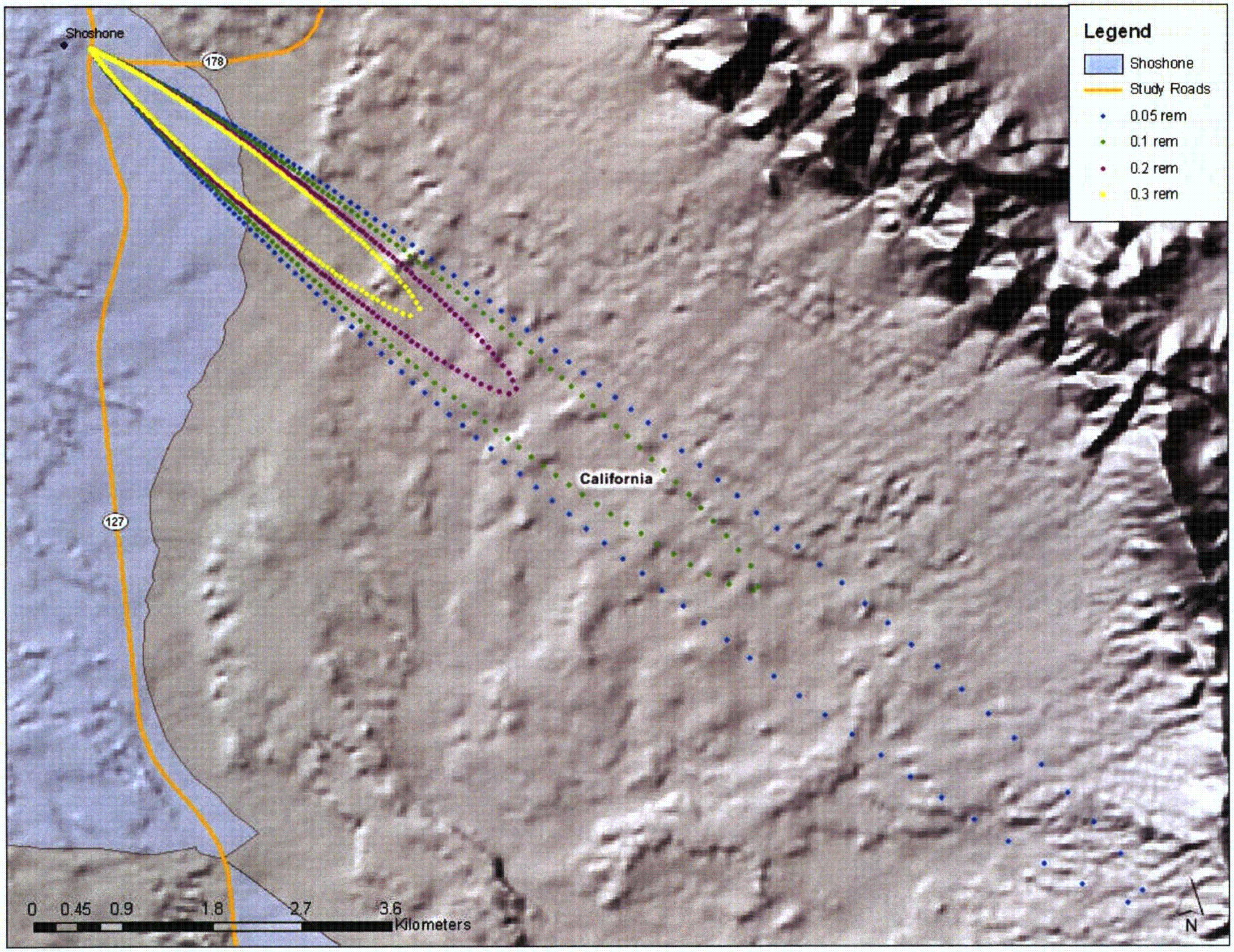

Figure 9. Acute dose isopleths in Shoshone, CA and surroundings: 0.3, 0.2, 0.1, and 0.05 rem

