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Integrated Technical Strategy

Environmental Restoration Project
A Department of Energy Environmental Cleanup Program

Los Alamos
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TABLE OF CONTENTS

1.0 INTRODUCTION 1-1
1.1 Purpose 1-1
1.2 Regulatory Framework 1-2
1.3 Watershed Approach 1-4
1.4 Integration with Laboratory Environmental Protection Entities 1-4
1.4.1 Environmental Working Group 1-4
1.4.2 Hydrogeologic Work Plan 1-6
1.4.3 Watershed Management Plan 1-6
1.4.4 Habitat Management Plan 1-7
1.5 Definitions 1-7

2.0 TECHNICAL STRATEGY AND IMPLEMENTATION 2-1
2.1 Watershed Integration 2-1
2.2 Risk Management 2-5
2.3 Risk Assessment 2-7
2.4 Conceptual Models 2-8
2.4.1 Facility, Land Use, and Exposure Profile 2-9
2.4.2 Ecological Profile 2-13
2.4.3 Physical Profile 2-17
2.4.4 Release Profile 2-20
2.4.5 Risk Management Profile 2-21
2.5 Exposure Models 2-21
2.5.1 Air 2-22
2.5.2 Surface Soil and Sediment 2-22
2.5.3 Surface Water 2-22
2.5.4 Alluvial Groundwater 2-24
2.5.5 Deep Groundwater 2-24
2.6 Investigation Approach 2-24
2.6.1 Soil and Sediment 2-25
2.6.2 Surface Water 2-26
2.6.3 Groundwater 2-26
2.6.4 Biotic Sampling 2-26
2.7 Computational Models 2-27
2.7.1 Process Models 2-28
2.7.2 Systems Models 2-28
2.7.3 Sensitivity and Uncertainty Analyses 2-28

3.0 INTEGRATED INFORMATION MANAGEMENT SYSTEM 3-1
3.1 Integrated Information Management Plan 3-1
3.2 Data Stewardship 3-3
3.2.1 Legacy Data 3-4
3.2.2 Non-ER Project Data 3-4
3.2.3 Modeling Data 3-5
3.3 Integrated Institutional Databases 3-6
3.4 Data Set Preparation 3-6

4.0 WATERSHEDS AND AGGREGATES 4-1
4.1 Identification of Watershed Aggregates 4-1
4.2 Documentation 4-1
4.3 Physical Descriptions of Watersheds 4-4
4.3.1 Los Alamos/Pueblo Watershed 4-4
4.3.2 Mortandad Watershed 4-7
4.3.3 Water/Cañon de Valle Watershed 4-11
4.3.4 Sandia Watershed 4-16
4.3.5 Pajarito Watershed 4-19
4.3.6 Ancho Watershed 4-23
4.3.7 Chaquehui Watershed 4-27
4.3.8 Frijoles Watershed 4-27

5.0 LONG-TERM SURVEILLANCE AND MAINTENANCE 5-1
5.1 Strategy 5-1
5.1.1 Surface Water 5-2
5.1.2 Vadose Zone 5-3
5.1.3 Groundwater 5-3
5.2 ER Project Closeout Plan 5-4

6.0 ER PROJECT PLANS AND REPORTS 6-1
6.1 Integrated Sampling and Analysis Plans 6-1
6.2 Integrated RFI Reports 6-1
6.3 Corrective Actions Reports 6-2
6.4 Watershed Completion Reports 6-2

7.0 REFERENCES 7-1

List of Figures

Figure 1.2-1. Integrated technical strategy and ER Project documents 1-3
Figure 1.4-1. Integrated technical strategy and other environmental protection entities 1-5
Figure 2.0-1. Watersheds draining the Pajarito Plateau 2-2
Figure 2.1-1. Integration of subsystems considered in the watershed approach to corrective actions 2-3
Figure 2.2-1. Decision points in the corrective action process 2-6
Figure 2.4-1. Current access controls within watersheds and aggregates 2-10
Figure 2.4-2. Proposed future land-use areas 2-11
Figure 2.4-3. Land transfer parcels in relation to the watersheds and aggregates 2-12
Figure 2.4-4. Planned locations of regional groundwater monitoring wells and existing monitoring, test, and observation wells 2-14
Figure 2.4-5. Existing surface water sampling locations in relation to watershed aggregates 2-16
Figure 3.0-1. IIMS activities and organizations 3-2
Figure 4.1-1. Watershed and aggregate map 4-2
Figure 4.3-1. Los Alamos/Pueblo watershed aggregates 4-5
Figure 4.3-2. Mortandad watershed aggregates 4-9
Figure 4.3-3. Water/Cañon de Valle watershed aggregates 4-13
Figure 4.3-4. Sandia watershed aggregates 4-17
Figure 4.3-5. Pajarito watershed aggregates 4-21
Figure 4.3-6. Ancho watershed aggregates 4-25
Figure 4.3-7. Chaquehui watershed 4-29
Figure 4.3-8. Frijoles watershed 4-30

List of Tables

Table 2.4-1 Regional Wells, Associated Watershed Aggregates, and Upgradient TAs 2-15
Table 4.1-1 Watersheds, Aggregates, and Associated PRSs 4-3

List of Acronyms and Abbreviations

AEI	area of environmental interest
BMP	best management practice
CDM	central data management
CMI	corrective measures implementation
CMS	corrective measures study
COPC	chemical of potential concern
D&D	decontamination and decommissioning
DARHT	dual-axis radiographic/radiography hydrotest
DCG	derived concentration guides
DOE	US Department of Energy
EPA	US Environmental Protection Agency
ER	environmental restoration
ERDB	environmental restoration (project) database
ESH	environment, safety, and health
EWG	environmental working group
FE	facilities engineering
FEHM	Finite Element Heat and Mass computer code
FIMAD	Facility for Information Management, Analysis, and Display
FM	facility management
FSF	field support facility
FY	fiscal year
GAE	general assessment endpoint
GEDD	general electronic data deliverable
GIS	Geographical Information System
GWDB	groundwater database
HE	high explosive
HMP	Habitat Management Plan
HSWA	Hazardous and Solid Waste Amendments
IIMP	integrated information management plan
IIMS	Integrated Information Management System
IM	interim measure
ITS	Integrated Technical Strategy
IWP	installation work plan
MDA	materials disposal area

NEPA	National Environmental Policy Act
NFA	no further action
NM	New Mexico
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
NRDA	Natural Resource Damage Assessment
OU	operable unit
PAD	Programmatic Assumptions Document
pdf	probability distribution functions
PEF	particulate emission factor
PRG	preliminary remediation goals
PRS	potential release site
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RIP	Repository Integration Program
RIP	Repository Integration Program
RLWTF	Radioactive Liquid Waste Treatment Facility
SAL	screening action level
SAP	sampling and analysis plan
SOP	standard operating procedure
STP	sewage treatment plant
SWAT	surface water assessment team
SWPP	Stormwater Pollution Prevention Plan
SWSC	sanitary wastewater system consolidation
T&EHMP	threatened and endangered species habitat management plan
TA	technical area
UC	University of California
VCA	voluntary corrective action
VCM	voluntary corrective measure
VF	volatilization factor
WMDB	Watershed Management Program database
WMP	Watershed Management Plan

1.0 INTRODUCTION

The Los Alamos National Laboratory (the Laboratory) Environmental Restoration (ER) Project reorganized in fiscal year (FY) 1998 to a matrix management system that consists of five focus areas: Canyons, Materials Disposal Areas (MDAs), Remedial Actions, Regulatory Compliance, and Analysis and Assessment. Three of these focus areas—called operational focus areas (Canyons, MDAs, and Remedial Actions)—are responsible for implementing corrective actions in the field. Two other focus areas (Regulatory Compliance, Analysis and Assessment) are tasked with ensuring consistency, compliance, and expediency in regulatory, technical, and configuration and quality issues that affect the operational focus areas. The matrix management structure has done much to strategically integrate activities across the operational focus areas. Subsequent to restructuring, in FY1999 the project completed a strategic plan, which objectively identified a preferred (i.e., compliant and cost-effective) path to completion. To formally implement this strategic path to completion, the project currently is rewriting its master project schedule. The integrated technical strategy was developed in response to project reorganization, strategic planning, and project scheduling.

In addition, the integrated technical strategy incorporates recommendations of the FY1999 independent cost estimate review, and meets a performance measure within Appendix F of the US Department of Energy/University of California (DOE/UC) contract by achieving these objectives:

- Establish objective decision criteria for completing corrective actions at individual potential release sites (PRS), an aggregate of PRSs, and, ultimately, a watershed comprising multiple aggregates.
- Integrate human-health, ecological, surface water, and groundwater considerations within a common decision framework.
- Provide data collection criteria that are based on applicable decision criteria.
- Tier to institutional natural resource management plans and ER Project plans.
- Establish a technical basis for prioritizing ER Project work.

This document is the project's basic interim planning tool for implementing a formal integrated technical strategy. The strategy will be incorporated into the installation work plan in FY2000, which then will become the single planning document for completing the ER Project in compliance with Module VIII of the Laboratory's Resource Conservation and Recovery Act (RCRA) Hazardous Waste Facility Permit (the Permit).

1.1 Purpose

This document is an interim tool for planning and implementing the requirements of the Permit in a manner consistent with the ER Project's strategic plan, incorporating emerging New Mexico Environment Department (NMED) and US Environmental Protection Agency (EPA) policies and guidance on risk-based corrective action. The basis of integration is a watershed approach to corrective actions. The technical strategy integrates work elements within the three operational focus areas (i.e., MDAs, Canyons, and Remedial Actions) to ensure protectiveness on adequate spatial and temporal scales that

recognize the mobility, toxicity, and persistence of potentially interactive contaminants, and the spatial distribution of potential receptors.

To successfully integrate risk-based decisions at the larger scales of PRS aggregates and watersheds, the strategy also integrates

- field investigations performed by various ER Project teams,
- assessments performed to evaluate ecological and human health risk,
- corrective action decisions,
- planning among ER Project focus areas, and
- institutional environmental protection and compliance programs.

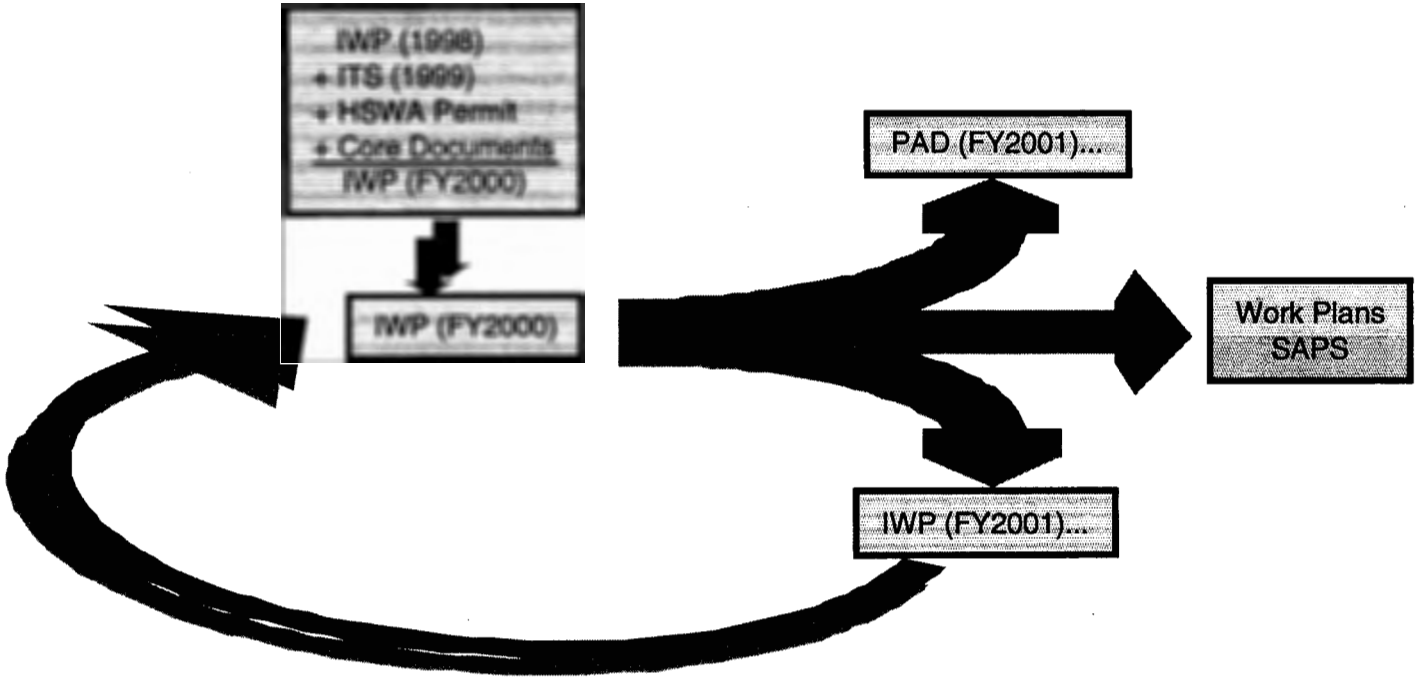
1.2 Regulatory Framework

Module VIII of the Laboratory's Hazardous Waste Facility Permit substantially incorporates EPA's proposed Subpart S to RCRA. Subpart S provides guidance at a national level for implementing a graded risk-based corrective action process.

The Laboratory's current Permit will expire in November 1999 and the Laboratory and NMED currently are negotiating its renewal; those negotiations are expected to continue into FY2000. It is expected that the renewed permit will continue to incorporate the Subpart S framework. The yet-to-be-drafted permit is also expected to address many critical elements of the integrated technical strategy discussed in Section 2 of this document, including

- a graded risk-based corrective action process,
- a watershed approach,
- PRS aggregation within watersheds, and
- characterization of groundwater contamination in the context of PRS corrective action.

The ER Project draft installation work plan (IWP) describes in general how the corrective action process is implemented in a manner that is compliant with the Permit (LANL 1998, 62060). The DRAFT IWP documents ER Project plans and procedures that apply equally to all PRS-specific corrective-action activities, such as quality control/quality assurance (QA/QC), worker health and safety, waste management, and public outreach. The IWP is supplemented by "core" documents, which describe technical approaches for similar types of sites (i.e., MDAs) and systems (i.e., Canyons), and by RCRA facility investigation (RFI) work plans and sampling and analysis plans (SAPs), which detail specific plans for investigating specific sites. As components of the integrated technical strategy, elements of the core documents for MDAs and canyons will be incorporated into the IWP in FY2000. Thereafter, the IWP will function as the principal planning document for completing the ER Project, and will be revised annually, or as necessary. The IWP will be implemented through work plans and SAPs. Specific assumptions affecting implementation will documented in the programmatic assumptions document, a "living" document supporting baseline development. Figure 1.2-1 illustrates the relationships among this document, core documents, work plans, and the IWP.



HSWA = Hazardous and Solid Waste Amendments
ITS = Integrated Technical Strategy
IWP = Installation Work Plan
PAD = programmatic assumptions document

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Figure 1.2-1. Integrated technical strategy and ER Project documents

1.3 Watershed Approach

In the past, the Laboratory's ER Project has made corrective-action decisions for individual sites based on one of three criteria: imminent or potential human health risk, imminent or potential ecological risk, or potential for contaminant mobilization by surface water. While this approach was both compliant and protective, it did not recognize the physical systems of which individual PRSs are a part. In FY1999, the ER Project reengineered its approach to become more systems-oriented, using the natural watersheds across the Laboratory installation to delineate discrete systems (aggregates) within which multiple PRSs will be investigated, assessed, and (if necessary) remediated together. This approach will gain efficiencies in characterization, assessment, and reporting, and will ensure protectiveness at a scale that accounts for potential cumulative impacts of multiple contaminant sources.

