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Bechtel SAIC Company, LLC

Test Plan For
Ash Redistribution, Lava Morphology, and Igneous Processes Studies
SITP-02-DE-001, Rev. 00

WBS Element 1.2.22.4.D (Work Package P4D1224DFU)

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REVISION/ADDENDUM HISTORY

Revision Number	Addendum/ Addendum Revision Number	Effective Date	Purpose of the Revision or Addendum
00	0	03/21/02	Initial issue.

DISCLAIMER

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1 INTRODUCTION

This test plan describes field, laboratory, and analytical studies that will be conducted by qualified personnel of the Bechtel SAIC (BSC) Disruptive Events Department in support of work described in the *Technical Work Plan (TWP) for Igneous Activity Analyses for Disruptive Events* TWP-WID MD-000007 (BSC, 2001). Model validation plans for any disruptive events models mentioned in this SITP are discussed in the TWP. This test plan covers field work to be completed during FY02 and laboratory/analytical work that will be started during FY02 and continue into FY03. The work is required to support studies related to the consequences from future igneous activity to a potential Yucca Mountain repository and, ultimately, to the receptor population (reasonably maximally exposed individual, RMEI). This work will specifically address the following:

- The physical volcanology of the Lathrop Wells eruptive center in the Yucca Mountain region, including the facies of the deposits, which relate to eruption mechanisms, lava flow morphology, and the original extent and nature of fallout tephra deposits.
- The subsurface "plumbing" of volcanoes that are analogous to basaltic volcanoes in the Yucca Mountain region.
- The surficial geomorphologic processes that control the redistribution of fallout tephra deposits (fluvial and eolian processes) and the resulting depositional or erosional features.

This work addresses the agreements between the DOE and the NRC with regard to resolution of the Igneous Activity Key Technical Issue (KTI) Subissue 2, Consequences of Igneous Activity. Section 5 of this plan maps the work to specific agreement items. Scientific notebooks will be used to record information regarding the field work activities and resulting data. The data and conclusions will be input to a revision of AMR *Characterize Eruptive Processes at Yucca Mountain, Nevada* (ANL-MGR-GS-000002, Rev. 0).

2 PRODUCTS SUPPORTED

This test plan is part of the Field Work Package for *Disruptive Events Field Investigations*, FWP-SB-02-002 (Esp, 2002, in process). This plan supports the License Application (LA) Product (WBS element 1.2.22.4.D), depending on the timing of submission of the license application.

Specifically, the testing described in this test plan will support a revision of the *Characterize Eruptive Processes at Yucca Mountain, Nevada* AMR (ANL-MGR-GS-000002), which, in turn, will support other DE modeling studies. Outputs of the revised eruptive processes report will support the TSPA for LA in the area of consequences of igneous activity. Field work will develop information that (through the eruptive processes report) will contribute to future revisions of the *Natural Analogue Synthesis Report* (BSC, 2002).

3 QUALITY ASSURANCE CONTROLS AND INTEGRATED SAFETY MANAGEMENT SYSTEM PROGRAM

The field work under this plan will be performed in full compliance with the Yucca Mountain Quality Assurance (QA) and Integrated Safety Management System (ISMS) requirements.

3.1 APPLICABLE QA PROCEDURES

3.1.1 Submittal of Preliminary Data

AP-3.15Q Managing Technical Product Inputs

3.1.2 Test Plan

AP-SIII.7Q Scientific Investigation Laboratory and Field Testing

3.1.3 Test Controls

AP-SI.1Q Software Management
AP-SIII.1Q Scientific Notebooks
AP-5.2Q Testing Work Packages
AP-SV.1Q Control of the Electronic Management of Information
AP-2.14Q Review of Technical Products and Data

All activities in the field will be coordinated with the Test Coordination Officer (TCO).

3.1.4 Equipment/Instrument Calibration Records

AP-12.1Q Control of Measuring and Test Equipment and Calibration Standards

AP-7.6Q Procurement of Item and Services

AP-7.7Q Acceptance of Items and Services

3.1.5 LANL Implementing Procedures

LANL-EES-DP-130	Geologic Sample Preparation
LANL-YMP-QP-08.1	Identification and Control of Samples
LANL-YMP-QP-S5.01	Electronic Information Management
LANL-EES-DP-129	ADEM Scanning Electron Microscope Operating Procedure
LANL-EES-DP-131	CAMECA SX-50 Electron Microprobe Operating Procedure
LANL-EES-DP-111	RIGAKU 3064 X-Ray Fluorescence Spectrometer Operating System

3.1.6 Nonconformance and Corrective Actions

AP 15.2Q Control of NonConformances

AP 16.1Q Management of Conditions Adverse to Quality

3.1.7 Record Controls

AP-17.1Q Record Source Responsibilities for Inclusionary Records
AP-SIII.3Q Submittal and Incorporation of Data to the Technical Data Management System

All records will be submitted to the Record Processing Center in records packages. Scientific notebooks will be archived per AP-SIII.1Q requirements.