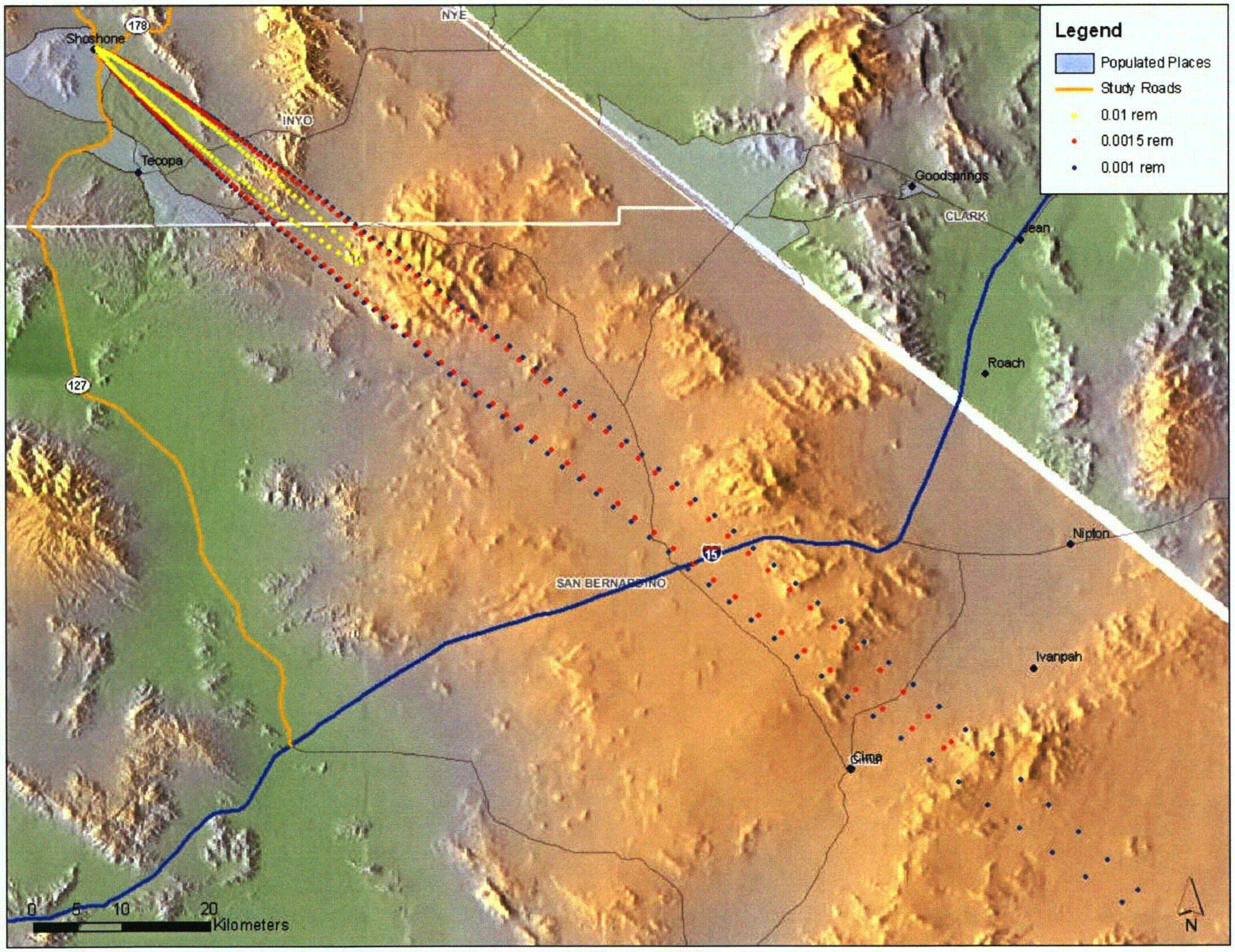

Figure 10. Acute dose isopleths in Inyo and San Bernardino Counties, CA: 0.01, 0.0015, and 0.001 rem

Long Term Population Dose and Latent Cancer Fatalities from Severe Accident

1-year and 50-year long-term dose estimates were made for the combined dose due to inhalation, ground shine, and cloud shine. For long-term population doses, ground shine due to deposited cesium is the major contributor. Other potential pathways, namely food, water and incidental soil ingestion, were not included in this calculation.