As described by the EPA, "Focusing on the whole watershed helps strike a balance among efforts to control point source pollution and polluted runoff, and protect drinking water sources and sensitive natural resources such as wetlands. A watershed focus also helps to identify the most cost-effective pollution control strategies [including corrective actions] to meet clean water goals. Working at the watershed level encourages the public to get involved in efforts to restore and protect their water resources and is the foundation for building strong clean water partnerships. The watershed approach is the best way to bring state, tribal, federal, and local programs together to more effectively and efficiently clean up and protect waters" (*33 USC §1251 et seq.*).

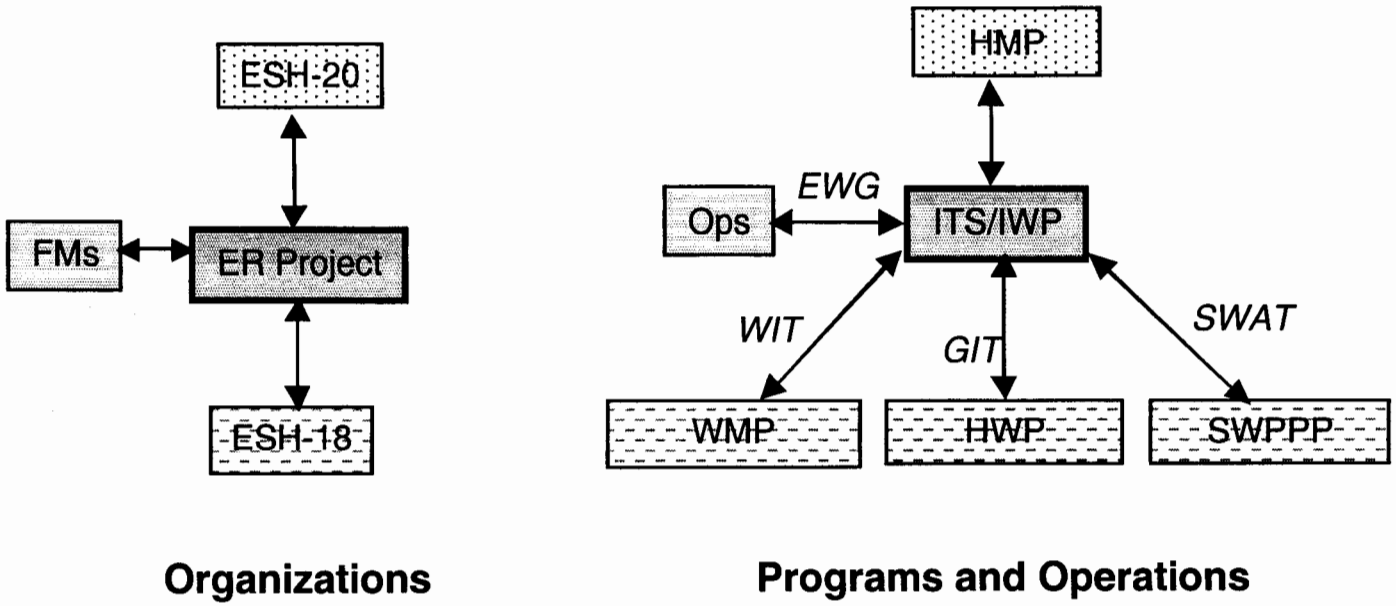
Through early and continuous interaction with the administrative authorities and outreach to stakeholders, the ER Project will identify and clarify issues that affect prioritization, selection, and implementation of investigations and, if necessary, corrective actions, within a watershed. Among the stakeholders with whom the ER Project will interact are federal and tribal representatives who can help establish the most appropriate context for risk assessment consistent with resource management and land-use priorities.

1.4 Integration with Laboratory Environmental Protection Entities

As currently envisioned, the ER Project will complete the corrective action process over the next decade. To maintain protectiveness and to ensure accountability after completion, the ER Project will formally integrate long-term maintenance and monitoring with institutional environmental protection and compliance programs. In addition, investigations and corrective actions have been and will continue to be performed in the context of environmental stewardship in collaboration with ongoing Laboratory programs and operations. Figure 1.4-1 illustrates the relationships between the programs and organizations briefly described in the following paragraphs.

1.4.1 Environmental Working Group

In March 1999, the Laboratory Director's Office established an environmental working group (EWG) to facilitate more effective communications and coordination among major environmental programs and operations. The EWG nominally consists of representatives from legal counsel; facility management; regulatory compliance programs for air, water, ecology, RCRA, National Environmental Policy Act (NEPA), and the Natural Resource Damage Assessment Act (NRDA); environmental stewardship; waste management; and environmental restoration. The ER Project and the EWG will forge enduring, documented commitments among Laboratory programs to maintain and ensure the protectiveness of corrective actions, including institutional control and long-term surveillance, maintenance, and monitoring.



ESH = Environment, Safety, and Health (Laboratory Division)
EWG = environmental working group
FM = facility management
GIT = groundwater integration team
HMP = Habitat Management Plan
HWP = Hydrogeologic Workplan
ITS = Integrated Technical Strategy
IWP = Installation Work Plan
Ops = operations
PAD = programmatic assumptions document
SWAT = surface water assessment team
SWPPP = Stormwater Pollution Prevention Plan
WIT = watershed integration team

F1.4-1 / ITS / 063099 / PTM

Figure 1.4-1. Integrated technical strategy and other environmental protection entities

1.4.2 Hydrogeologic Work Plan

The Laboratory's Water Quality and Hydrology Group (ESH-18) submitted, and the NMED approved, the hydrogeologic work plan in 1998 (LANL 1998, 59599). The hydrogeologic work plan describes how the Laboratory intends to characterize its hydrogeologic setting and monitor its hydrologic resources. The hydrogeologic work plan also describes the conceptual model of the Laboratory's hydrogeologic setting. The conceptual model is updated annually in the groundwater annual status report, based on the results and interpretation of data obtained through the sequential installation of groundwater monitoring wells (LANL 1999, 63516).

The integrated technical strategy will use hydrogeologic work plan data to support corrective action decisions. The integrated technical strategy also will use the results of ER Project analyses and assessments to sequence the installation and prioritize the placement of regional groundwater monitoring wells. This close interaction between the ER Project and the hydrogeologic work plan will be accomplished through the project's continued participation in groundwater integration team activities.

The groundwater integration team is a forum for technical exchange and coordinated planning for the different Laboratory organizations involved with groundwater issues. The primary objective of the hydrogeologic work plan is to characterize subsurface water flow and improve the conceptual and quantitative understanding the groundwater system. The groundwater integration team focuses on characterizing regional aquifer flow and defining recharge pathways to the regional aquifer. The ER project will need to assess the potential for contaminant transport to the regional aquifer and potential impacts on water supply wells and groundwater adjacent to the laboratory. These assessments cannot be performed in a meaningful way without the knowledge gained through the hydrogeologic work plan activities. A secondary objective of the hydrogeologic work plan is to investigate occurrences of contamination in the subsurface. Wells installed through the hydrogeologic work plan will provide contaminant nature-and-extent information that can be used to more efficiently scope additional nature-and-extent activities. Finally, many (if not all) hydrogeologic work plan wells will be used for long-term groundwater monitoring.

1.4.3 Watershed Management Plan

The Laboratory's draft watershed management plan (WMP) describes proposed surface water monitoring activities in each of the watersheds included in the integrated technical strategy (LANL 1999, 62920). An extensive network of weir and water sampling stations is being installed that will allow characterization of flow and transport of contaminants in the canyons at the Laboratory. The WMP contains details of the drainage characteristics and sampling locations for each watershed. The sampling program will provide useful characterization information on surface flow and contaminant transport. During the lifetime of the ER Project, the data collected will help identify problem areas and to confirm that stabilization and remediation strategies have been implemented properly. Long-term monitoring is an equally important part of the WMP in terms of project needs by ensuring that any contamination in watersheds remains at acceptable levels and if not, that remediation/stabilization measures will be implemented.

The surface-water monitoring network described in the draft WMP will support ER Project efforts by providing monitoring data complementary with the scale of PRS aggregates. The location of surface water monitoring stations, typically at the downstream boundaries of aggregates, ideally compartmentalizes the drainage such that contaminant signatures can be more easily traced back to their origins.

The draft WMP proposes convening a watershed integration team to (1) identify drainages affected by Laboratory operations; (2) understand the consequences of Laboratory operations in terms of water quality; (3) implement a watershed planning and management structure; and (4) identify and implement appropriate corrective measures.

The ER Project also coordinates with the draft WMP through implementation of draft Standard Operating Procedure (SOP) LANL-ER-SOP-2.01, "Surface Water Site Assessments." This SOP provides a systematic approach for identifying potential impacts of contaminant migration from a PRS via stormwater runoff erosion. A surface water assessment team (SWAT) was established to provide recommendations for the installation of best management practices (BMPs) at PRSs, based on SOP 2.01 scores in combination with an assessment of the contaminants present at the site. The SWAT consists of representatives from the ER Project, Water Quality and Hydrology Group (ESH-18), the NMED Surface Water Quality Bureau, the NMED DOE Oversight Bureau, and Laboratory Facility Management. Recommendations are provided to the ER Project and Facility Management for evaluation and implementation, if necessary.

1.4.4 Habitat Management Plan

The Laboratory's habitat management plan (HMP) characterizes the habitat across the Pajarito Plateau to help program and project managers plan activities that are protective of sensitive biological communities. The ER Project will use the HMP to implement the integrated technical strategy, using maps of core and buffer zones for sensitive habitats in the assessment phase to identify sensitive receptors, in the investigation phase to plan fieldwork in the least disruptive manner, and in the remediation phase to promote restoration.

1.5 Definitions

This section includes definitions that may be unique to this document.

aggregate Physical delineation within a watershed that is used for grouping contaminated sites for the purposes of planning and implementing the Laboratory's ER Project corrective action process in a more efficient and systems-oriented manner.

background contamination Contamination in environmental media that predates releases from project sites; required to distinguish between contaminated and noncontaminated media for environmental investigations conducted at the Laboratory, to establish cleanup levels, and to parameterize contaminant fate and transport models.

baseline contamination Contamination in environmental media associated with Laboratory and commercial processes that are present, but not necessarily related to, project sites and required to define nature and extent of contamination for environmental investigations conducted at the Laboratory; and to establish cleanup levels.

complex site Site comprising one or more PRSs within an aggregate that has one or more of the following features:

- multiple contaminants,
- multiple exposure pathways,

- potential for interaction with other sources,
- a requirement for innovative or engineered approaches to remediation, and
- a requirement for long-term surveillance and maintenance.

corrective action process One or more of a series of activities (initial site assessment, site characterization, interim actions, evaluation of remedial alternatives, and implementation of selected remedy); also refers to RCRA facility assessments, RFIs, corrective measures studies, and corrective measures implementation (CMI).

cumulative risk Risk that integrates multiple sources, effects, pathways, and contaminants, through common human and ecological receptors, points of compliance, and/or times of compliance.

groundwater Water existing in geologic media below the ground surface; occurs in three forms beneath the Pajarito Plateau:

alluvial water—Shallow groundwater contained in canyon bottom alluvium, usually under perched conditions.

perched water—Groundwater in a saturated zone that lies some distance above the regional water table.

regional aquifer—Geologic material containing the regional water table and the continuous saturated zone.

model In this document, a numerical calculation or simulation of one or more unobservable processes, including the fate and transport of contaminants in the environment and the consequences (risks) of these contaminants on living organisms (including humans) and ecosystems.

nature and extent of contamination How much of what kind of contaminant from an ER Project source is present in which environmental media over which dimensions.

nature—Chemicals that are present in or have been released to the environment; determined by detection of a chemical in one or more environmental samples. In the case of naturally occurring or widespread anthropogenic chemicals, "detection" should be interpreted as detection above background or baseline concentrations.

extent—How much of a given chemical is present in the environment and where it is; inferred from measurements of chemical concentrations in environmental samples. "How much" is estimated as total inventory or by the maximum observed concentration; "where" must be answered both in terms of which environmental media are affected and by estimates of the boundary of the affected volume (both area and depth).

residual contamination Anthropogenic constituents remaining in environmental media after completion of corrective actions by the ER Project.

stream Water naturally flowing on the ground surface; in this document, two categories are important:

ephemeral stream—Stream or reach of a stream that flows briefly only in direct response to precipitation or snowmelt on the immediate locality; its channel bed is always above the water table of the region adjoining the stream.

perennial stream—Stream or reach of a stream that flows continuously throughout the year in all years; its upper surface generally is lower than the water table of the region adjoining the stream. Syn: permanent stream, live stream.

2.0 TECHNICAL STRATEGY AND IMPLEMENTATION

Eight watersheds of the Pajarito Plateau cross the Laboratory boundary and drain to the Rio Grande. These watersheds, shown in Figure 2.0-1, comprise physical and biological systems that may be impacted by historic and current operations of the Laboratory.

Each watershed represents an independent system with respect to surface water processes and (to a lesser but significant extent) habitats. These independent surface water systems interact at varying degrees with subsurface groundwater systems through the process of recharge. The larger watersheds include several subbasins that drain surface water separately from specific mesas. The ER Project uses these smaller drainages, in general, to define spatial aggregates in planning, prioritizing, and implementing corrective action activities that are consistent with the preferred path to completion. This preferred path has been identified through strategic planning for the ER Project (LANL 1999, 63448).

Ultimately, corrective actions will be completed to ensure the long-term protection of human and ecological receptors from residual contamination (i.e., contamination remaining in environmental media after completion of corrective action) within a watershed. This will be accomplished by

- assessing cumulative risk (i.e., human health and ecological risk from all sources, through all pathways and exposure routes) from all residual contaminants that have the potential to affect common receptors, and
- monitoring environmental media for significant mobilization of residual contamination, with contingencies established to respond if action thresholds are exceeded.

2.1 Watershed Integration

The ER Project will use watersheds as its framework for completing corrective actions. Watersheds are natural integrators of important environmental transport pathways—surface water, groundwater, and air. Any given watershed or aggregate may contain multiple PRSs—some on mesa tops, some on hillsides, and some on canyon floors. The physics of surface water hydrology naturally integrates contamination within a watershed: Given sufficient flux, water may dissolve many contaminants, and mobilize insoluble or particulate constituents as sediments. Regarding groundwater, the vast majority of groundwater recharge occurs beneath watersheds. Soluble contaminants collected by surface water thereby may be transported by recharge into groundwater systems. Finally, watersheds may integrate wind-borne contaminants from multiple sources by channeling winds and entrained contaminants. Figure 2.1-1 illustrates the relationship between the physical transport subsystems that are naturally integrated within a watershed.

To initiate an integrated watershed approach to corrective actions, the ER Project has accomplished these activities:

- delineation of watersheds that drain Laboratory property;
- subdivision of large watersheds into geospatial aggregates;
- assignment of all PRSs to watersheds or aggregates within watersheds;
- prioritization of watersheds and aggregates for planning work; and
- description of work elements necessary to complete corrective actions for aggregates and watersheds.