4 PURPOSE AND OBJECTIVE

4.1 PURPOSE OF TESTING

The results of these field, laboratory, and analytical studies of physical volcanology and ash and soil redistribution will be used to provide parameter values, ranges, and uncertainties for direct application in disruptive events modeling and analysis by Total System Performance Assessment (TSPA) for the consequences of igneous activity. Field work will also contribute to development of YMP analog information. Parameters will include: relative proportions of explosive (tephra) versus non-explosive (effusive) igneous products, conduit size and shape, surface sediment (ash and soil) erosion and deposition rates at Yucca Mountain, potential distribution of contaminated ash from a hypothetical eruption through a repository, and rate of transport of contaminated ash toward and away from an RMEI by eolian and fluvial processes.

4.2 OBJECTIVE OF TEST

The objective of the disruptive events field investigations is to provide an improved scientific basis to support development of conceptual models and descriptive parameters for the physical volcanological character of the most likely type of eruption that could affect the repository, as well as for the processes by which erosion and redistribution of volcanic ash downgradient occur toward the reasonably maximally exposed individual. Direct observations and measurements of analog basaltic volcanoes, their products, and tephra dispersal and erosional patterns and processes will provide the appropriate comparisons with a potential volcanic disruption of a repository at Yucca Mountain.

5 WORK SCOPE

5.1 PRODUCT DESCRIPTION

This section describes in detail the purpose of specific activities, the types of field work to be performed, the data that will be collected, specific products of the field work, and links to TSPA models. The work products and subsequent analyses of these products in Model Reports or other documents support meeting the requirements of NRC KTI Igneous Activity, Subissue 2 Consequences of Igneous Activity agreement items (Krier, 2001). The physical volcanology work supports meeting agreement items KIA 2.3 (analog tephra volumes appropriate for Yucca Mountain region, 2.5 (conduit elongation) and 2.18 (magma ascent/flow, conduit localization).

The ash redistribution work supports meeting agreement item 2.17 (eolian and fluvial mobilization, transport and deposition).

Both phases of the work support the future development of an eruptive processes model and a tehpra redistribution model. There is the potential that data collected by both phases could improve the basis for validation of the disruptive events PA ASHPLUME software (V1.4, STN 10022-1.4LV-00) and improve the basis for key parameters used in modeling ash distribution. The conduit diameter measurement activity will produce data that is important to the disruptive events PA Waste Packages Hit calculation (DTN MO0010SPAOUT01.002 and DTN MO0010SPAVOL01.001).

5.1.1 Physical Volcanology Study Component, Lathrop Wells Cone

The purpose of the physical volcanology study is to characterize the basic physical volcanological characteristics of the Lathrop Wells volcanic center, the youngest of the Quaternary basaltic eruptive centers in the Yucca Mountain region. The work will result in collection of data on the following characteristics of the volcanic ash and lava products, which relate to the eruption dynamics (magma ascent rate, volatile content) that produced the center: distribution and volume percentages of pyroclastic (ash) and effusive (lava) facies, macroscopic xenolith content of pyroclastic deposits and lavas, vesicularity and morphology of pyroclasts, and morphology of lavas. A component of the physical volcanology work is the conduit width study that is described in detail in section 5.1.2. Field work will build upon existing surface maps of the Lathrop Wells cone showing the number of identified flows and pyroclastic facies and will extend the data outward to the observed area of the dispersed tephra sheet. The field work will support description of the original lateral distribution, thickness, stratigraphy, and grain size of pyroclastic facies and the morphological characteristics of lava flows.

Several samples from Lathrop Wells cone will be collected and sent to Brown University (Rhode Island) for analysis of properties to help constrain volatile content and ascent rate of magma. Analysis of samples by Brown University petrologic laboratory is contingent on qualification of that laboratory and its procedures; qualification efforts are currently underway. Brown University services will be acquired through a Los Alamos National Laboratory purchase order.

Data collected are significant to TSPA-LA model components where the volume of the eruption is significant (volcanic eruption scenario, input to ASHPLUME model). The relative proportion of effusive and more violent phases during eruption, which also impact the volcanic eruption scenario, will be better constrained as a result of collection of these data.