The methodology of arriving at population dose estimates utilizes the fact that long-term dose estimates are directly proportional to acute dose estimates. Estimating a long-term dose estimate then simply becomes an exercise in finding the correct multiplier. This was done using RISKIND, which provides estimates of both acute and long-term dose. Examining the dose estimates at given distances, it was determined that a 1-year long term dose was 3.8 times greater than the corresponding acute dose, and a 50-year dose was 53.3 times greater than the acute dose. The results for the long-term population dose estimates are given in Table 17.

To calculate the number of expected LCF, we again divide the population dose by 1,000 rem, as was done in the incident-free dose calculation.

Table 17. Latent cancer fatalities due to population dose

	Population Estimate 2000
Acute population dose in 24 h (person-rem)	0.577
LCF	0.00058
Long-term population dose in 1 y (person-rem)	5.68
LCF	0.0057
Long-term population dose in 50 y (person-rem)	108
LCF	0.108

The long-term population doses are theoretical doses to which the population would be exposed if no remediation and/or evacuation took place. If a severe accident takes place, no cleanup takes place and people live in Shoshone for another 50 years, then the expected latent cancer fatalities are 0.108. This would be approximately 0.21% of Shoshone's population in 2000. From this it follows that evacuation and remediation is absolutely necessary in the case of a Category 5 accident involving a nuclear waste shipment.

In case of a full evacuation, followed by perfect remediation, the population dose would effectively be the acute dose, with an estimated number of latent cancer fatalities of 0.00058 cases. This is 0.001% of the respective town population of Shoshone. However, perfect remediation is not possible. Therefore, the acute dose and the corresponding LCF have to be understood as a lower bound. Due to the necessarily imperfect remediation, the actual population dose in case of an accident would be higher in any case.

Estimated Area Requiring Remediation

There is currently no universally accepted decontamination level for areas subjected to radioactive contamination. However, there are a few general guidelines. For example, the EPA set a cleanup level at an above background effective dose of 15 mrem/year for Superfund sites[16], including exposures from all pathways. The Nuclear Regulatory Commission specifies a cleanup level of 25 mrem/y in its Radiological Criteria for License Termination. The EPA has also issued a Protective Action Guide[17] that states the doses in any single year after the first must not exceed 0.5 rem and that the cumulative dose over 50 years (including the 1st and 2nd years) must not exceed 5 rem. For this analysis, we will use both the EPA criteria for Superfund sites and the EPA Protective Action Guides to estimate the area requiring remediation. Rem is once again used as the unit to measure the amount of damage to human tissue from a dose of ionizing radiation.

Looking at Figure 10 and Table 18, for the first year after the postulated accident, we see that a person living along the 10 mrem acute-dose-isopleth would receive a yearly dose of 38 mrem due to ground shine, cloud shine, and inhalation. If instead we take the 50-year individual dose and divide by 50 to get an average annual long-term dose, the 10 mrem plotted isopleth corresponds to an average yearly dose of 11 mrem/y, near the EPA cleanup level for superfund sites. Therefore, according to this threshold, nearly the entire area under the 10 mrem acute-dose-isopleth will have to be remediated. This corresponds to a total area of 65 km^2. Most of this area is outside of Shoshone, but the EPA cleanup standards are valid also outside of the town.

This is clearly a prohibitive cleanup action. In addition to the vast region outside of Shoshone that would have to be remediated, a major part of the town would have to be scraped - buildings, streets, grass, and so on. We have not estimated here the considerable economic costs of evacuating and remediating the Shoshone area, including the cost of waste disposal, lost business and property devaluation, though we have made estimates for urban areas for the State of Nevada.