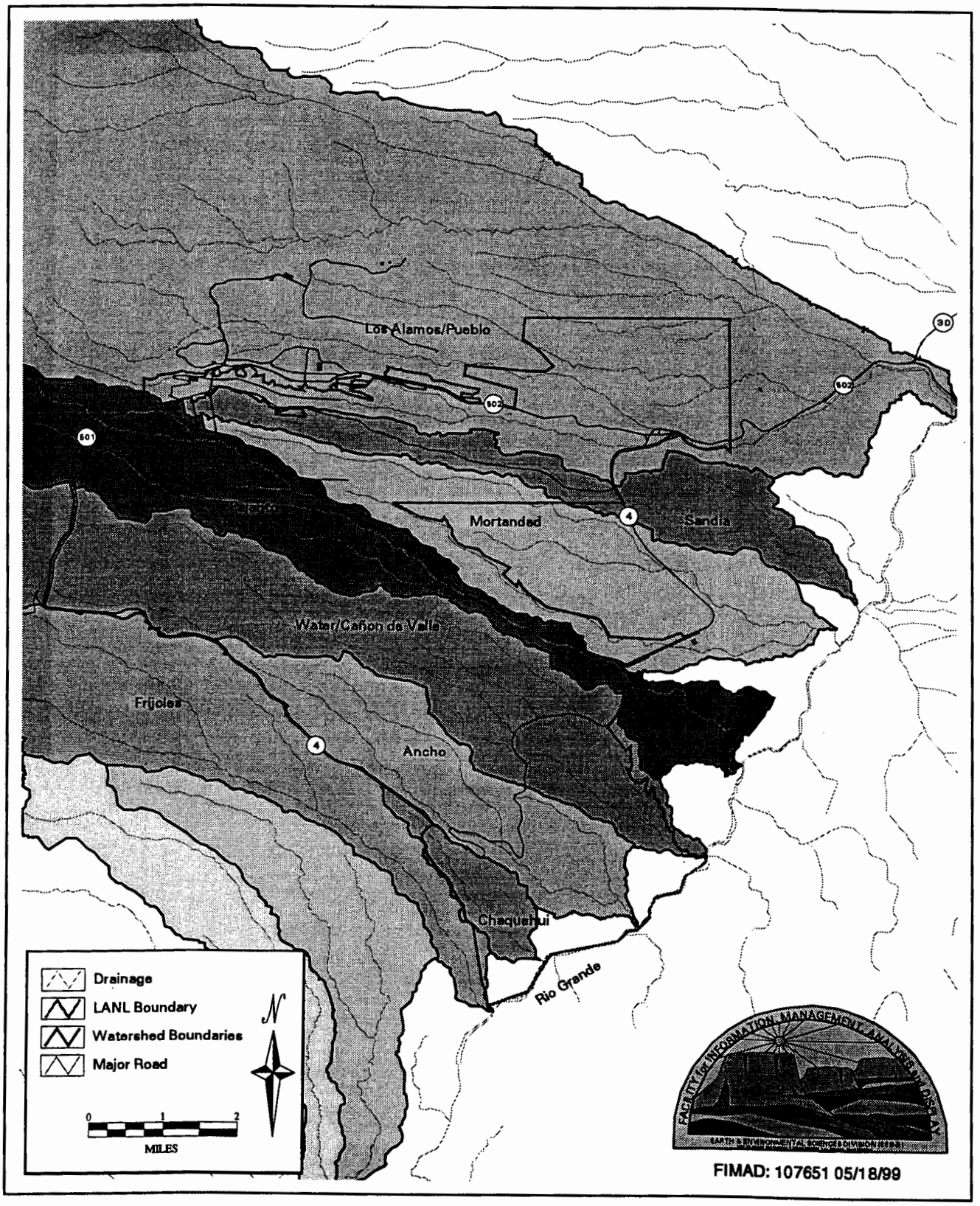


Figure 2.0-1. Watersheds draining the Pajarito Plateau

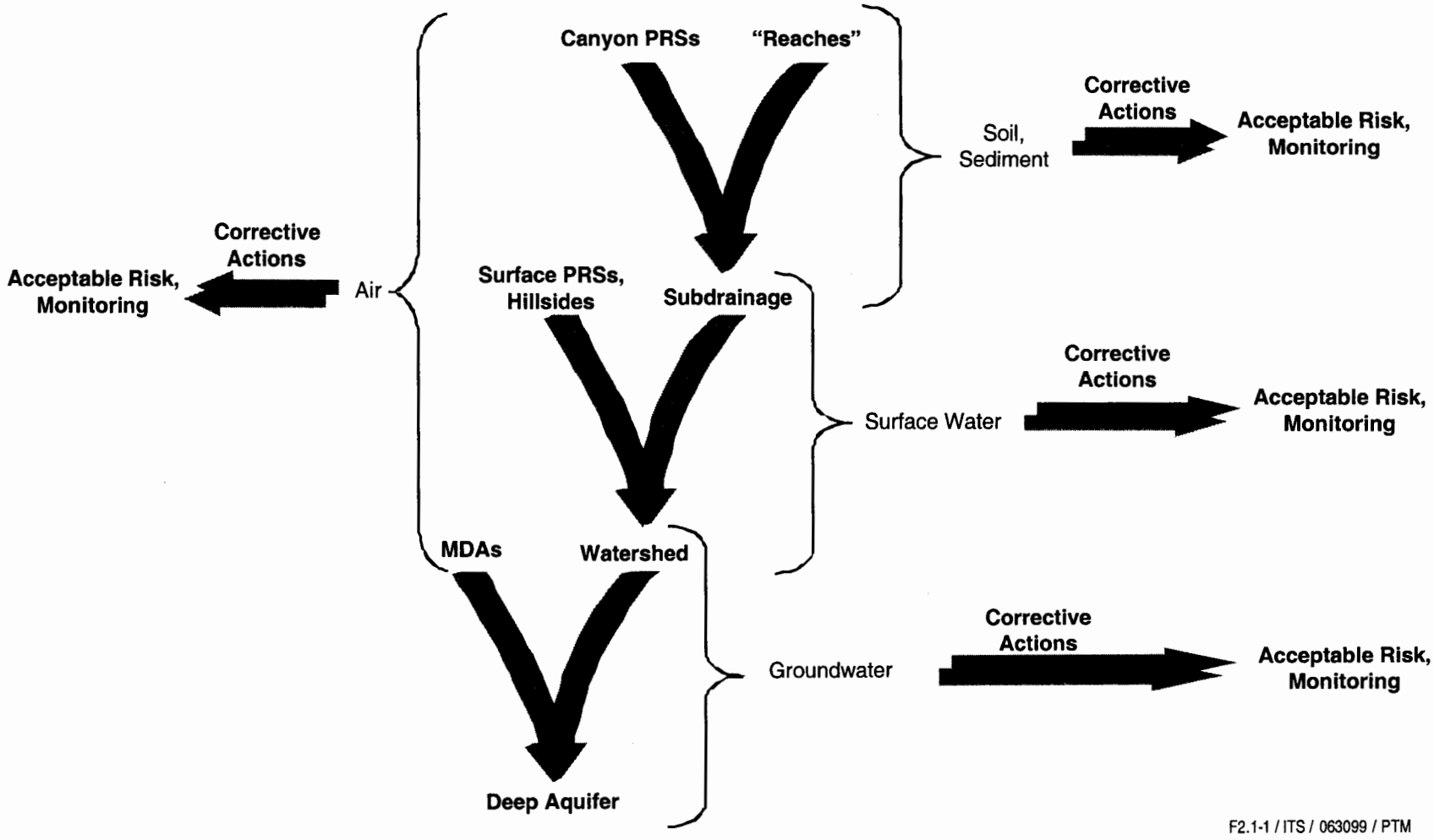


Figure 2.1-1. **Integration of subsystems considered in the watershed approach to corrective actions**

To implement the integrated technical strategy, standard approaches to the following activities will be developed and documented:

- combining data sets from multiple PRSs and non-ER resources;
- performing risk assessments for multiple sources and multiple pathways;
- integrating investigations across PRS and focus area boundaries to fill significant data gaps, as necessary, to perform the multi-source, multi-pathway risk assessment; and
- developing conceptual exposure models for each watershed, incorporating data from aggregate investigations and assessments, Canyons investigations, institutional biological assessments, and air, surface water, sediment, and groundwater monitoring programs.

These standard approaches will be implemented to perform the following general sequence of activities to complete corrective actions:

- For each aggregate,
    1. assemble and interpret environment, safety, and health (ESH) surveillance data and up-to-date ER Project investigations data to characterize the natural system (i.e., hydrogeology, ecology);
    2. formulate a conceptual site exposure model that incorporates contaminant and natural-systems characterization data, identifying common transport and exposure pathways that effectively "link" individual PRSs within an aggregate;
    3. complete Canyons Focus Area surface and subsurface investigations, consistent with the technical approach described in the core document for canyons investigations (LANL 1997, 62316);
    4. complete the Phase 1 RFI for any MDAs, consistent with the technical approach described in the MDA core document (in preparation);
    5. assemble and screen contaminant data from all non-MDA PRSs to identify chemicals of potential concern (COPCs);
    6. modify the conceptual site exposure model, as appropriate, to reflect new information;
    7. evaluate imminent risk to human and ecological receptors based on present-day nature and extent of contamination at a PRS, MDA, or canyon reach; and
    8. implement corrective actions (i.e., interim measures [IMs], voluntary corrective actions [VCAs], voluntary corrective measures [VCMs]) within aggregates, as necessary, to reduce imminent risks.
- For each watershed,
    1. evaluate the potential future cumulative risk resulting from air and water transport of residual PRS contamination within, between, and beneath a watershed, using fate and transport models;

2. implement corrective actions within aggregates, as necessary, to reduce potential cumulative future risk from residual contamination;

3. establish long-term maintenance and monitoring programs based on projected risk-limiting pathways within a watershed, including action thresholds and contingencies; and

4. monitor environmental media within watersheds for residual contaminants of concern at locations and frequencies most likely to serve as early indicators of potential risk.

2.2 Risk Management

The ER Project risk-management strategy focuses on a single end-state vision:

> Upon completion of corrective actions; residual contamination left in place after final actions is and will remain below acceptable-risk thresholds; long-term surveillance and maintenance are implemented by the Laboratory; and sensitive ecosystems are preserved.

To reach this end-state across the 43-mi^2 (97 km^2) Laboratory installation and adjacent lands requires integrated investigations, assessments, and decisions across the operational focus areas to evaluate the effect of contamination within impacted natural systems. Investigations are designed to characterize contaminants and the systems in which they reside to support credible risk assessments. Risk assessments are designed to provide risk managers with information to evaluate alternative decisions. Alternative decisions may include source removal, in situ source stabilization, access controls, intrinsic remediation, long-term surveillance and maintenance, or combinations of these approaches. Investigations and assessments are technical activities, the outcome of which influences but does not define an alternative decision.

Figure 2.2-1 illustrates high-level sequencing of risk-based decision points within the ER Project's approach to integrated corrective actions within watersheds.

The ER Project conducts an initial assessment to identify contamination that poses imminent substantial endangerment and warrants expedited action (i.e., VCA, VCM, IM). Beyond those actions, the emphasis of the integrated technical strategy is to evaluate impacts of environmental contamination from a systems perspective. This emphasis requires the timely completion of Canyons Focus Area investigations of surface and subsurface media. Completing the Canyons' investigations is a prerequisite to completing the conceptual exposure models for potentially interacting contaminant sources (including active Laboratory and commercial facilities).

The next assessments are at the aggregate level, using data from multiple PRSs joined by common exposure pathways. These data, in combination with local background or industrial baseline data (see Section 2.43), support decisions to reduce potential risks by remediating PRSs or aggregates. The final assessment for a watershed relates to cumulative risks over space and time. These assessment decisions require fate and transport modeling to support future risk estimates and risks associated with contaminants in the vadose zone and deeper groundwater. In watersheds where substantial contaminant inventories are left in the environment, modeling results support decisions to perform further corrective actions and/or design long term monitoring.

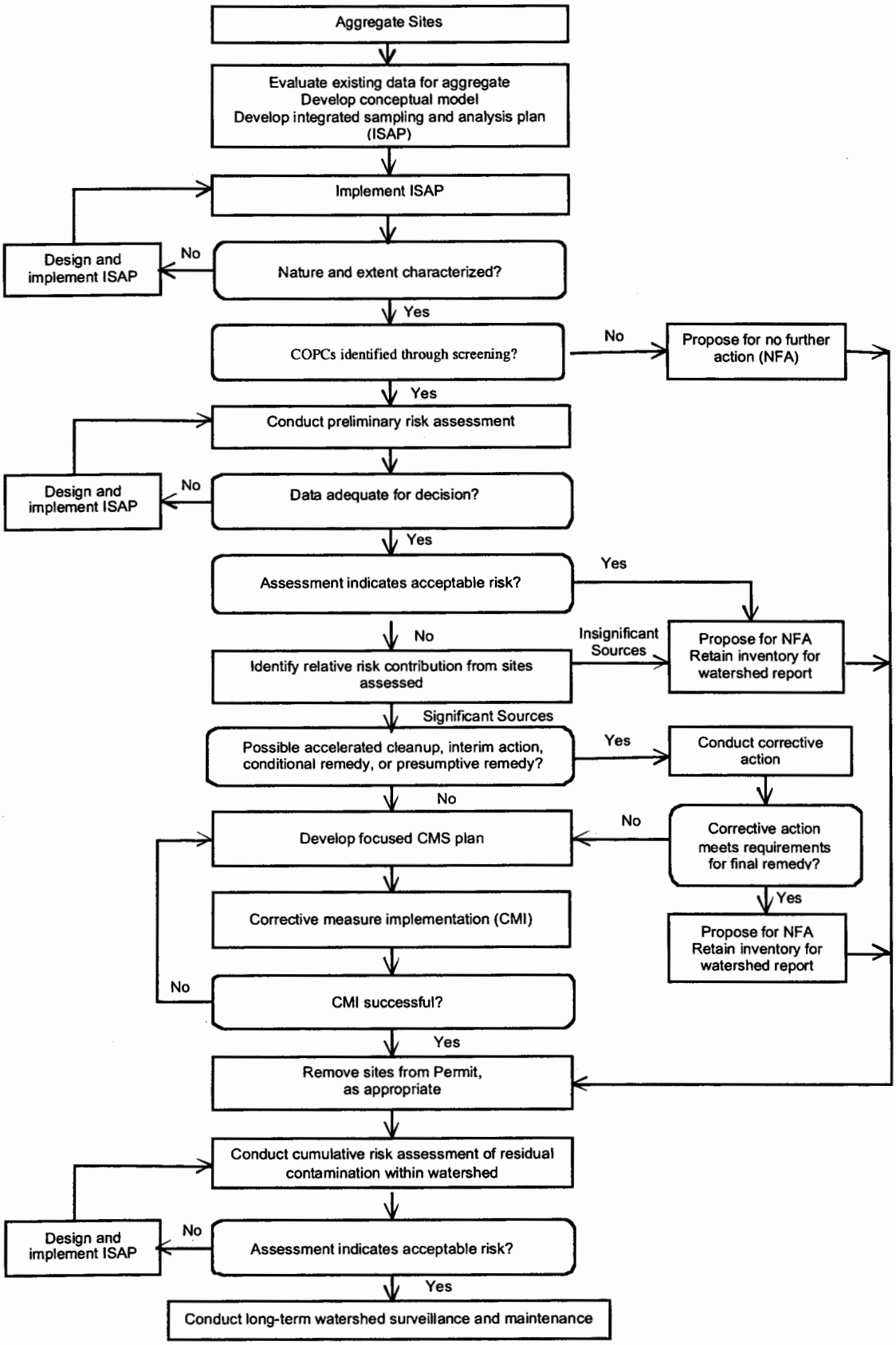


Figure 2.2-1. Decision points in the corrective action process

Depending on data analysis and risk assessment results, the surface ecosystem, the vadose zone, and the deep groundwater may be treated as separate compartments and may be decoupled in the decision-making process. This is because the time horizon to recognize and respond to a problem in an observable ecosystem is much shorter than the time horizon to recognize and respond appropriately to contamination within the vadose zone or the deep groundwater. Making decisions that are fully integrated across the surface ecosystem, the vadose zone, and deep groundwater may unnecessarily delay surface-related actions. At the completion of a watershed, the ecosystem, vadose zone, and deep groundwater will be recoupled (i.e., assessed together) in a cumulative risk assessment.