Products:
Map (scale 1:6,000) of the distribution of primary tephra deposits, reworked tephra deposits, and lava flow types erupted from Lathrop Wells cone.

Table of field locations, ash descriptions, and measurements of thickness, stratigraphy, and grain size (range and maximum) of the pyroclastic facies.

Map/tables of xenolith content of primary pyroclastic deposits. Specific locations of field counts will be determined during field mapping based on outcrop or sub-crop exposure and availability. In addition to field description, laboratory microscopic counts of small xenoliths may be required.

Tables of vesicularity (volume percent) and morphology of pyroclasts; fraction of explosive versus non-explosive erupted volume at Lathrop Wells cone, estimates of mass flux.

5.1.2 Conduit Width Study Component

The purpose of the conduit width study is to examine the shallow subsurface plumbing of basaltic volcanic vents which are analogous to eruptive centers in the Yucca Mountain region. Field work will focus on collection of data that support obtaining a more comprehensive data set on the size and geometry of conduits that feed alkali basalt/hawaiite eruptions. The current distribution for conduit diameter is based on one direct data point and one inferred data point. The current assumption for modeling is that conduits are circular in cross section.

The field work will describe conduit geometry size and shape, estimate of the level of (eroded) exposure, and the role of pre-existing faults on dike and conduit formation. Sites chosen as analogs for this study include Paiute Ridge (NTS), Grants Ridge (NM), and several well-exposed volcanic edifices in the Rio Puerco (NM) basin. Limited sampling for chemical analysis will be done to confirm the basalt geochemical type.

Data collected are significant to TSPA-LA model components that use parameters affecting the number of waste packages hit in the volcanic eruption scenario. The current assumption is that all waste packages directly within a conduit provide no further protection to the waste, therefore conduit diameter and geometry have a direct impact on dose for this scenario.

Products:
Maps (scale 1:6,000 or otherwise appropriate) showing conduit geometry, including some detail on lithologic facies distribution to ensure capture of complete conduit geometry, and structural features (e.g., faults) in surrounding host rocks.

Tables of conduit geometry parameters: new conduit diameter and shape distributions

5.1.3 Ash and Soil Redistribution Study Component

The ash and soil redistribution study component includes two parts: (i) study of ash redistribution through the Fortymile Wash drainage system, and (ii) study of the Lathrop Wells tephra sheet.

(i) Study of ash redistribution through the Fortymile Wash drainage system

The purpose of the ash redistribution study is to develop a geologic basis for the fate and transport of contaminated basaltic ash from hypothetical eruptions through a repository, after the eruptive products have been deposited in the form of a tephra sheet. Data collected will support determining whether the area of the RMEI is an area where sediment, potentially carrying waste, is accreting or eroding. The data will provide a technical basis to test the assumption that the risk effects (i.e., effective annual dose) of eolian and fluvial remobilization of contaminated ash are bounded by conservative modeling assumptions in the current model for dose from contaminated ash as the site of the RMEI.

Field work will sample to determine, at several locations, the thickness of Cs-137-bearing sediments for the purpose of establishing a framework from which erosion or deposition rates of sediments may be determined. Used in this manner, Cs-137 is a tracer. This bomb-pulse cesium was first produced ~50 years ago with the advent of atmospheric testing of nuclear weapons and can provide a marker for determining the volume of sediment being transported down slopes and washes during the past ~5 decades. The simple procedure requires digging a small hole, 30 cm to 1 m deep, on slopes or in or along washes, noting the stratigraphy of the exposed sediment, and taking several ~150 g samples of sediment/ash at vertically spaced points from the wall of the hole. The samples are later analyzed for their Cs-137 content. The assumption is that for each hole there will be a Cs-137 abundance related to bomb-pulse Cs deposition and a depth below which there will be no Cs-bearing sediment, corresponding to sediments which are older than ~50 years. Volumes of sediment/ash that have been moved down the washes can be inferred from the values obtained.

Products: (i) rate of sediment mobilization off slopes, (ii) rate of sediment transport in Fortymile Wash drainages, (iii) rate of transport by eolian processes, (iv) sediment deposition rate at the RMEI location, (v) changes in particle-size distributions during fluvial transport, (vi) table of thickness of sediments containing Cs for each sampling location and description of sediment character for layers in sampled profiles (i.e., fluvial or eolian deposit, particle size distribution, etc.), (vii) map with sampling locations and aerial extent of geomorphic surfaces and features being sampled.