Using the EPA Protective Action Guides, Table 18 shows that the locations on the 100 mrem acute-dose isopleth correspond to a first-year dose of 0.38 rem, just below the Protective Action Guide limit. The 100 mrem acute-dose isopleth also corresponds to a first-year dose of 5.33 rem over 50 years, just above the Protective Action Guide limit. Hence, the area that would require remediation is 4.4 km^2. Thus, the area needing clean up is somewhere between 4.4 and 65 km^2.

[16] OSWER 9200.4-18, 1997.
[17] EPA 400R-92-001, 1992.

Table 18. Area in need of remediation

Isopleth of acute dose (rem)	Total area within isopleth (km^2)	1-y-dose on isopleth (rem)	50-y-dose on isopleth (rem)	Average annual dose for 50-y-dose (rem)
100	0.002	380	5,330	106.6
50	0.004	190	2,665	53.3
10	0.023	38	533	10.66
5	0.048	19	266.5	5.33
3	0.084	11.4	159.9	3.2
2	0.13	7.6	106.6	2.13
1	0.29	3.8	53.3	1.07
0.5	0.65	1.9	26.75	0.54
0.4	0.84	1.52	21.32	0.43
0.3	1.2	1.14	15.99	0.32
0.2	1.9	0.76	10.66	0.21
0.1[1]	**4.4**	**0.38**	**5.33**	**0.11**
0.05	10	0.19	2.67	0.053
0.01[2]	**65**	**0.038**	**0.53**	**0.011**
0.0015	467	0.0057	0.08	0.0016
0.001	678	0.0038	0.053	0.0011

1: Boundary of region in need of remediation using EPA Protective Action Guides levels
2: Boundary of region in need of remediation using EPA Superfund cleanup level

Estimated Economic Consequences of Decontamination and Cleanup

Table 19 presents the figures of the dollar and area estimates by Chanin and Murfin for each of the three contamination areas.

Table 19. Decontamination cost estimates: severe spent fuel accidents in Inyo County

	Area heavily contaminated (km^2)	Area moderately contaminated (km^2)	Area lightly contaminated (km^2)	Cost/km^2, heavy contamination	Cost/km^2, moderate contamination	Cost/km^2, light contamination	Total Cleanup Costs
Category 5 rural accident	0.004	0.005	0.039	\$394,604,748	\$182,592,165	\$128,263,609	\$7,493,661

Table 19 shows that even without considering all of the economic impacts associated with the aftermath of a spent fuel transportation accident, the dollar figures would indicate a substantial consequence. These cleanup cost estimates would be significantly greater if meteorological conditions were different. For example, a higher wind speed or more stable atmospheric conditions would have contributed to a greater downwind dispersal and, consequently, greater contaminated areas.

Non-Radiological Risk

An increase in the number of truck shipments on the study roads will also increase the overall non-radiological risk. The truck operations through Inyo County will have numerous impacts not related to the release of radioactivity. Some of these include impacts to land-use and ownership; air quality; hydrologic resources; biological resources and soils; cultural resources; socioeconomics; noise and vibration; aesthetics; environmental justice; utilities, energy, and materials; and waste management.

The key non-radiological risk during the shipping campaign will be the increase in non-release accidents, including fatalities and injuries, attributable to the increased truck traffic. This involves trucks transporting loaded casks to the repository as well as returning shipments of empty casks. The number of non-release or Category 1 accidents expected on the three study routes under the Southern Alternative shipping were shown in Table 11 and under the North – South routing scenario were listed in Table 12. These numbers ranged from 5.94 to 29.1 depending upon the route taken and the transportation alternative scenario used.

The expected number of fatalities due to accidents for both occupational and non-occupational individuals was determined using RADTRAN. Once again we multiply this number with 52,367 – 105,985 for the Southern Alternative Route and by 27,750 – 55,112 for the North – South Route. Table 20 shows the fatality rates for both the Southern Alternative and the North – South routing scenarios.