As management decisions are made for selecting a final remedy and/or final cleanup levels, the risk consequences for human and ecological health will be integrated. Integrated risk-based decisions will balance the consequences of leaving contaminants in place with the consequences of the physical (from source removal) or chemical (from onsite treatment) effects of implementing remediation. In implementing the integrated technical strategy, both preferred remedies and final cleanup levels will be optimized in the context of both physical disruption and risk reduction at appropriate spatial scales. The EPA remedy-selection criteria provide the basis for evaluating and optimizing alternative clean-up levels and final remedies (EPA 1988, 63513).

2.3 Risk Assessment

In implementing the integrated technical strategy, the investigation-assessment-decision process graduates in scope until acceptable risk is ensured across the impacted landscape (i.e., aggregate or watershed). Integrated assessment areas within aggregates will be defined after contaminant data from PRSs within an aggregate are analyzed within the context of the physical system, which is partially defined by Canyons investigation results. Investigation and assessment boundaries may be limited to a single PRS, or may encompass MDAs, PRSs, drainages, and canyon floors. Scope will depend upon the features, events, and processes that may result in risk-significant exposures. Risk-significant exposures are defined by the characteristics of the contaminants, the natural system within which they reside, and human factors such as land use. These characteristics are contained in the conceptual site exposure model of the assessment area.

Conceptual exposure models graphically describe what is known or suspected about contamination, contaminant fate and transport, exposure pathways, and potential human and ecological receptors at temporal and spatial scales dependent on controlling exposure pathways. For aggregates and watersheds containing risk-significant contamination, the conceptual exposure models will be implemented using mathematical models, as necessary, to visualize current conditions or extrapolate future conditions.

In addition to adapting risk assessment for different spatial and temporal scales, the complexity of assessments may be modified to accommodate different decisions. Relatively simple and conservative screening assessments can be used to (1) identify individual sites that pose imminent risk, and (2) differentiate (among interacting sites) individual sites that contribute insignificantly to overall risks from those that are major contributors to risk. Increasingly more realistic site-specific risk assessments can be implemented for choosing alternative corrective actions when systems uncertainties are significant, spatial and temporal scales are large, and future risks are unacceptable. The assessments can be graded in complexity to meet specific decision-making needs with confidence. Finally, risk assessments are used

to decide on preliminary remediation goals, evaluate alternative final actions, and determine final clean-up levels after final actions are chosen.

Cumulative risk assessment involves the consideration of ecologic or human health risk to a receptor caused by the accumulation of risk from multiple pathways and sources (EPA 1997, 63517). Within the integrated technical strategy, cumulative risk will be assessed at the watershed scale as a completion activity, and may also be assessed within aggregates, if necessary, to ensure acceptable risk. A distinguishing aspect of cumulative risk is that transport of residual contamination within a watershed (or aggregate) is modeled to simulate potential convergence at one or more common receptors. In the watersheds, the human receptor is at the watershed boundary, generally at the downstream, eastern end. Ecological receptors are those that use or are distributed over the entire watershed area, such as the peregrine falcon, elk, or ponderosa pine. At this scale of assessment, contaminant impacts can be evaluated in the context of other, multiple stressors. Assessment time scales will be adequate to address the persistence of the risk-significant stressors.

Source terms will be measured and/or calculated for each environmental transport pathway: air, surface water, groundwater, and soil. Air source terms will integrate vapor-phase and suspended-particulate contaminants along the length of the watershed. Surface-water source terms will integrate soluble and sediment-bound residual contamination over space and time along the watershed. Soluble contaminants within a watershed will be evaluated as necessary to ensure protection of groundwater resources and to ensure acceptable risk through groundwater ingestion exposures. Contaminated soil will be a source term for water and air transport pathways, and for food-web exposure pathways.

The complexity of the risk assessment approach for a given site depends upon how close assessment results are to applicable thresholds. If the assessment results are well below the applicable criterion, screening can support a decision for no action. If the assessment results are well above the criterion, remediation or stabilization is indicated and more sophisticated assessments are not warranted. When the contaminant data (plus uncertainties) are close to the applicable criterion, additional assessment effort is intended to reduce uncertainties and provide better information for evaluating potential risks versus the costs to reduce them. Sensitivity and uncertainty analyses (see Section 2.7.3) are used to determine the adequacy and sufficiency of data to support a specific decision.

The tiered approach to human health risk assessment used by the ER Project is consistent with the EPA guidance (EPA 1989, 08021; EPA 1998, 63140), and follows the NMED's risk based decision framework (NMED 1998, 57761). The tiered approach to ecological risk assessment follows EPA guidance as described in "Screening Level Ecological Risk Assessment Approach for the Environmental Restoration Project at Los Alamos National Laboratory" (LANL 1998, 57916; Ryti et al. 1999, 63303).

2.4 Conceptual Models

The watersheds that drain the Pajarito Plateau are geologically, hydrologically, and ecologically diverse. In addition, they contain multiple PRSs (which fall within one or more operational focus areas) and extend beyond Laboratory boundaries. The technical approach to investigation, assessment, and remediation recognizes this diversity by allowing assessment areas to cross PRS and focus area "boundaries," as appropriate, to accommodate potentially interacting sources. To implement the integrated strategy, the relevant attributes of multiple PRSs will be incorporated into a common conceptual model of contaminant nature and extent, fate and transport, and exposure. The sources of information used to develop

conceptual models will be controlled and documented for consistent application in implementing the integrated technical strategy.

The principal types and sources of information to be used in framing conceptual exposure models are discussed in this section. The EPA Region 6 draft risk management strategy discusses elements of a conceptual model according to profiles, which are used as a framework for Sections 2.4.1 through 2.4.5. (EPA 1998, 63140). The size of an assessment area and the number of PRSs it contains are uniquely determined by a set of profiles that applies to the contamination within that area.

2.4.1 Facility, Land Use, and Exposure Profile

The facility, land use, and exposure profile of the conceptual site exposure model includes current land use and planned future land use. This profile should also identify actual resource-use locations (e.g., water supply wells, timber harvesting, hunting, and active pedestrian and equestrian trails). The ER Project Community Involvement Office maintains current maps of such locations. Insofar as they represent the planned future locations of regional aquifer monitoring wells and surface-water samplers identified in the hydrogeologic work plan and the draft watershed management plan, respectively, these factors will be incorporated into the integrated technical strategy (LANL 1998, 59599; LANL 1999, 62920). Locations and types of access to potentially contaminated media influence the selection of human health and (to a lesser extent) ecological risk-assessment pathway assemblages.

One or more facility, land-use, and exposure profiles may be required to assess all PRSs within an aggregate, as well as an entire watershed.

2.4.1.1 Present and Future Land Use

Site accessibility is a major factor in selecting likely human receptors in determining present-day risk. From the perspective of site access, there are four categories. In order of low-to-high restrictions, they are public-access, controlled, limited-security, and high-security areas. Figure 2.4-1 shows these areas and their associations with the watersheds.

The Laboratory site development plan (LANL 1995, 57224) identifies two land uses that impact the ER Project risk assessment process. One is the 30-year planning horizon for the Laboratory's mission and the continued operation of present-day facilities. The other is present and future access to Laboratory-impacted property. Both of these considerations will influence the selection of assessment pathways used to evaluate risk associated with existing contamination. Future land use for the Laboratory consists of nine zones (Figure 2.4-2). The maps in Figure 2.4-3 will be referred to in identifying exposure pathways in the integrated risk assessment strategy until additional information becomes available with the development of a new comprehensive land-use plan for the Laboratory.

In developing the comprehensive land-use plan, the planning committee will

- evaluate site ecologic, economic, social, and cultural factors;
- integrate with NEPA and NRDA;
- analyze options based on stakeholder future-use preferences, Laboratory mission requirements, ecosystem sustainability goals, and economic sustainability goals; and
- select use options through a facilitated process.