Data collected from this work will produce an improved technical basis for the conceptual model (and supporting parameters) used by TSPA for the RMEI site with regard to the dominant sedimentation process (erosional or accretionary). This conceptual model impacts whether the source term from contaminated ash in soil might be increased or decreased to reflect erosion or accretion at the site. Data collected will also support an improved technical basis for the parameter distribution for grain size that is relevant to the inhaled dose for the biological dose conversion factor (BDCF) analysis.

(ii) Study of the Lathrop Wells tephra sheet

The purpose of the Lathrop Wells tephra sheet study is to characterize the tephra sheet deposited from the Lathrop Wells volcanic center~75ky, the youngest of the Quaternary basaltic eruptive centers in the Yucca Mountain region. In this study, data will be collected on the physical characteristics of the pyroclastic facies of the volcanic ash, such as deposit thickness, particle size distribution of deposit, ash volume per unit volume of sediment, nature of ash deposit (air fall, fluvial reworking, eolian reworking, etc.).

A factor that is also needed for a geologic basis for tephra redistribution is the change in modern hydrologic and eolian processes, due to a future climate change, that would accompany erosion of a hypothetical fresh tephra sheet. In order to constrain this, we will gather field data on the distribution of tephra from the ~75 ka eruptions of Lathrop Wells volcano, an analog for a potential future eruption at Yucca Mountain. The redistribution of the Lathrop Wells ash over the last ~75 ky was under a range of climatic conditions that are similar to the range of conditions likely to occur during the next 10 ky.

The volume of the eruption is a key input parameter in the ASHPLUME code which is run in GoldSim. Volume is used to calculate eruption column height which is important to dispersal in the volcanic eruption scenario, and therefore, to dose. The assumptions of the relative duration/volume of various phases from violent to effusive is an underlying factor affecting the applicability of the ASHPLUME code, and is important to the volcanic eruption scenario conceptual model for PA.

Product:
Conceptual tephra redistribution model supported by parameter values and distributions, including deposit thickness, particle size distribution, ash volume per unit volume of sediment, depositional nature of ash deposit (e.g., air fall, fluvial reworking, etc.).

5.2 RESPONSIBLITIES

This work will be carried out by scientists in the YMP Disruptive Events (DE) Department, the U. S. Geological Survey, and Brown University (Rhode Island).

YMP DE Department: Planning/coordination of field activities; execution of field activities, including collection of samples; field data collection, including mapping/description of sample points, lithologies, and stratigraphic succession of tephra; sample analysis involving description, scanning electron microscope analysis, sieve analysis.

USGS: Assist in planning and execution of field activities described above.
Brown University: Petrologic analysis and data reduction of basalt samples at elevated temperatures and pressures to determine volatile contents of parent magma; delivery of said data to YMP DE scientists.

5.3 ACTIVITIES AND TASK DESCRIPTION

This section describes activities associated with each study component described above. It is written at a level that provides a clear structure with some limited flexibility in field procedures and approaches. Significant variations from these activities and detailed task executions will be incorporated into appropriately assigned scientific notebooks.

General methodology:

- Geologic mapping will involve standard geologic mapping techniques on topographic and/or aerial photograph bases. Standard mapping information will include distribution of lithologic types of interest, structural elements (e.g., faults) on an appropriate scale (1:6,000 on a topographic base). (Responsibility: LANL and USGS.)
- Samples of rock types will not require special handling in the field. Samples will be collected in plastic or cloth sampling bags and/or plastic bottles with appropriate sample numbers; sample collection points are plotted on a map base and recorded in appropriately assigned scientific notebooks. Sampling can be accomplished with geologic picks (for consolidated materials) and hand shovels (for unconsolidated materials). Sample sizes of 50 to 100 cm^3 will be adequate for all analyses other than sieve analyses, which will require a representative sample from each location of 400 to 500 cm^3. (Responsibility: LANL and USGS.)
- Measurements of bed thickness, attitudes of geologic features (e.g., conduit length and width, strike and dip of faults and dikes), and geographic locations will be done using tape measures, hand compasses, and hand-held global positioning system (GPS) units, where appropriate. (Responsibility: LANL and USGS.)
- Laboratory testing of ash will include standard sieve analyses for size distributions; petrographic analysis for mineral identification and alteration textures, scanning electron microscope and binocular microscope analysis for phase identification, grain morphology, and vesicularity amount and geometry; binocular microscope for analysis of unconsolidated materials; gamma spectrometry for measurement of Cs^{137}; electron microprobe analysis for mineral and glass compositions; x-ray fluorescence and instrumental neutron activation analysis (INAA) for analysis of chemical composition of tephra deposits; x-ray diffraction for mineral identification and volume percentages. (Responsibility: LANL.)