Table 20. Expected fatalities for the Southern Alternative and North – South Routing scenarios

	Southern Alternative					
	Proposed Action Scenario			*Modules I and II Scenario*		
	Route 1	**Route 2**	**Route 3**	**Route 1**	**Route 2**	**Route 3**
Occupational	0.54	0.53	0.80	1.10	1.07	1.61
Non-Occupational	1.92	1.86	2.81	3.88	3.77	5.68
	North – South Routing					
	Modules I and II scenario			*Modules I and II Scenario*		
	Route 1	**Route 2**	**Route 3**	**Route 1**	**Route 2**	**Route 3**
Occupational	0.29	0.28	0.42	0.57	0.56	0.84
Non-Occupational	1.02	0.99	1.49	2.02	1.96	2.95

Another key non-radiological risk is the human health impacts from exposures to pollution caused by vehicle exhaust from loaded and unloaded trucks and escort vehicles. The total latent fatalities that are expected over the entire shipping campaign (24 years – Proposed Action, 39 years – Modules I & II) can be seen in Table 21.

Table 21. Latent fatalities expected to the population near the study roads from exposures to vehicle exhaust

	Southern Alternative		
	Route 1	**Route 2**	**Route 3**
Proposed Action	0.0054	0.0056	0.0079
Modules I & II	0.0109	0.0113	0.0159
	North/South Alternative		
	Route 1	**Route 2**	**Route 3**
Proposed Action	0.0029	0.0030	0.0042
Modules I & II	0.0057	0.0059	0.0083

6. Conclusion

One of the many beneficial outcomes of this task is the ability to compare study route alternatives through Inyo County. Based on the risk models outputs, Routes 2 and 3 appear to have the highest impacts. Route 1 is the shortest distance to the repository at Yucca Mountain while Route 2 travels through the densely populated city of Pahrump and Route 3 contains high numbers of tourists and motorists visiting Death Valley National Park.

Distance is a major factor in determining differences among the study routes. Expected accidents for all severity categories are highest along Route 3, which travels through Death Valley National Park and is the longest of all the study routes.

Based on the risk models for expected non-radiological risk, Route 3 is also the most damaging. The values for expected fatalities and latent fatalities due to exposure to vehicle exhaust are the highest along this route. These high estimates can once again be contributed to the fact that there are a high number of tourists and motorists visiting Death Valley National Park and using the study road.

However, in the case of the impact to the population, Route 2 appears to be the highest risk. Route 2 has the highest population risk as well as the highest fatality and morbidity estimates. The unit risk factors are calculated for one person per square kilometer per kilometer of route traveled. These numbers are then multiplied by the appropriate population densities for each route and number of kilometers traveled. This can be contributed to the fact that the study route travels through the city of Pahrump in Nevada.

It has also been shown that a severe transportation accident leading to a release of radioactive particulates is both possible and credible in Inyo County. Such an accident would lead to high radiation exposures due to inhaling and ingesting radioactive particulates and from groundshine. In the case of Inyo County, the worst-case accident scenario would involve several factors. The most severe consequences would occur in an area that is highly populated. An accident with steep grades, high speeds, and one that leads to a long duration fire could be the most severe. Also, conditions that increase response time would increase the overall severity of the accident. This includes accidents positioned in areas with limited or no communication, located in floodplain areas during storms, or in areas such as Death Valley National Park that may contain a high tourist population at the time of an event. The accidents postulated in this report are not "worst-case" scenarios in the sense that one could not imagine a worse situation from happening. Rather, they are severe, yet credible, accidents, with the understanding that they are meant to be representative of the types of severe accidents that could happen in different areas of Inyo County.

Remediation of the contamination plume from a Category 5 accident to EPA CERCLA cleanup standards involves an area 65 km^2, extending 35 km downwind. The economic costs of such an accident would be considerable. DOE shipments are insured under Price-Anderson insurance, but the timing of the payouts is problematic since this requires a Congressional authorization.