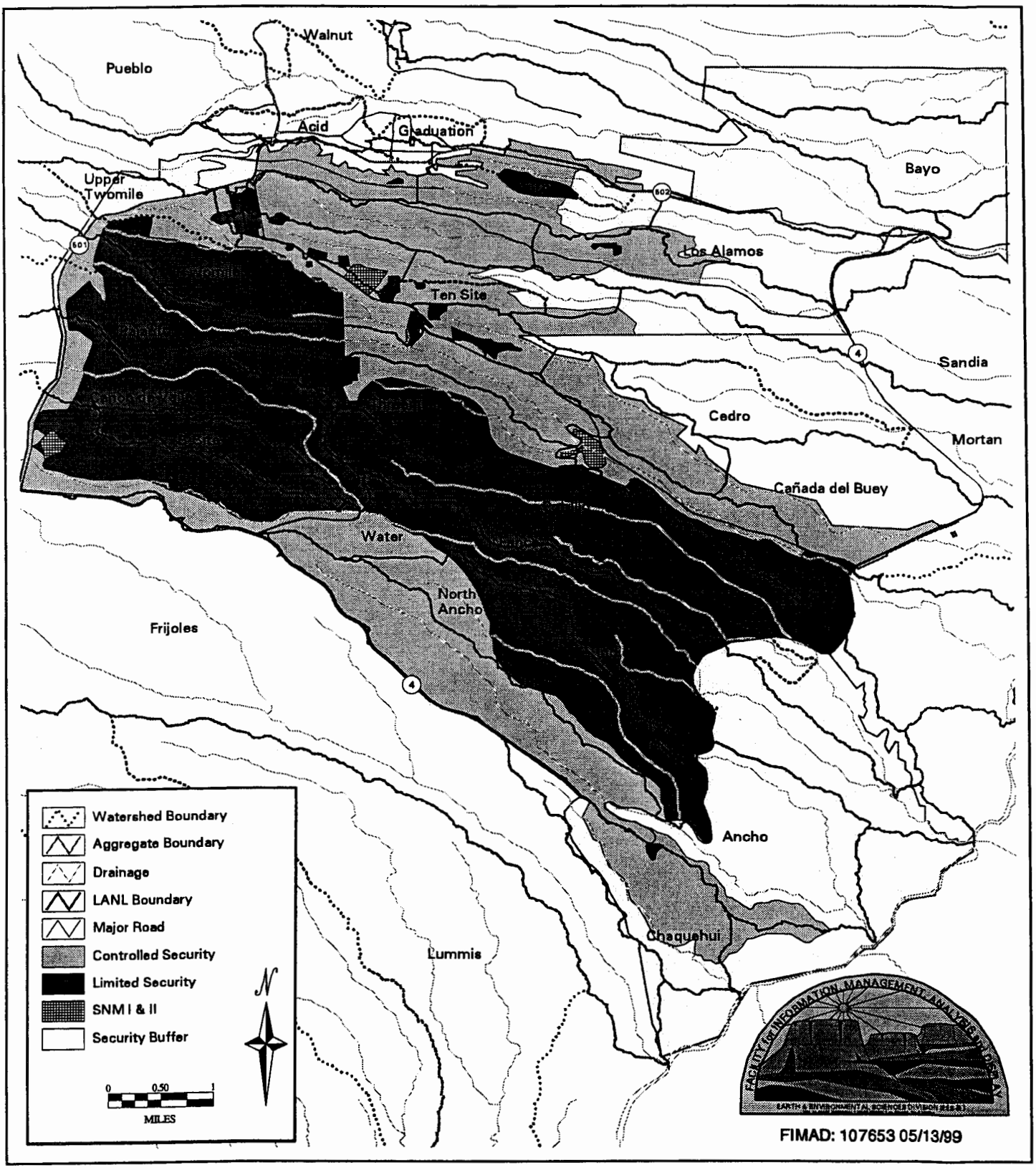


Figure 2.4-1. Current access controls within watersheds and aggregates

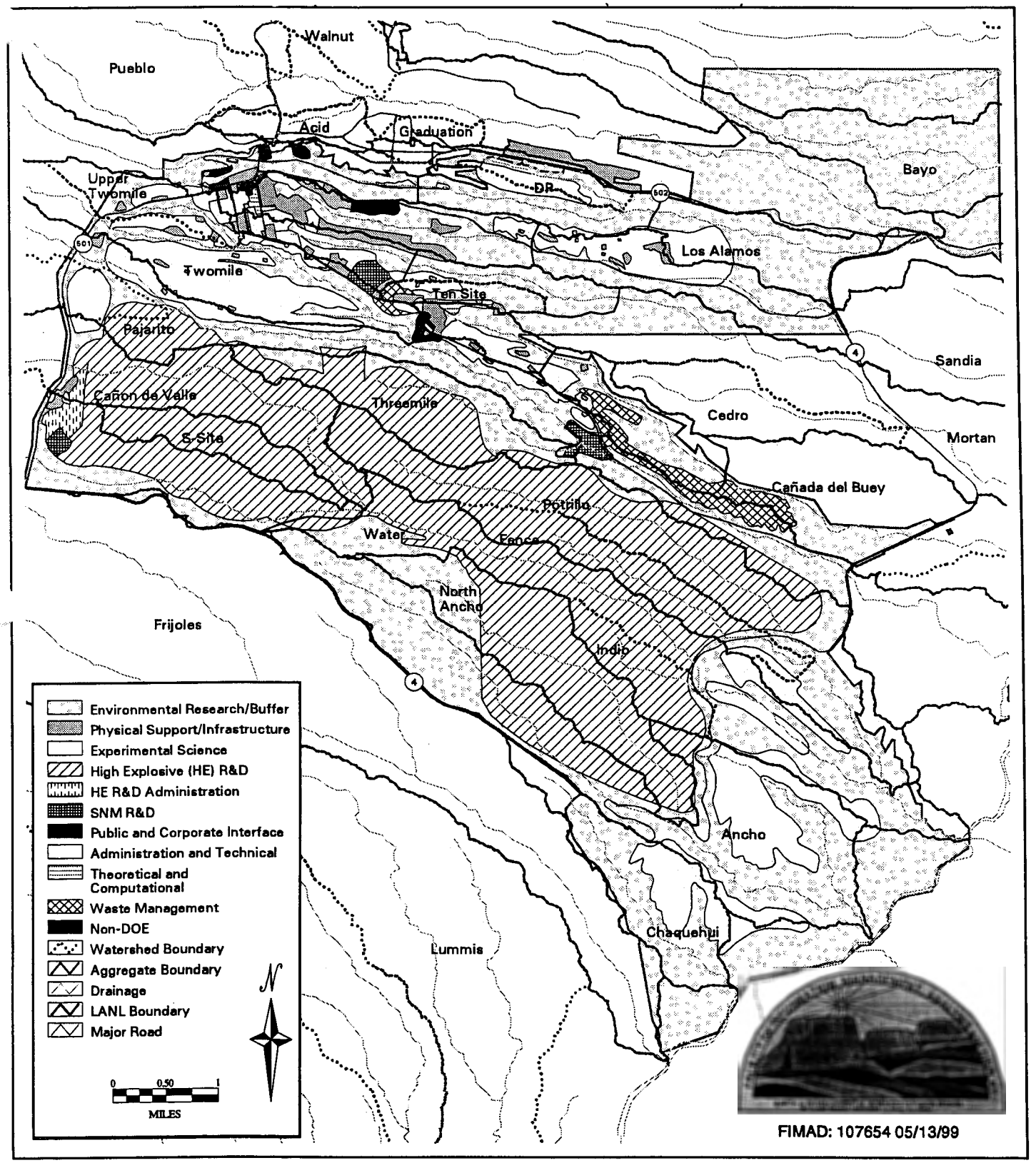


Figure 2.4-2. Proposed future land-use areas

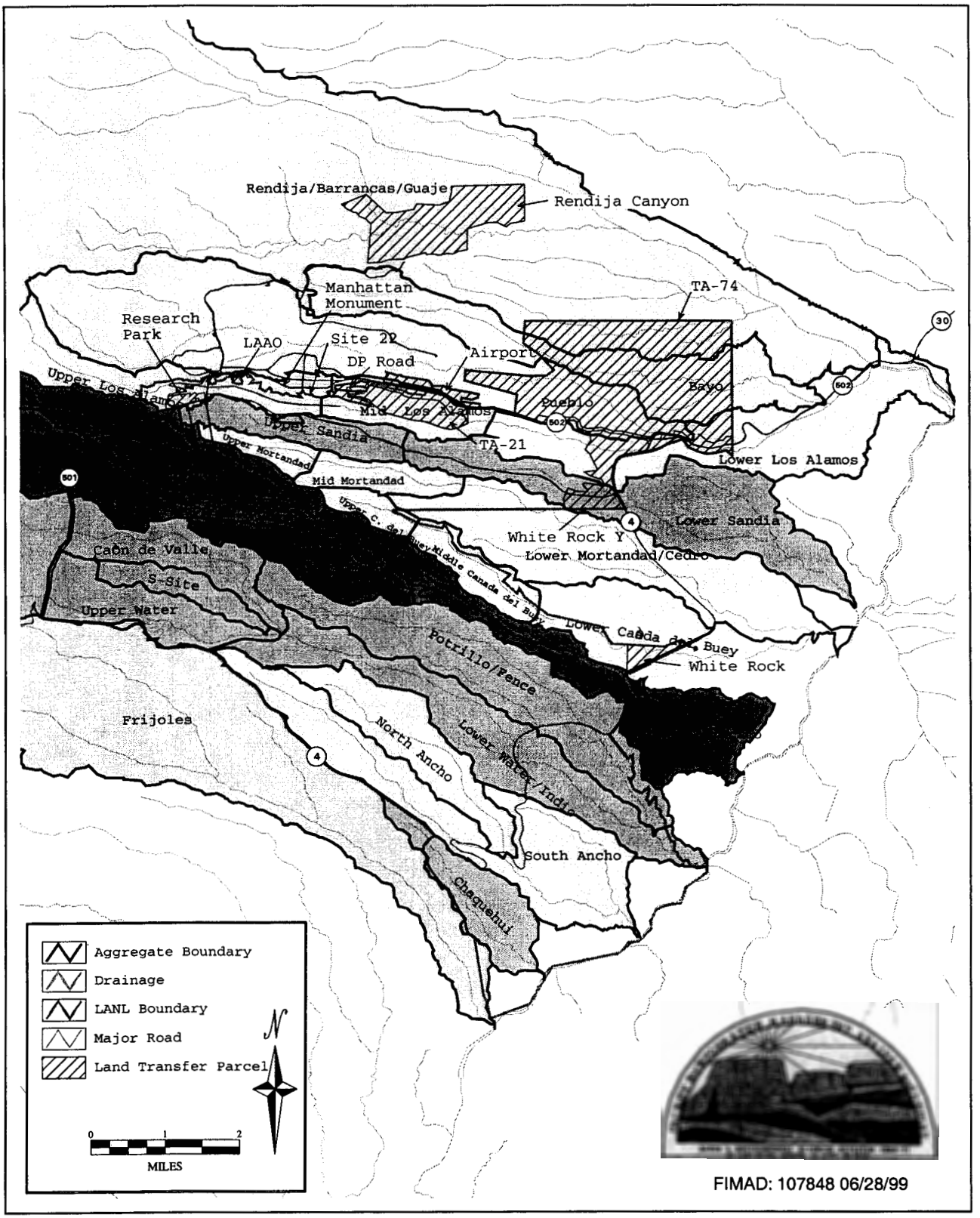


Figure 2.4-3. Land transfer parcels in relation to the watersheds and aggregates

Another important consideration regarding land use is the potential for transfer of parcels to the County of Los Alamos and/or the Pueblo of San Ildefonso (LANL 1999, 63090). The DOE has tentatively identified for transfer 200 PRSs located with 10 parcels. Figure 2.4-3 identifies these parcels in relation to the watersheds and aggregates evaluated in the integrated technical strategy.

The TA-21 parcel contains 154 PRSs. The White Rock Y and the TA-74 parcels include portions of one or more watershed aggregates.

2.4.1.2 Regional Groundwater Supply and Monitoring Wells

Monitoring wells exist in both alluvial and regional groundwater bodies, while supply wells draw only from the regional aquifer. The locations of these wells have an important bearing on the exposure profile of the conceptual model.

In implementing the hydrogeologic work plan, the Laboratory will install 32 regional aquifer wells downgradient from large geographic areas that historically have been used for major operations and activities, and account for a considerable portion of residual environmental contamination (LANL 1999, 59599). These wells will provide long-term water quality monitoring for these sites. Figure 2.4-4 identifies the existing wells and planned locations of a total of 32 regional groundwater monitoring wells within the 8 watersheds crossing the Laboratory boundaries.

Many of the regional aquifer wells have been defined and prioritized as downgradient from PRSs containing large contaminant inventories. Table 2.4-1 lists the locations of the regional aquifer ("R") wells, as originally planned, identifying the associated watershed and aggregate, and significant upgradient technical areas (TAs) containing one or more significant PRS.

2.4.1.3 Surface Water Sampling Locations

The planned surface water-monitoring network described in the draft watershed management plan includes existing sampling locations and gauging stations, and new gauging stations (LANL 1999, 62920). Proposed gaging stations will be located just above the confluence of each major drainage and subdrainage, and at each drainage and its downstream boundary, or as near as possible. Samples collected through this proposed network can be used to (1) characterize the quality of water and assess the presence of contaminants in a main drainage before influence from a sub-drainage, (2) characterize the quality of water and assess the presence of contaminants in a subdrainage before it enters a main drainage, and (3) characterize the quality of water that may flow off DOE property. Figure 2.4-5 identifies the locations of existing and planned surface water sampling stations within the watersheds and aggregates.

2.4.2 Ecological Profile

The ecological system within which investigations, assessments, and corrective actions will be accomplished has important effects on the design and implementation of those activities. Due to its elevation gradient and complex terrain, the Pajarito Plateau supports multiple ecosystems and habitats. The ER Project and other Laboratory environmental programs have invested significant resources in describing components of the regional ecosystem. The results of these efforts will serve as primary references in developing ecological profiles for conceptual site exposure models.

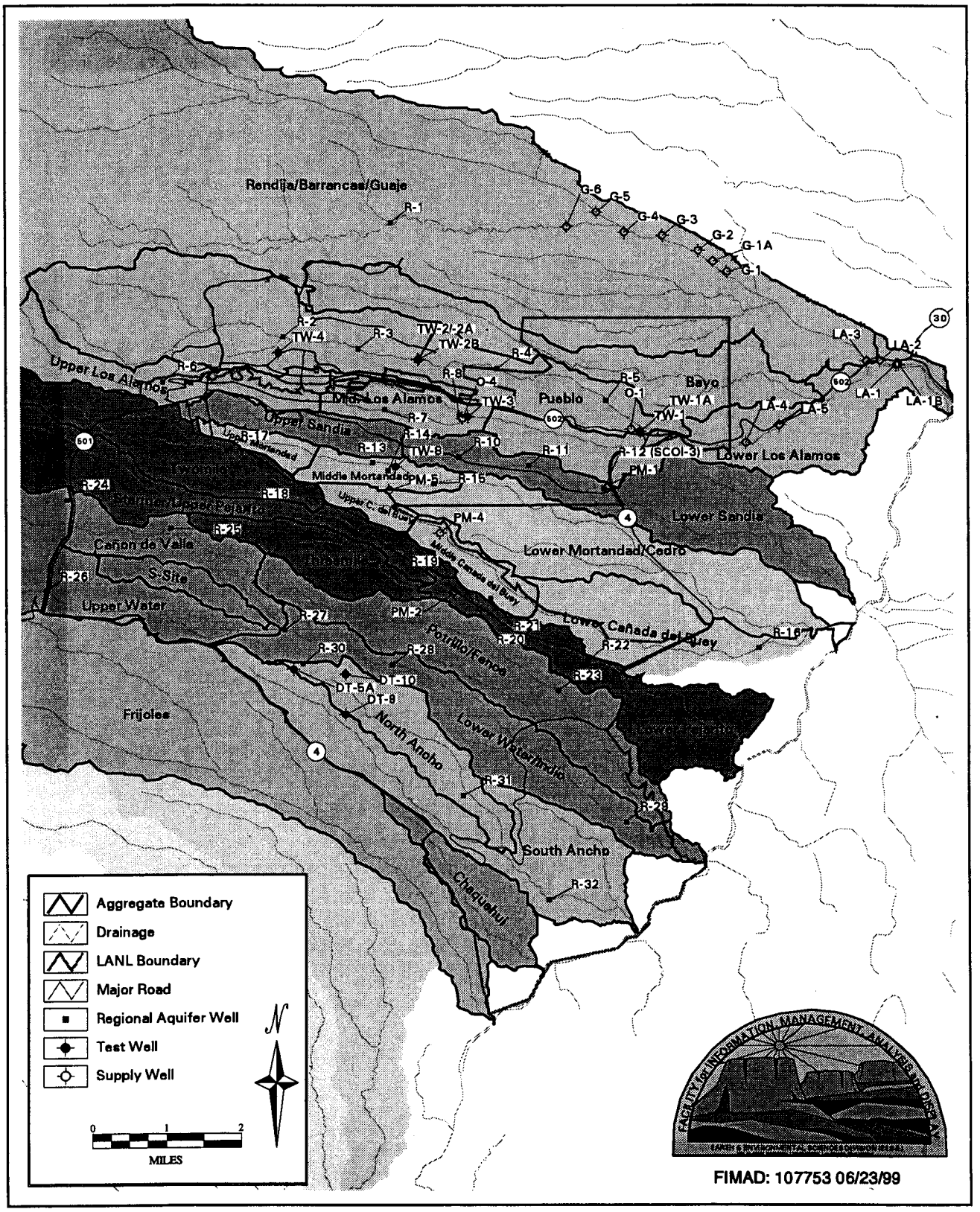


Figure 2.4-4. **Planned locations of regional groundwater monitoring wells and existing monitoring, test, and observation wells**

Table 2.4-1
Regional Wells, Associated Watershed Aggregates, and Upgradient TAs

Well	Watershed	Aggregate	Upgradient TA
R-1	Los Alamos/Pueblo	Rendija/Barrancas/Guaje	None
R-2	Los Alamos/Pueblo	Pueblo	45
R-3	Los Alamos/Pueblo	Pueblo	45
R-4	Los Alamos/Pueblo	Pueblo	73, 45
R-5	Los Alamos/Pueblo	Pueblo	73
R-6	Los Alamos/Pueblo	Upper Los Alamos	None
R-7	Los Alamos/Pueblo	Middle Los Alamos	21, 1, 2, 3, 43, 41
R-8	Los Alamos/Pueblo	Middle Los Alamos	21, 1, 2, 3, 43, 41
R-9	Los Alamos/Pueblo	Lower Los Alamos	21, 1, 2, 72, 73, 3, 43
R-10	Sandia	Lower Sandia	3, 61, 53
R-11	Sandia	Lower Sandia	3, 53, 61
R-12	Sandia	Lower Sandia	3, 53, 61
R-13	Mortandad	Middle Mortandad/Ten Site	3, 48, 35, 59
R-14	Mortandad	Middle Mortandad/Ten Site	35, 48
R-15	Mortandad	Middle Mortandad/Ten Site	35, 50, 3, 48
R-16	Mortandad	Lower Canada del Buey	54, 63, 46, 51
R-17	Pajarito	Twomile	3, 58, 62, 59
R-18	Pajarito	Starmer/Upper Pajarito	8, 9, 22, 69, 40
R-19	Pajarito	Starmer/Upper Pajarito	22, 6, 40, 50, 66
R-20	Pajarito	Lower Pajarito	18, 51
R-21	Pajarito	Lower Pajarito	18, 51
R-22	Pajarito	Lower Pajarito	54, 18
R-23	Water/Cañon de Valle	Potrillo/Fence	15, 36
R-24	Water/Cañon de Valle	Cañon de Valle	None
R-25	Water/Cañon de Valle	Cañon de Valle	16
R-26	Water/Cañon de Valle	Upper Water	None
R-27	Water/Cañon de Valle	Lower Water/Indio	16, 28, 11, 37
R-28	Water/Cañon de Valle	Lower Water/Indio	16, 28, 11, 37
R-29	Water/Cañon de Valle	Lower Water/Indio	71, 68, 16, 28, 11, 37
R-30	Ancho	North Ancho	49
R-31	Ancho	North Ancho	39, 49
R-32	Ancho	South Ancho	49, 70