5.3.1 Physical Volcanology Study Activities

The goal is to map the original extent of the Lathrop Wells cone tephra sheet, which resulted from the ~75-ka old eruption and growth of the volcanic cone. Field work will build upon existing surface maps of the Lathrop Wells cone (Map ID YMP-97-148.0, Geology of Lathrop Wells Volcanic Center) showing the number of identified flows and pyroclastic facies and will extend the data outward to the observable remnants of the dispersed tephra sheet. It is expected that primary tephra deposition was influenced by and concentrated in the direction of the winds that predominated during eruption but also that tephra was distributed 360° around the cone. These tephra beds are now covered by as much as 1 m of eolian and fluvial sediments. Distribution will be determined by observations of exposures in washes and road cuts, and by hand-digging small "ash-pits" to determine presence, thickness, and stratigraphy of the beds. Bed stratigraphy will be documented and correlated among locations to determine the extent of explosive versus non-explosive facies as determined by grain textures and bed fabrics.

The discrimination of primary fallout tephra from tephra components reworked by later eolian and/or fluvial processes will be made in the field based on grain texture, nature of the matrix, and stratigraphic context, and in LANL laboratory analyses by standard sieve analyses for size distribution and microscopic study of mineralogy, vesicularity, and rounding of ash. Also, tephra distribution, eruptive and effusive component ratio, and tephra size ranges will support calculation of magma eruption rates (kg s^{-1}) to be calculated by the eruptive processes report analysis to further characterize the dynamics of tephra emplacement. Some of the data collected under this activity will be directly transferable to the Lathrop Wells Tephra Sheet Study (Section 5.3.3) and will not result in duplication of effort. A subset of collected samples will be sent for petrologic analysis at Brown University (Rhode Island) experimental petrology laboratory. Laboratory analysis of samples will help determine ranges of pressure-temperature (P-T) conditions applicable to Lathrop Wells phenocryst assemblage, H_2O and CO_2 solubility relations for magma volatile content, and magma ascent rate estimation based upon hornblende reaction rims compositions. This will constrain any rate limiting factors that may influence the explosivity and shockwave formation caused by magma intrusion into a repository.

5.3.2 Conduit Width Study Activities

Conduit width study activities are a straightforward set of field measurements and mapping of the geometry of volcanic plumbing at the earth's surface as exposed in eroded volcanic piles, necks, and dikes. Much of the work can be done in the laboratory, prefacing field work by measurements of conduit geometries from aerial photographs of each location, where available. Then, at each location, lithologic contacts between intrusive (conduit) rock and equivalent extrusive (effusive) lithologies will be field checked to decrease uncertainties in photographic measurements of width. Measurements will be made using hand-held compasses, tape measure, and GPS units to check outline and dimensions of conduits feeding the volcanic edifice, including any observed changes with depth in the exposures such as branching, widening, narrowing, etc. Complexities could arise in differentiating the feeder plumbing from effusive products (proximal surface lava flows). To determine conduit plumbing from effusive facies, observations such as contact orientations, degree of crystallinity, degree of quenching (glass), vesicularity, flow foliations, and flow morphology will be used and made essential components of map and outcrop descriptions in appropriately assigned scientific notebooks. Samples may be taken for laboratory analysis (e.g., scanning electron analysis, binocular examination/description, x-ray fluorescence analysis; see list of procedures in Section 3.1.5) at LANL to help determine facies origins; no special sample handling is required. Sample locations will be marked on the maps with GPS locations and sample descriptions will be entered in scientific notebooks.

5.3.3 Ash and Soil Redistribution Study Activities

<u>Ash Redistribution through the Fortymile Wash Drainage System</u>

The ash redistribution study will start with an initial *scoping study* to obtain background information on the amount and distribution of Cs on stable land surfaces, on alluvial fans built southward from Yucca Mountain into the Amargosa Valley, and on eolian deposits near where alluvial fan deposits enter the Amargosa Valley. For the scoping study, 3-5 stable geomorphic surfaces (surfaces not connected to the hillslope) will be selected for Cs testing. Surfaces selected will include those on the east and west side of Yucca Mountain, those mantled with varnish-coated cobbles, and surfaces with surficial sandy deposits. Vertical samples will be taken below each surface. Samples of 100-250 gms will be collected over a 3-5 cm thickness at increasing depths. Sample storage will be in small, wide-mouth plastic bottles, with no special handling required. Samples being used by the responsible party will be identified with YMP bar code designations per YAP-SII.4Q. GPS locations will be collected for each site along with digital photographs. Field descriptions for each site will be entered into appropriately assigned scientific notebooks. Current plans are that the scoping study will be Non-Q work.