A sabotage or terrorist attack is also a credible event that would lead to a release of radionuclides. The outcome of a sabotage or terrorist attack will vary according to the type of attack, the weaponry used, the location, as well as other variables.

The Final EIS for the Yucca Mountain Facility presents an estimate of the consequences of a truck accident in an urban environment under average atmospheric conditions. The release fractions assumed are based on a 1999 Sandia Report[18] which used computer modeling to estimate the release fractions resulting from the successful penetration of a cask. The Sandia study predicts release fractions resulting from the penetration of a shaped charge device and an anti-tank missile using a shaped charge analysis program[19]. The study found that the shaped charge, called HEDD1 in the study, produced more severe consequences than the anti-tank missile, called HEDD2. The study predicted that the HEDD1 would penetrate one wall of the GA-4 truck cask, which has a wall thickness of about 2.6 inches of stainless steel and 2.65 inches of depleted uranium, leaving an effective entry-hole diameter of 9.02 cm (Luna, 4.3) and striking 2 of the 4 PWR fuel assemblies. The release fractions were predicted to be smaller due to the larger volume and therefore smaller contribution from blowdown.

Another, more powerful example is the Kornet E laser guided anti-tank missile that has the capability to penetrate 1,200 mm of steel armor or 4.5 meters of concrete. This type of weaponry weighs 65 kg and can be installed and ready for use in three minutes, operated by three men, and deployed on vehicular platforms. Therefore, the threat of a sabotage or terrorist attack on a nuclear waste shipment leading to a radioactive release is substantial.

Interstate 15 (I-15), located in San Bernardino County, CA is a likely alternative to the study roads that pass through Inyo County. A separate transportation risk assessment would compare the relative risks of I-15 to the study roads analyzed in this study.

[18] Luna, Neuhauser, and Vigil. 1999.
[19] Vigil, Manuel G, 1988.

Radiation doses and the risk of a severe accident would be determined. Based on this assessment, it is possible that California could designate I-15 as the preferred route. However, I-15 is opposed by the state of Nevada because nuclear waste will travel directly through the Las Vegas metropolitan area.

7. References

Chanin, DI and WB Murfin, 1996. "Site Restoration: Estimation of Attributable Costs from Plutonium-Dispersal Accidents," Sandia National Laboratories, SAND96-0957.

Chun, Witte and Schwartz, 1987, "Dynamic Impact Effects on Spent Fuel Assemblies," Lawrence Livermore National Laboratory, UCID-21246.

EPA 400R-92-001. "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents." US EPA Office of Radiation Programs, 1992.

Fisher et al, 2000. "Shipping Container Response to Severe Highway and Rail Accident Conditions," Lawrence Livermore National Laboratory, NUREG/CR-4929.

"Hotspot Health Physics Code, Version 1.06." Lawrence Livermore National Laboratory. Steven G. Homann, contact.

Luna, Neauhauser, and Vigil, 1999. "Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments," Sandia National Laboratories, SAND99-0963.

Neuhauser, K.S. and Kanipe, F.L. 2000. "RADTRAN 5, User Guide," Sandia National Laboratories, SAND2000-1257.

OSWER 9200.4-18, "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," Aug. 22, 1997.

Resnikoff and Lamb, "Spent Fuel Inventory and Location with Time", August 2001.

Sprung et al, 2000. "Reexamination of Spent Fuel Shipment Risk Estimates," Sandia National Laboratories, NUREG/CR-6672.

USDOE, 1995. "RISKIND-A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel," Argonne National Laboratory, ANL/EAD-1.

USDOE, 2002. Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. pp 6-37.

US NRC, 1996. Generic Environmental Impact Statement for License Renewal of Nuclear Plants.

Vigil, Manual G, 1988. "Optimized Conical Shaped Charge Design using the SCAP Code," Sandia National Laboratories, SAND88-1790