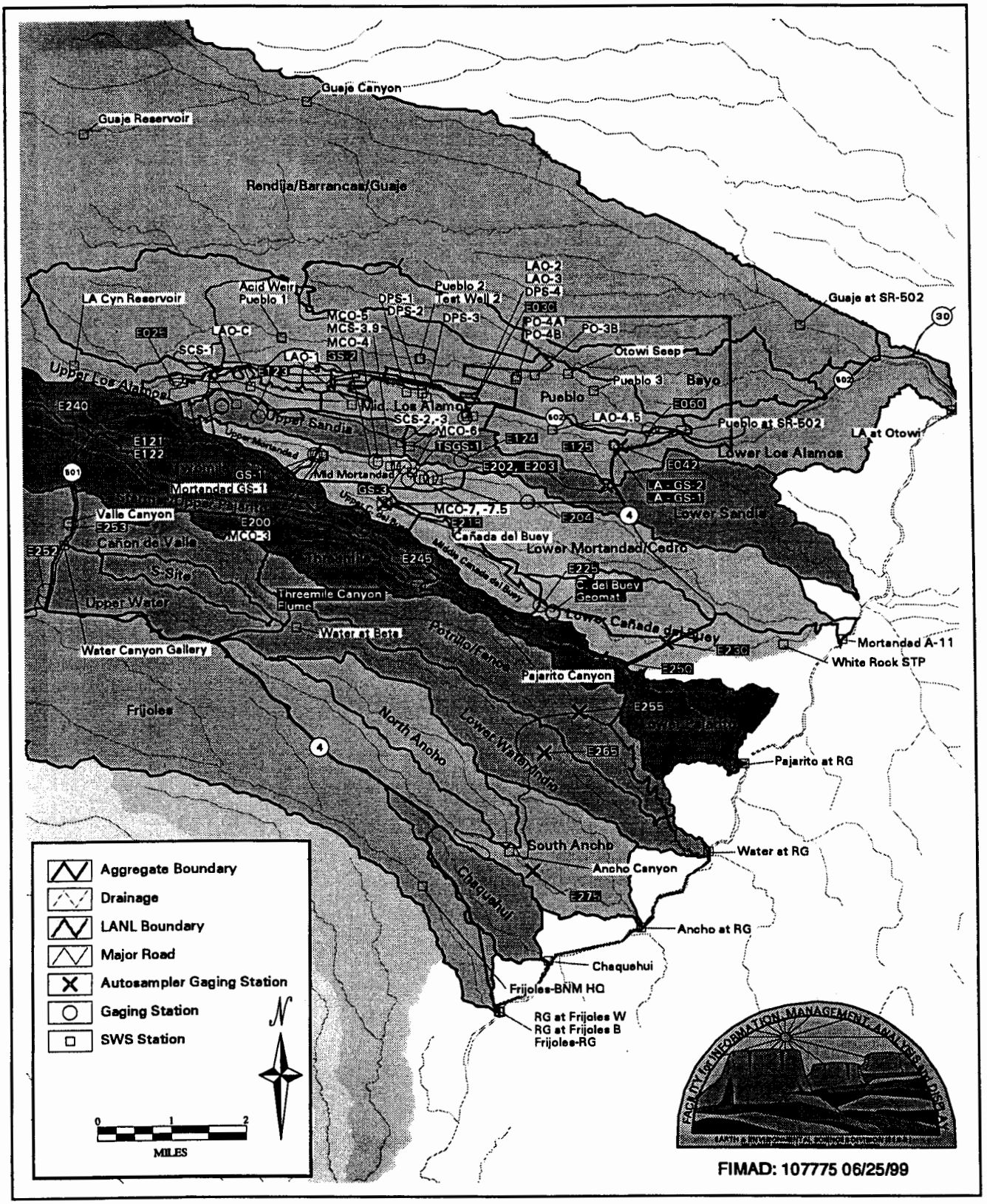


Figure 2.4-5. Existing surface water sampling locations in relation to watershed aggregates

It is likely that multiple ecological profiles will be required to assess all PRSs within an aggregate. This is due to the variability of available water, which translates into a highly inhomogeneous habitat distribution, especially at the watershed level.

2.4.2.1 Threatened and Endangered Species Habitat Management Plan

The Laboratory's threatened and endangered species habitat management plan (T&EHMP) provides information regarding vegetation types and habitat for threatened and endangered species (LANL 1998, 63511). Since the location of threatened and endangered species is considered unclassified sensitive data, habitats are generalized as areas of environmental interest (AEIs) and include a buffer that obscures precise locations.

Only trained authorized personnel will have access to actual threatened and endangered species location maps. The ER Project has a single point of contact for maintaining maps, and for interpreting and communicating relevant information from the T&EHMP to construct realistic and consistent ecological profiles.

2.4.2.2 Biological Assessments

Biological assessments were prepared for ER Project operable units (OUs) in the early 1990s. While they are strictly "valid" only for a period of two years for the purposes of consultation with the US Department of the Interior Fish and Wildlife Service, these documents contain information that remains relevant to ecological profiles. For example, they describe the results of previous reconnaissance, habitat, and species-specific biological surveys, and identify floodplains, wetlands, and extant flora and fauna.

2.4.2.3 General Assessment Endpoints

The ER Project is collaborating with other Laboratory, state, and federal organizations to define general assessment endpoints (GAEs), a framework for selecting a representative subset of potential ecological receptors. A document describing the GAEs and their application is in development, and the GAE approach to ecological risk assessment is being piloted as part of the TA-16 260 CMS (Kelly et al. 1999, 63510)

2.4.2.4 Ecotoxicity Database

The ER Project eco-risk database that is in development (FY1999—FY2000) will provide the computational framework for estimating toxicological effects of environmental contaminants on ecological resources at the Laboratory. It represents the algorithms for implementing ecological screening (Kelly et al. 1999, 63510). The database incorporates the standard input parameters for ecological toxicity calculations performed within the ER Project, as well as documentation for selection of these parameters.

2.4.3 Physical Profile

The features, events, and processes included in the conceptual site exposure model that may affect contaminant release, fate and transport, and exposures are called the "physical profile" of the model. The physical profile should represent the undisturbed or steady-state conditions at a site, reflecting the prerelease status.

If "baseline" or "background" contamination not associated with a PRS is present, it should be reflected in the physical profile. Background and baseline chemical characterization of environmental media become important when the project develops a conceptual model and designs a SAP, identifies appropriate assessment endpoints, evaluates risk due to contamination, and evaluates remediation alternatives. To characterize contamination that is not associated with a PRS, the ER Project collects background and baseline data through investigations that are not necessarily focused on specific PRSs.

Qualified data for developing the physical profile for an aggregate or watershed will be available electronically (see Chapter 3). The integrated technical strategy will use comprehensive and configuration-controlled set of electronic data management and visualization tools to describe the following features of an aggregate or watershed:

- topography,
- meteorology,
- vegetation,
- surface-water hydrology,
- surface geology,
- subsurface geology,
- groundwater hydrology,
- background ambient media chemistry, and
- baseline (non-PRS-related) ambient media chemistry.

A single physical profile may or may not be sufficient to address all conceptual exposures to contamination within an entire aggregate. For example, a perched aquifer may be confined to only a small area beneath an aggregate, or an alluvial aquifer may support a wetland of limited extent within a portion of an aggregate but completely infiltrate at another portion of that aggregate. Whether or not such features should be evaluated as separate (but consistent) or composite physical profiles depends upon the other profiles of the conceptual site exposure model.

Existing sources of data for developing the physical profile of the conceptual model for an assessment area within an aggregate and, ultimately, a watershed include the following:

- Canyons investigations (well completion reports, reach reports),
- Monitoring Well Installation Program well completion reports,
- groundwater annual reports, and
- data collected by other federal and state agencies, including the US Geological Survey.

In addition, a controlled set of hydrogeologic maps is being developed by the ER Project in FY1999, which will serve as the primary reference for qualified hydrologic and geologic data for developing physical profiles for conceptual exposure models for risk assessments. This sitewide atlas will feature

- surface topography;
- subsurface structure, depth, and thickness;
    - Tshirege Member of Bandelier Tuff,
    - Tsankawi Pumice Bed/Cerro Toledo Interval,
    - Otowi Member of Bandelier Tuff,
    - Guaje Pumice Bed,
    - Puye Formation,
    - Cerros del Rio basalts,
    - Totavi Lentil, and
    - Santa Fe Group;
- geology at the regional water table; and
- cross sections of major canyons, mesas, and other selected portions of the Pajarito Plateau.

The sitewide atlas will provide a documented reference set of qualified geologic and hydrologic data that will be used for data visualization, conceptual model development, and numerical modeling (Section 2.7). The sitewide atlas will be implemented as an electronic database through a configuration management process for maintaining geologic and hydrologic data used for data visualization, conceptual models, and numerical modeling.

2.4.3.1 Background Data Sets

Background data values for both solid media and water are needed to distinguish between contaminated and uncontaminated media and to establish cleanup levels for sites scheduled for remediation. This information becomes important when multiple sites are being evaluated together.

Background concentrations of inorganic chemicals and radionuclides in soils, sediments, and Bandelier Tuff have been published (Ryti et al. 1998, 62750). In addition the NMED has approved the methodology for using background values in the corrective action process. Similar documents will be developed for surface water, alluvial groundwater, deep groundwater, and air. These data sets will be developed using data from aggregate-related field investigations, supplemented as necessary. Background surface water data may also become available when the final watershed management plan is implemented.

2.4.3.2 Baseline Data Sets

Location-specific baseline data sets are needed when levels of non-PRS-related chemicals associated with industrial processes operations or sources not within an aggregate are commingled with PRS-related contamination. Baseline data sets will be compiled to assist the project in making remediation decisions for affected sites. The first baseline data sets are being proposed as part of the integrated SAP for TA-35 being prepared in FY1999. The ER Project will develop and document decision criteria for compiling and using baseline data sets. These criteria will be negotiated with and approved by the administrative authority.

2.4.4 Release Profile

The release profile identifies the distribution and magnitude of COPCs. It is combined with the physical profile to complete the description of contaminant nature, extent, fate, and transport within the conceptual exposure model. One or more release profiles may be necessary to fully describe an aggregate, depending on the persistence, mobility, and toxicity of COPCs present, and the physical profiles of the system. A single release profile will be developed for the cumulative risk assessment for a watershed.

Field data and archival information are the primary references for developing the release profile, and fate and transport models may be used in combination with field data for developing the release profile for complex sites, including MDAs.

Field data used to develop release profiles may come from one or more PRSs within one or more operational focus areas. Ultimately, data characterizing all residual contamination will be combined to complete the "final" release profile for a watershed. Within an aggregate, data from Canyons Focus Area investigations will be used to complete the release profile for complex sites within the Remedial Actions Focus Area that contain mobile and persistent contaminants at one or more PRSs, and for MDAs, to the extent supported by the physical profile. The "boundaries" of a release profile will be uniquely defined by the nature and extent of contamination within a common physical system (see Section 2.4.3, Physical Profile, in this document), and by the risk context (see Section 2.4.5, Risk Management Profile, in this document). An example of how data from several PRSs are being composited to define release profiles will be described in the integrated SAP for TA-35.

Additional data sources, which may be input into the ER Project database, if necessary, and after they are appropriately qualified, include

- former decontamination and decommissioning activities, including FUSRAP;
- earlier waste site studies, including CEARP investigations;
- soil and sediment on-site and perimeter surveys performed by ESH Division;
- air monitoring, National Pollutant Discharge Elimination System (NPDES), and stormwater monitoring data from ESH Division;
- ongoing waste site studies, such as MDA G perimeter sampling;
- DOE Oversight Bureau data (including ER sample splits);

- EPA Region 6 data;
- data collected by pueblos; and
- data collected by NMED.

2.4.5 Risk Management Profile

According to the EPA Region 6 draft risk management strategy, "...the risk management profile is used to illustrate the relationship between releases and risks (and) how the release-risk relationship can be altered by implementing remedial actions" (EPA 1998, 63140). The risk management profile can include the

- summary of risks,
- impact of remedial option on release and exposure characteristics,
- performance monitoring locations and media, and
- contingency plans in the event performance monitoring criteria are exceeded.

In the integrated technical strategy, risk management profiles will be used to describe and evaluate alternative risk-based decisions. These profiles will be consistent with the facility, land use, exposure, ecological, physical, and release profiles used to describe an assessment area. While all other profiles are based largely on objective information, the risk management profile is based on certain subjective aspects into risk-based decision making. To provide a structure to the decision-making process, the ER Project risk managers will use the EPA's threshold and balancing criteria (EPA 1988, 63513):

> EPA established a two-phased evaluation for remedy selection. During the first phase, potential remedies are screened to see if they meet 'threshold criteria;' remedies which meet the threshold criteria are then evaluated using various 'balancing criteria' to identify the remedy that provides the best relative combination of attributes. The four threshold criteria are that all remedies must: (1) be protective of human health and the environment; (2) attain media cleanup standards; (3) control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases...; and (4) comply with applicable standards for waste management. The five balancing criteria (are): (1) Long-term reliability and effectiveness; (2) reduction in toxicity, mobility or volume of waste; (3) short-term effectiveness; (4) implementability; and (5) cost.

2.5 Exposure Models

Exposure models for human health and ecological risk will integrate air, terrestrial, and water pathways to the extent supported by the conceptual model. In general, exposure models used in the integrated technical strategy are consistent with traditional approaches. This section discusses components of exposure models that are not contained in the IWP but will be considered in the integrated technical strategy.

The integrated technical strategy will follow standard scenarios drafted in FY1999 used for human health exposure assessments, unless other more appropriate scenarios are identified on a site-specific basis. Approaches to ecological exposure assessments will follow EPA guidance.

2.5.1 Air

Chronic exposure to soil contaminants by ambient air inhalation is commonly evaluated using EPA's particulate emission factor (PEF) and volatilization factor (VF) equations. These equations are used to define the relationship between soil-contaminant concentrations and concentrations in ambient air for nonvolatile and volatile chemicals, respectively. Both models are conservatively biased in that they assume an effectively infinite source of contamination. The PEF and VF equations have in common a dispersion model that was developed by EPA for an on-site receptor and a ground-level area source. The EPA used this dispersion model for six source areas ranging in size from 0.5 to 30 ac (12 ha), and for 29 cities in nine climatic zones within the contiguous United States. The ER Project may use tabulated model output for selecting a dispersion term for the PEF and VF models for relatively large assessment areas. Alternatively, the dispersion model can be run by the assessor for site-specific conditions by obtaining a copy of EPA's industrial source complex model (EPA 1996, 59902).

In addition to the dispersion term, both the VF and PEF equations contain other site-specific parameters that must be defined appropriately for a specific assessment. For the VF model, the most critical of these site-specific parameters are the air-filled and water-filled soil pore space. For the PEF model, the most important site-specific information relates to soil erodibility and meteorological conditions that affect dust emission. Site- or region-specific information to better define these parameters for the VF and PEF equations can be used to obtain more accurate estimates of air exposure when data for long-term chemical concentrations in air are unavailable.

2.5.2 Surface Soil and Sediment

The geographical scale of a terrestrial assessment influences the risk assessment approach. When screening decisions are made, comparisons of analytic results from sediment and soil samples to screening action levels (SALs) can be conducted at any geographical scale, from single PRSs to entire mesa-tops or hillsides (LANL 1998, 62060). At the preliminary assessment level, site-specific assessments will be developed through scenarios, consistent with the aggregate conceptual model. Comparisons to preliminary remediation goals (PRGs) for certain scenarios, such as recreational user or construction worker, will be performed for geographical scales that are reasonable for the scenarios. For example, for an aggregate containing mesa-top and hillside PRSs, mesa-top PRGs may be most appropriately based on an industrial worker scenario, while hillside PRGs may be more reasonably based on a trail-user scenario. For very large areas that may be impacted by non-PRS contamination, analytical results will be compared against site-specific background and/or baseline data to support reasonable applications of PRGs and site-specific risk assessments.

To assess ecological exposures to surface soil and sediment contaminants, analytical results will be compared against the values contained in the ecotoxicity database that is being developed during FY1999—2000.

2.5.3 Surface Water

Exposure assessments that incorporate surface water pathways must be consistent with their aggregate-specific conceptual models, especially the physical profiles describing surface water features, events, and processes. Surface water hydrology within each watershed and most aggregates is complex, with base

flows fluctuating seasonally and annually. This section discusses how surface water assessments will be performed based on the nature of surface water.

Surface water exposure pathways will reflect the percentage of the year when a spring or stream is flowing. A stream or spring will not be considered in surface-water pathway assessments if it flows less than 25% of the year. Ecological risk assessments will consider terrestrial and/or aquatic receptors, depending upon the availability of water relative to the amount necessary to sustain particular habitats. Wildlife exposures through drinking water pathways may be appropriate, using prorated exposures based upon the estimated percent of the year when the stream or spring is flowing.