Study sites will also be selected on each of the 3 alluvial fans that redistribute sediment from Yucca Mountain. At each fan site, a vertical profile of sediments will be collected in 5 cm thicknesses at a natural exposure. Three to six samples will be collected at each site at regular spacing determined by the height of the exposure. A similar approach will be used at nearby eolian deposits.

Activities of the Cs survey will include establishing ranges of Cs abundance in the different environments, determination of the thickness of the sediment that contains Cs, and the depth to Cs-free sediment. If subsequent lab analyses show that all samples contain Cs, then the sampling profile will be extended to greater depth until Cs-free sediment is identified. Sample collection, storage, identification and site location will be as previously described. Field description for each site will be entered into appropriately assigned scientific notebook.

All sediment samples will be sent to a qualified laboratory for analysis by gamma spectroscopy. Products from the scoping study will include a map (standard topographic map base) showing sampling locations and aerial extent of geomorphic surfaces and features being sampled, and tables of thickness of sediments containing Cs for each sampling location and description of sediment character for layers in sampled profiles (i.e., fluvial or eolian deposit, particle size distribution, etc.)

Based on results from the scoping study, we will construct a plan for sampling of the Fortymile Wash alluvial fan, the unnamed fan at the base of Jackass Flats, and the Crater Flat fan, just southeast of Amargosa Valley. Sample transects will be established longitudinally along the length of the fans and laterally (at least two transects) across the fans. At selected sampling locations profiles will be exposed (by shovel) and sampled and described as was done in the scoping study. Sample collection, storage, identification and site location will be as previously described. Field description for each site will be entered into appropriately assigned scientific notebooks. All sediment samples will be sent to a qualified laboratory for analysis by gamma spectroscopy. Results of analyses will be used to delineate the thickness of the Cs-rich sediment layer at each sampling location and then utilizing this data, calculate the sediment volume deposited on the fans since bomb pulse Cs was first produced during nuclear testing (~50 yrs). The rate of sedimentation by fluvial and eolian processes will be calculated for the location of the RMEI.

A qualitative assessment will be done of nature, quantity and particle size distribution of material mobilized from hillslopes in the Fortymile Wash tributary heads, by mass wasting, fluvial and/or eolian processes. These results will be used to estimate the rate of stripping of these hillslope areas. Vertical profiles in natural exposures in several of the Fortymile Wash tributaries and in the main wash will be sampled and a volume of ash (from the Lathrop Wells eruption) per unit volume of sediment will be estimated for each sediment layer exposed in the profile. Samples will be collected from each sediment layer for a subsequent, more detailed, microscopic analysis, description, and estimate of ash volume. The results will be used to determine the trend/amount of dilution by other sediments of the ash outward from the hillslopes toward the RMEI and to estimate the volume of ash transported to that location. Data will be used to estimate the bounding values of ash and sediment accretion at the location of the RMEI. Sample collection, storage, identification and site location will be as previously described in the scoping study. The field description for each site will be entered into scientific notebooks.

The results of these studies will be used in PA calculations to calculate whether the source term should be added-to or subtracted-from based on the accretion or erosion rate of potentially contaminated, ash-bearing sediment per time period following transport of a tephra sheet from Fortymile Wash to the location of the RMEI.

<u>Lathrop Wells Tephra Sheet Study</u>

In this study, data will be collected on the physical characteristics of the pyroclastic facies of the volcanic ash, such as deposit extent, thickness, particle size distribution of deposit, ash volume per unit volume of sediment, nature of ash deposit (air fall, fluvial reworking, eolian reworking, etc.). Some of this data will be made available from the Physical Volcanology Study Activities (Section 5.3.1). The field work will include description and/or measurement of the lateral distribution, thickness, stratigraphy, and grain size (range and maximum) of these pyroclastic facies. All work will be documented in scientific notebooks and will include measurements with tape measures, hand-held compasses, GPS, topographic base maps and aerial photographs where appropriate, and sampling of tephra for laboratory analysis. Laboratory analysis at LANL will include sieve and microscopic analysis to aid in determining nature of the deposit at specific locations.

5.4 SCHEDULE

Table 1 shows an example FY02-FY03 schedule for all field and laboratory studies related to disruptive events/igneous activity. Actual schedules will depend on having approved planning documents and resources available by the projected start dates. As with all field work, weather conditions and accessibility can also impact schedules.

Table 1. Preliminary schedule for igneous activity field investigations, based on estimated March 15, 2002, start.