2.5.3.1 Perennial Stream Segments and Springs

Perennial stream segments flow regularly, and perennial springs bear water regularly. The analysis of exposures associated with contaminated perennial waters depends upon stream- or spring-specific hydrology, and the potential for exposures.

Risk assessments of contaminated sites containing perennial water and located in industrial areas will evaluate pathways consistent with restricted land and water use. These pathways include industrial worker, construction worker, and environmental worker. In areas of the Laboratory that are clearly within the institutional boundary of the facility and where public access is unrestricted, perennial water-exposure pathways will reflect recreational and resource-user activities. In uncontrolled areas and areas designated for land transfer, risk assessments will consider perennial water exposures from ingestion and and/or garden irrigation pathways.

The decision to include the water pathway in the residential scenario will be influenced by the production capacity of the stream relative to residential needs and the topography of the canyon reach and whether human habitation is feasible. The state of New Mexico does not recognize default minimum production values for residential water use, because some residences in New Mexico are supported by groundwater supplies producing less than the national standard.

Where perennial streams or springs exist, ecological risk assessments will be conducted with aquatic and riparian pathways and endpoint species. The methodologies for these assessments are currently in review.

2.5.3.2 Ephemeral Stream Segments and Springs

Ephemeral stream segments and springs are transient to the point of being insignificant in the context of a nominal 30-year chronic exposure for human health risk assessment. The surface water pathway is not relevant to these conditions.

Sampling and analysis of storm events may be useful for estimating dissolved contaminant and particle-bound contaminant transport down-canyon. Sampling storm-related stream flow will also be used to support the physical profile of the conceptual site exposure model.

For ecological risk assessment, ephemeral streams and springs will be evaluated as aquatic and/or terrestrial habitats, based upon the abundance and persistence of water. Wildlife exposures through drinking water pathways may be appropriate, using prorated exposures based on the estimated percent of the year when the stream or spring is flowing.

2.5.4 Alluvial Groundwater

Alluvial groundwater exposure pathways will be considered in certain human health risk assessments. If the land is under institutional control, exposure to groundwater through the drinking water pathway will not be evaluated. However, incidental exposure to groundwater may be relevant to the environmental-worker scenario.

Ecological risk assessments will consider contaminated alluvial water a drinking-water source for wildlife and a habitat for aquatic species, if they are accessible (within a few feet of the surface).

2.5.5 Deep Groundwater

The relevance of deep groundwater exposures in human health risk assessments is the subject of much discussion within the ER Project. The ultimate approach to deep-groundwater exposure modeling cannot be elucidated here, but will be reflected in future revisions of the hydrogeologic work plan, IWP, and the Laboratory Permit. Recent project discussions have considered the following:

- In situations where, during installation of regional aquifer wells, contamination is found in the regional aquifer that can be directly attributed to one or more PRSs within an aggregate, groundwater exposures will be a part of the integrated assessment.
- For assessment areas within aggregates where no groundwater pathway is identified or suspected, the groundwater pathway analysis will not be considered in the integrated assessment, for either ecological or human receptors.

Given the relatively sparse information available about the deep groundwater and hydrology beneath the Pajarito Plateau, fate and transport models will be used to integrate the deep groundwater with decision-making (see Section 2.7).

2.6 Investigation Approach

This section describes the overall investigation approach of the integrated technical strategy. Some aspects of this approach are documented in the core document for canyons investigations (LANL 1997, 62316), the MDA core document (in preparation), the draft IWP (LANL 1998, 62060), the hydrogeologic work plan (LANL 1998, 59599), and the draft watershed management plan (LANL 1999, 62920). This discussion will be fully developed in FY2000 when the core documents and the integrated technical strategy are incorporated into the IWP.

If assessments of contaminant nature, extent, and risk can be confidently accomplished for one or more PRSs within an operational focus area, investigations will be completed within that focus area in accordance with core documents and/or work plans. When multiple PRSs from one or more operational focus areas are known or suspected to overlap (now or in the future), integrated investigations will be implemented. The release profile supporting the integrated investigation design will be developed using data from all media, across all affected focus areas. Through the completion of integrated databases and qualification of historic data, all data from PRSs within an aggregate will be available for combining at multiple spatial scales. The data quality objectives process will be used to identify significant data gaps, using mathematical models to the extent warranted by the complexity of the conceptual site exposure model and the quality and quantity of available data.

The integrated investigation approach involves sampling environmental media that potentially could integrate sources within an aggregate. Surface water and groundwater sampling will proceed with the implementation of the hydrogeologic work plan and the watershed management plan, while soil and sediment sampling will occur at various spatial scales by the ER Project. Investigations of aggregates containing multiple PRSs will be implemented through integrated SAPs.

Integrated SAPS are designed to collect data across areas containing multiple PRSs. As an integrated SAP is developed, Canyons reach data will be reviewed to identify COPCs, transport potential, and the importance of water pathways at a site. If necessary, based on the conceptual model, surface or alluvial water samples will be included. In addition, baseline samples will be collected for sites impacted by non-PRS contamination.

Data collected through integrated SAPs contribute to multiple analyses, including RFI reports for individual PRSs, integrated RFI reports, Canyons surface investigations, long-term monitoring plans, and, ultimately, watershed completion reports.

2.6.1 Soil and Sediment

Well-integrated (i.e., across PRS and focus area boundaries) soil and sediment sampling is critical to the development of the conceptual site exposure model for assessments within aggregates and watersheds. Canyon sediment investigation data will be heavily used to develop conceptual models for aggregates and watersheds.

The horizontal extent of contamination along a canyon (watershed or aggregate) is assumed to be controlled by floods that have carried contaminants (as sediment) downstream from the original contaminant release location (e.g., a mesa-top PRS). To bound the extent of contaminated sediment transport, geomorphic mapping will be used to identify sediments deposited by floods after a contaminant release occurred, all of which may contain contaminants above background levels. Once these potentially contaminated sediments are mapped, the vertical extent of contamination is assumed to be bounded by the thickness of the sediment that has been deposited since initial contaminant releases. Subdividing the sediments within a reach by age and particle size and sampling and analyzing the sediment packets identifies the horizontal and vertical extent of contamination above risk thresholds. Canyon sediment mapping and characterization also provide important information for the physical and release profiles for an aggregate and watershed.

Determining the nature of contamination for mesa-top and hillside PRSs includes identifying the spatial variability and trend in concentrations in the context of the site conceptual model, which may be greatly influenced by the results of the canyons investigations. Where data support bounding the horizontal and vertical extent of contamination to concentrations below background values (or nondetect values for organics), extent is clearly defined. However, data often show a discernable decreasing trend in concentrations towards background values or generally low values at the perimeter of the affected area. These lower values are below concentrations that would result in unacceptable human health and ecological risk. Considered in the context of a site-specific conceptual model, a case often can be made that the area of contamination of concern relative to human and ecological health is sufficiently bounded.

If contamination from PRS outfalls within an aggregate is known or suspected to have reached the canyon bottom, sampling to define horizontal extent will be conducted from the top to bottom of the

outfall. The bottom will be defined as the toe of the colluvial slope. When PRSs are drained by a distinct channel that leads directly to the valley floor, the channel will be characterized to the point at which it enters the floodplain. When a floodplain is absent, sampling will be conducted to the point where the colluvial slope and hillside channels intersect the main canyon drainage.

2.6.2 Surface Water

Stormwater runoff data will be obtained from Watershed Management Program sampling and will support general assessment of fate and transport of contaminants. The Canyons Focus Area will sample perennial reaches and reaches with seasonally persistent base-flow conditions for human health and ecological risk assessment purposes. More detailed descriptions of the characterization of surface sediments and alluvial groundwater are described in the work plans for individual canyons.

The technical approach for risk assessment will correspond to the EPA Region 6 draft risk management strategy (EPA 1998, 63140) and generally will follow the strategy described in the reach reports for Los Alamos and Pueblo Canyons. (LANL 1998, 59667; LANL 1998, 59160; LANL 1998, 59159).

2.6.3 Groundwater

The ER Project will schedule characterization of the deep groundwater in concert with other remedial activities in the same watershed. However, potential contamination issues will be evaluated outside the watershed framework unless groundwater contamination is found to occur as a result of an individual PRS. If this is the case, the ER Project will assess the extent of such contamination under the standard regulatory framework. The ER Project proposes to evaluate groundwater in general, in accordance with the hydrogeologic work plan (LANL 1998, 59599).

Deep wells will be drilled to collect information about the occurrences and quality of perched intermediate-depth groundwater as well as the regional aquifer. The need to install dedicated intermediate-depth wells for characterization or monitoring purposes will be evaluated after the perched groundwater systems are initially characterized by the regional aquifer wells. In addition, a new nature-and-extent drilling investigation will be initiated if regional aquifer wells drilled under the hydrogeologic work plan detect significant groundwater contamination.

Groundwater investigations will follow an iterative approach in which information obtained from each borehole will be evaluated in the context of the hydrogeologic conceptual model updated in groundwater annual reports. These ongoing evaluations will be made in collaboration with other investigators implementing the hydrogeologic work plan and may lead to changes in the locations and numbers of future boreholes. Changes in the scope and schedule for groundwater investigations will be negotiated annually with regulators.

2.6.4 Biotic Sampling

Ecological risk assessments depend upon estimates of the transfer of contaminants from environmental media into food webs and across trophic levels. Many of the transfer factors that are used for modeling food-web effects are based upon limited laboratory studies and limited numbers of species. Additionally, site-specific conditions, such as soil type and contaminant speciation, can modify the transfer of contaminants across trophic levels in unpredictable ways. Consequently, ecological risk modeling

equations typically incorporate conservative assumptions in order to be protective under a wide variety of site conditions.

Collecting biotic samples to estimate contaminant transfers and exposures may be necessary to support realistic ecological risk assessments and subsequent remedial decisions. This most likely will be the case in threatened or endangered species habitat where the goal changes from protecting populations to protecting individuals.

Ecological risk decisions are often made in a weight-of-evidence context. Considerations include contaminant concentrations in environmental media relative to toxicological reference values, observable effects that are associated with high-contaminant concentrations and absent at low-contaminant concentrations, and adverse responses by test organisms to sample media in bioassay studies. Biotic sampling can be used to refine the first line of evidence if the other lines of evidence are ambiguous or not practically available. Often this will be a matter of collecting plant materials to develop empirical estimates of transfers for soils to plants.

In addition, field surveys for indicators of ecosystem health such as recruitment, reproduction, diversity, and other factors used to assess ecosystem integrity. This would involve comparing sites with known contamination to reference sites with limited or no contamination.

2.7 Computational Models

In implementing the integrated technical strategy, the ER Project will use data analysis to support risk-based decisions whenever possible. However, there are instances when collecting data is either impractical or impossible. This is the case for any future estimate of conditions, or for evaluating the potential consequences of rare events, such as large floods, population effects of contaminants upon higher trophic level species, or migration rates of contaminants in deep groundwater. To supplement, interpret, or assess field data under various scenarios captured in the conceptual site exposure model, computer models may be used.

The ER Project plans to use models of two categories: deterministic process level models and probabilistic systems level models. Deterministic process models will be developed and used to evaluate fate and transport of contaminants in air, surface water, sediment, and groundwater separately, using representative field data to calibrate the models. Probabilistic systems models will be used to evaluate the ultimate risk-impact of contaminant fate and transport through all relevant environmental pathways at once, using probability distribution functions to represent potential variations in field conditions. The process-level models are a tool for evaluating specific aspects of a given transport pathway. The systems-level model allows an evaluation of the significant aspects of the process models in the context of risk. Process level models are more rigorous, while systems level models are more versatile.

A set of standard computational tools will be used, when they are consistent with a physical profile, to simulate contaminant transport in groundwater, surface water, sediment, and air for complex sites. Detailed process models will be developed and evaluated for a limited set of complex sites, as needed to support ongoing, high-priority activities. Process models calibrated for a few relatively well-characterized sites are expected to be useful in describing other sites without having to invest in detailed models for every site. These process models will be used to parameterize a systems-level model that may be applied more broadly. An example of an approach evaluating the applicability of one model for more than one site

is described in the MDA core document (in preparation); the methodology is being used in the RFI report for the MDAs at TA-54 (in preparation).

2.7.1 Process Models

To date, process models have been used to simulate water flow and contaminant transport from complex sites on and within representative mesas, subbasins, and canyons. The first two subsurface transport models were developed for use in defining the release profiles from MDA G and along Los Alamos Canyon, which are relatively well characterized. The groundwater models use the Finite Element Heat and Mass (FEHM) transport computer code developed at the Laboratory. Surface water runoff is being modeled using the SPLASH code, using TA-16 runoff into Ancho Canyon as a test application in support of the corrective measures study (CMS) plan for that site. To evaluate the utility of erosion models, the KINEROS computer code is being tested at TA-54, a complex site for which sediment data are available for calibrating the model. A modeling framework for simulating atmospheric transport of gas-phase and suspended-particulate contamination is scheduled for development in FY2000—FY2001. The development, implementation, and results of the fate and transport models will be shared with the administrative authority.

2.7.2 Systems Models

One systems model the ER Project plans to use to integrate abstracted (simplified) process models is the Repository Integration Program (RIP) (Miller and Kossick 1998, 63139). The RIP code will be used to calculate risk to human and ecological receptors, integrating fate and transport along all relevant physical (environmental) pathways as calculated in the process models. By evaluating uncertainties in the risk assessment results attributed to uncertainties in specific parameters used in the models, RIP will also be used to identify significant data gaps. Two important applications of this decision-support tool will be prioritizing the siting and installation of groundwater wells identified within the hydrogeologic work plan, and the calculation of cumulative risk in the completion of a watershed containing residual contamination.

The ER Project has used another systems model, RESRAD, to support risk-based decision for several years. The primary use of RESRAD has been to calculate screening levels for radionuclides in surface soils and sediments. In FY2000, RESRAD will be evaluated for consistency with other models that will be used in the integrated technical strategy.

Another systems model being considered for application in ecological risk assessments at the watershed level is BioTran, which was developed at the Laboratory. As watershed data are compiled, BioTran may be used to evaluate ecological impacts at watershed and larger (regional) scales. The results of such modeling would be integrated with the results of biological surveys that measure ecosystem health in situ.

2.7.3 Sensitivity and Uncertainty Analyses

All models have some associated uncertainties. Some of these uncertainties reflect uncertainties in the field data used as boundary or initial conditions, and others reflect mathematical simplifications and approximations within the computer programs. The more complicated the processes or systems being modeled, the greater the number of uncertainties. However, uncertainties are not equally significant. For example, if a contaminant is insoluble in water, the potentially large uncertainty in recharge rate is not a significant factor in calculating groundwater pathway risk for that contaminant. One of the powerful uses

of models is sensitivity analysis—identifying the uncertainties to which the results of the model are sensitive. In risk-based corrective actions, this is an especially useful application of process models, which calculate risk as an endpoint.

Sensitivity and uncertainty analysis will be performed at all levels of modeling. The results will be used to identify data needs to support specific decisions with a sufficient degree of confidence

3.0 INTEGRATED INFORMATION MANAGEMENT SYSTEM

The success of the integrated technical strategy will rest in part on its capability to efficiently share compatible information and data among ER Project focus areas and stakeholders involved in decision-making. Information must be readily accessible to support conceptual models. Environmental data must be provided to internal and external stakeholders within reasonable time frames. ER Project end users need to retrieve information quickly and reliably, and with confidence in the quality and content of the data. These goals will be achieved through implementation of an Integrated Information Management System (IIMS) to control the collection, storage, retrieval, and dissemination of electronic information and data.