Activity Description	SCHEDULE	
Lathrop Wells Cone		
Map/describe pyroclastic facies and lava morphology	15-Mar-02	30-Aug-02
Xenolith field analysis	15-Mar-02	30-Aug-02
Describe and sample tephra sheet	15-Mar-02	30-Sep-02
Laboratory analysis of samples	01-May-02	30-Oct-02
Soil Redistribution Analyses		
Field/lab analysis of Cs at YM	15 Mar-02	13-Dec-02
Field examination of recent debris flows near YM	13-Jun-02	10-Jul-02
Determine Lathrop Wells tephra distribution	3-Sep-02	18-Oct-02
Conduit Size/Geometry Analysis		
Select conduit analog sites	15-Mar-02	17-Apr-02
Field measurements of conduit geometries	15-Mar-02	24-May-02
Sample analysis (limited)	28-May-02	28-Jun-02
Experimental Petrology Studies		
Collect and deliver samples to Brown University lab	01-Apr-02	30-Apr-02
Determine P-T conditions for Lathrop Wells phenocryst assemblage	30-Apr-02	16-Aug-02
Determine H_2O and CO_2 solubility vs. pressure	16-Aug-02	20-Mar-03
Determine ascent rate based on hb reaction rims	16-Aug-02	20-Mar-03

6 SCIENTIFIC APPROACH/ TECHNICAL METHODS

6.1 PRE-TEST CALCULATION / ANALYSIS / MODEL PREDICTIONS

Pre-test analysis and prediction will be based on geologic maps that show the general location of volcanic features and certain types of Quaternary alluvium that pertain to tephra/soil redistribution studies. These analyses will provide locations where field studies will be conducted.

6.2 FIELD MAPPING METHODOLOGY

Field mapping will be done on topographic and/or aerial photograph bases, with the use of hand-held compasses and GPS units. Locations of field measurements (e.g., unit contacts, station and sample sites) will be marked on the appropriate base. Detailed observations will be entered into scientific notebooks and tied back to station identifiers on the topographic and photographic bases.

6.2.1 Technical Methods

Technical methods for geologic mapping and sampling will be described in their appropriately assigned scientific notebooks by the investigators.

6.3 IDENTIFICATION OF COMPUTER SOFTWARE

Standard, commercially available word processing software and graphics software are used to record, compile, and prepare the data for submittal to the project in digital form and to prepare the data for eventual publication. Commercially available software may also be used to download location data from hand-held GPS units to desktop/laptop computers. This will be described and the qualification status identified as appropriate in the investigators' scientific notebooks.

6.4 DATA RECORDING AND DATA REDUCTION

6.4.1 Data Collection System

Field mapping data will be recorded by hand on orthophoto maps and in scientific notebooks. Selected geologic field data may be recorded electronically using a digital camera or other digital recording device such as a Personal Digital Assistant. Location data may be acquired using GPS. Field mapping data will be compiled and then digitized on compilation maps. Data reduction will be done in analyses in analysis reports that utilize the data.

6.4.2 Data Application

Field mapping data will be used to complete a geologic map and geologic cross sections, and to describe volcanic units and subunits, and geologic structures in the scientific notebooks. See the discussions in Section 5 for a more detailed discussion of data application.

6.4.3 Data Distribution

Through data submittals to the TDMS, and eventual publication.

6.5 ANALYSIS AND MODELING DURING AND AFTER TEST

Work described in this section is intended to ensure that two test operational constraints are met:

Test results are compared with pre-test predictions in time to allow for modification of the testing procedure and collection of new data, if necessary. This constraint will be implemented by comparing the pre-test predictions to the observational data collected and by considering whether the information fulfills the data accuracy and precision requirements as depicted in the pre-test predictions.

Data format and content are compared with the data requirements for analysis and/or modeling. The purpose of the comparison is to ensure that the data are adequate and sufficient to support the work for which the information was collected. The objective of the evaluation is to provide an opportunity to modify or extend testing activities if the data needs were either incorrectly defined or must be extended because of additional requirements. This constraint will be implemented by reviewing the information needs for the analysis and/or modeling for which the data was collected.

6.6 METHODS TO RECORD DATA AND RESULTS

This information is covered in section 6.4, Data Recording and Data Reduction.

6.7 ACCURACY AND PRECISION

Accuracy and precision for field data collected for this 1:6,000 scale field mapping study will be the same as that for previously published 1:6,000 scale geologic maps for the Yucca Mountain Project (e.g., Day et al., 1998). There are no other pre-defined requirements for the accuracy, precision, and representativeness of the results. Scientists carrying out the work will describe uncertainties and the representativeness of results in the appropriately assigned scientific notebooks, as appropriate.

6.7.1 Experimental/Sampling Artifacts

Not Applicable.

6.7.2 Instrument Calibration and Instrument Error

Cesium-137 measurements and petrologic analyses of samples will be done by qualified measurement laboratories according to YMP QA procedures currently in place. Calibration of instruments will be performed according to manufacturer's practices and guidance and will be documented, along with instrument error, in reporting documents.

6.7.3 Handling Unexpected Results/Conditions

6.7.3.1 Unexpected Results

Because this is largely a set of data collection and deduction exercises, unexpected results play a lesser role than in, say, an engineering or numerical modeling problem. However, unexpected results will be documented in scientific notebooks by observation, attempts to explain the occurrence, and description of alternative methods to resolve the issue, if any resolution is required.

In the case of Cs investigation, should subsequent lab analyses reveal that all samples within the sampled sedimentary column contain Cs, then the sampling profile will be extended to greater depth until Cs-free sediment is identified.

6.7.3.2 Unexpected Conditions

None identified.

6.7.4 Approach for Test Results

Use of test results are described in Sections 5.3.1, 5.3.2, and 5.3.3.

7 INTERFACE CONTROL

7.1 PERFORMANCE ASSESSMENT

The results of the field, laboratory, and analytical studies will be used to provide parameter values, ranges, and uncertainties for direct application in disruptive events analysis and by TSPA. Data reduction will be performed using some of the parameters and the resulting product will be used in disruptive events and TSPA analyses. Parameters will either directly, or through data reduction analyses, support calculation of: relative proportions of explosive vs. non-explosive igneous products, volatile contents of magmas, potential distribution of contaminated ash from a hypothetical eruption through a repository, conduit size and shape, rate of transport of contaminated ash toward and away from a RMEI by eolian and fluvial processes, and grain size distributions for both ash and sediment. .

7.2 DESIGN

The parameters listed above may influence repository design if features are added to the design to mitigate consequences of igneous activity. However, modification of the design in response to the potential disruption by igneous events is unlikely.

7.3 PROCESS MODELS

The results of this work will be incorporated into the revised *Characterize Eruptive Processes at Yucca Mountain, Nevada* report and will support documentation of the disruptive events Eruptive Process Model, which will be revised in FY03. Results may also be used by the ASHPLUME model MR report, which will be a new document developed during FY02-FY03. Conduit diameter data will support development of the model in the *Number of Waste Packages Hit by Igneous Intrusion* AMR (CAL-WIS-PA-000001 REV 00) which will be revised in FY03.

7.4 PARAMETERS

Parameters are listed in Section 7.1 above.

8 MANDATORY HOLD POINTS

No mandatory hold points have been identified for the implementation of this test.

9 SECURITY

Test facility and data security is provided by the DOE/NV Safeguard and Security Division (SSD), YMP/BSC Security Department, and direct security support provided by Wackenhut Services (WSI). All work performed on or near the NTS will be performed in compliance with DOE, YMP/BSC, and WSI security orders/directives.

10 OTHER INFORMATION

Other information related to this test will be contained in scientific notebooks maintained by the project scientists and will be included as portions of a record package or in the final records packages documenting this activity during closeout.

11 REFERENCES

BSC, 2001, *Technical Work Plan for Igneous Activity Analyses for Disruptive Events* OCRWM Plan: TWP-WIS-MD-000007, Rev. 00. MOL.2001213.0111

BSC, 2002, *Natural Analogue Synthesis Report* TDR-NBS-GS-000027. Las Vegas, Nevada: CRWMS M&O. (in process).

CRWMS M&O, 2000a, *Characterize Eruptive Processes at Yucca Mountain, Nevada* ANL-MGR-GS-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000517.0259

CRWMS M&O, 2000b, *Number of Waste Packages Hit by Igneous Intrusion* CAL-WIS-PA-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000602.0054

Day, W.C.; Potter, C.J.; Sweetkind, D.S.; Dickerson, R.P.; and San Juan, C.A. 1998, *Bedrock Geologic Map of the Central Block Area, Yucca Mountain, Nye County, Nevada.* Miscellaneous Investigations Series Map I-2601. [Washington, D.C.]: U.S. Geological Survey. ACC: MOL.19980611.0339

DOE, 2002, *Yucca Mountain Science and Engineering Report*, REV 01, DOE/RW-0539-1, Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

Esp, M., 2002 (in preparation), *Disruptive Events Field Investigations*, FWP-SB-02-002, Rev. 0.

Krier, D., 2001, "*Meeting Summary Igneous Activity Tech Exchange.*" E-mail from D. Krier to J. Burford, September 7, 2001, with attachments. ACC: MOL.20010914.0199