Figure 3.0-1 illustrates the relationship between planned and existing components of the IIMS, including affected organizations and their respective (integrated) activities.

3.1 Integrated Information Management Plan

The ER Project IIMS team formed in FY1999 includes ER Project representatives directly responsible for generating and handling information, as well as representatives from the groundwater integration team and the watershed integration team, and an independent information management specialist. The goal of the IIMS team is to ensure QA for information retrieved and to ensure that ER Project information is captured, stored, and retrieved in a manner that meets the needs of ER Project end users. The IIMS team will develop an integrated information management plan (IIMP) in FY2000. As part of the IIMP, a data management plan and implementing procedures will address

- how data usability decisions are made for ER Project and non-ER Project data;
- when and how tables of imported data are constructed and maintained within the ER Project database (ERDB);
- how the pedigree of ER Project and non-ER Project data is determined and described parametrically; and
- how non-ER Project data are combined with ER Project data for assessment purposes.

Thereafter, the existing records management plan will become subordinate to the IIMP (LANL 1998, 62060).

The ER Project IIMS integrates technical and management systems. IIMS technical components include

- the ERDB, the Geographical Information System (GIS), and the associated Facility for Information Management, Analysis, and Display (FIMAD) processes;
- the field support facility (FSF) and central data management (CDM) processes; and
- ER Project support to institutional databases.

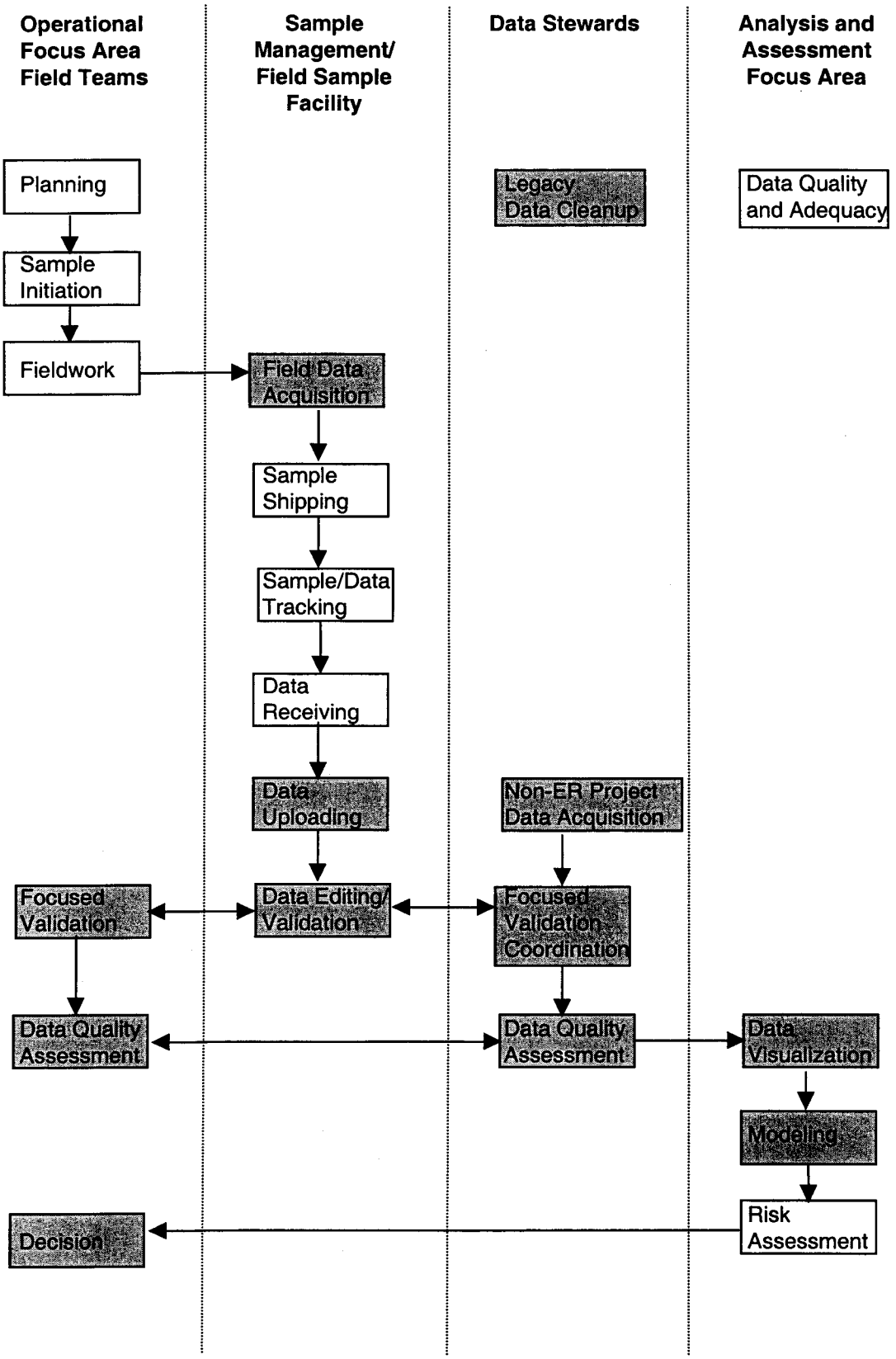


Figure 3.0-1. IIMS activities and organizations

IIMS management components are

- the PRS core database;
- deliverables documents and performance measure tracking systems;
- project planning and control systems;
- the human resources database;
- the ER Project internal and external web pages; and
- a procurement tracking system.

In FY1999 the ERDB is being reengineered to facilitate the storage and retrieval of data sets for PRSs and canyon reaches within the boundaries of aggregates and watersheds. The GIS data for PRSs, aggregates, and watersheds will be updated and maintained in coordination with the preparation of associated RFI and aggregate reports. Direct links between the tabular data in ERDB and the spatial coverages in GIS will be created. Software application tools for reporting tabular data and charts, for spatial display of tabular data, and for support of modeling and data visualization will be developed to ensure consistency in data reduction, reporting, and display.

The field data-collection system and FSF processes will be reengineered to ensure that field data and sample metadata are collected and managed in a controlled manner. FSF and CDM will work with the Analysis and Assessment Focus Area to manage the flow of data from the field through their inclusion in the ERDB.

The ER Project groundwater, surface water, and borehole core data sets that currently exist in the ERDB are not in a state or form that permits their integration with institutional databases. Reengineering the ERDB will ensure that it becomes structurally compatible with these databases, and conforms to quality requirements developed by both project and nonproject sources.

The IIMS will include formal entity relationships for associating PRSs consistently in all technical and management databases. In addition, links will be established within the deliverables, performance measures, project planning and control, and procurement tracking systems to improve ER Project business management and help reduce overhead costs.

Web tools will be designed, implemented, and maintained to disseminate selected data sets from the ERDB to internal ER Project end users, and to facilitate information exchange with regulators and external stakeholders.

3.2 Data Stewardship

The goal of data stewardship is to optimize the accessibility, quality, and compatibility of technical data compiled by multiple field teams across the operational focus areas. This goal applies to existing ER Project ("legacy") data, newly generated ER Project data, and non-ER Project ("institutional") data (e.g., ESH data, modeling results). To meet this goal, data stewards—personnel knowledgeable in both data production and end uses—will be deployed from the Analysis and Assessment Focus Area to the operational focus areas; they will be tasked with coordinating the technical aspects of data sets.

Data stewards will ensure that the overall requirements for data set preparation are met. This function includes the following activities:

- developing QA metrics for auditing individual data sets;
- ensuring that the data has passed through the QA process and meets the applicable data QA metrics or are appropriately flagged to indicate deficiencies;
- assigning appropriate data pedigree categories to data indicating both the degree of adherence to data QA metrics and other characteristics of the data;
- ensuring the data, including associated metadata, are substantially complete before the data set is released to users; and
- identifying the associated hardcopy records and ensuring that they are substantially complete and accessible.

3.2.1 Legacy Data

All ER Project electronic data residing in the FIMAD database through FY1999 is considered legacy data because it was not collected according to a formal data management plan or controlled implementing procedures. As part of the data stewardship function, the ER Project is undertaking a legacy electronic data cleanup effort to improve the quality of the electronic data set and facilitate data analysis and assessment. Data-set cleanup will occur according to the priorities identified in the ER Project baseline.

The legacy data cleanup effort is focused on locating the hardcopy records that support the electronic record, identifying the critical fields required for data analysis and assessment, defining a consistent set of fields for different electronic data streams, and performing fundamental QA checks on these fields. All legacy data will be migrated to the reengineered ERDB by the end of FY2001.

3.2.2 Non-ER Project Data

The integrated technical strategy relies on the compilation of nonproject and project data to formulate site conceptual models for appropriate assessment areas. Where these nonproject data are maintained in institutional databases that are integrated with the ERDB, the sponsoring teams or organizations will provide data stewardship. When a nonproject data set is imported into the ERDB, however, a data steward for the imported data set will be identified to ensure that the data are as complete as possible and conform to the standard formats for project data.

To the extent possible the ER Project will cooperate actively with the developers of nonproject environmental databases to identify compatible database designs and data dictionaries. The data steward will be responsible for determining the source and pedigree of imported data in accordance with ER Project data validation procedures.

3.2.3 Modeling Data

At least two aspects of modeling data make these data sets quite different from those the ER Project has assembled to date for site characterization or in support of VCAs:

1. Modelers need data for every parameter in the model. Quantitative calculations cannot be completed without values for all parameters. Therefore, modelers first must document data sources and characterize the usability and appropriateness of available data, given their intended use within the model.

2. From the perspective of the modeling application, the available data invariably are incomplete, spatially and/or temporally. Modelers must process raw/reduced data to generate parameter values on a grid, estimate the source term (possibly as a function of time), or derive parameters in other forms required by the model. Therefore, modelers next must document what was done with the data to prepare them for use in the model and for characterizing uncertainties introduced in this process.

Determining data usability for modeling requires evaluating objective measures of data quality and other indicators of data pedigree in the context of the specific problem or application. The available data may be of poor quality by standard metrics, but if they are the only data available, they may be used (with appropriate restrictions).

The following issues will be addressed in a standardized way as the integrated technical strategy is implemented:

- How well-documented are the sampling and analytical protocols by which the data were produced?

- Are the data representative of the parameter of interest? Some factors that might lead to unrepresentative data are

  - samples (on which hydrogeologic measurements were made) were not collected from the geological strata of interest, or from the geographic region being modeled;

  - the drilling method may have modified the physical or chemical properties of the sample;

  - surface water samples are time-weighted composites rather than flow-weighted composites, or the samples contain only suspended sediments (although movement of bedload sediments could be the main contributor to transport of contaminants); and

  - the analytical method used produces measurements that are biased relative to the quantity of interest.

- Are the data complete (i.e., do they represent the full range of conditions to be modeled)? Examples of factors that could lead to incomplete data are

  - soil samples were biased by field measurements toward more heavily contaminated areas; and

  - surface water samples are grab samples representing only the rising limb of the hydrograph from storm events, with no available data from tails of events or baseflow conditions.

Among the modeling data sets to be maintained is the GIS maps underlying the Laboratory sitewide hydrogeologic atlas, the initial version of which will be completed in FY1999.

When models are used to support regulatory decisions, it is critical to have codes that have been thoroughly tested and maintained under a rigorous QA program. The models implemented in the integrated technical strategy have been or will be thoroughly documented.

3.3 Integrated Institutional Databases

The ER Project actively participates in the development and maintenance of institutional databases that are critical to the integrated technical strategy approach. To ensure its strategic needs are met, the ER Project supports the Laboratory's groundwater database (GWDB) and the Watershed Management Program database (WMDB), which are managed by the Laboratory's Water Quality and Hydrology Group, ESH-18. The institutional databases will meet the data management requirements of the hydrogeologic work plan (LANL 1998, 59599) data-collection effort, watershed-scale surface water data collection under the final watershed management plan (LANL 1999, 62920), and long-term monitoring on project closeout. Development of the GWDB as a repository for sitewide groundwater and hydrogeologic data began in FY1999. Development of the WMDB, which will store watershed surface water monitoring data, is expected to begin in FY2000.

The ER Project and ESH-18 are working jointly to ensure that similar data types, table structures, limited lists, data dictionaries, and data management processes will be shared by both organizations. To further that goal, ER Project technical personnel participate as members of the groundwater integration team and watershed integration team information management subcommittees. The ER Project will provide data stewards for specialized data sets such as geochemical, hydrogeologic, and geotechnical data. ER Project personnel will participate in data validation, data reduction, and data reporting for these institutional data sets. ESH-18 will provide technical representatives to the ER Project IIMS team and the database design committee.

3.4 Data Set Preparation

The integrated technical strategy will use existing and new data—taken from project and nonproject sources—to support analysis of multiple sources and assessments of multiple transport and exposure pathways. The larger assessment areas will require the integration of background and baseline data and non-ER Project data (e.g., institutional monitoring data) with PRS data. Data and derived parameters used in analysis and assessment must be configured and controlled to ensure reproducibility of reported outcomes, consistent updating as new information is acquired, and external validation of results. A document is being developed in FY1999 to describe the configuration control required for models used to support ER Project decisions.

Data sets range in size from those describing single PRSs to those describing residual contamination along an entire watershed. All data will reside in the ERDB, and will be prepared and presented (tabulated) in a consistent format. Summary statistics will be derived from the electronic data for the watershed completion reports. The electronic data will also be the source for contaminant profile calculations such as maximum concentrations and inventory, which will be generated and reported

annually. Contaminant profile information will be used to update the conceptual model and assessment approach for each watershed.

Computer-based tools developed in FY2000 and FY2001 will be implemented to visualize data (both analytical and model results) in two and three dimensions. The objectives of this activity are to develop and apply data visualization and spatial analysis applications to

- develop geospatial data models of ecologic, geologic, hydrologic, and contaminant parameters necessary for risk assessment and the development of contaminant inventories; and
- communicate the basis for scientific and management decisions in a visual format.

Finally, data-set planning and preparation will be designed to support the Laboratory's general electronic data deliverable (GEDD), such that future implementation of the GEDD will not induce additional reengineering of the ERDB.

4.0 WATERSHEDS AND AGGREGATES

The ER Project follows a systems approach to corrective actions, using watersheds to delineate natural drainage systems. The total area of the eight drainages (watersheds) is about 120 mi^2 (270 km^2). Individual drainages range from Chaquehui at 1.58 mi^2 (3.55 km^2) to Los Alamos at about 50 mi^2 (112 km^2). To define work at a tractable scale, the watersheds have been subdivided into aggregates within which corrective action activities will be implemented. Many aggregates contain several PRSs, and others contain only one.

4.1 Identification of Watershed Aggregates

Watershed aggregates were delineated by a team of individuals from each ER Project focus area, ensuring that the process and results were equally responsive to technical, regulatory, and programmatic priorities and concerns. The following criteria were identified:

- consistency with canyons conceptual model (fluvial geomorphology),
- recognition of known contamination,
- presence of surface-water monitoring stations,
- understanding of the complexity of physical system,
- consistency with reaches previously identified and investigated,
- consistency with ecological risk assessment approach,
- recognition of perceived vulnerabilities,
- compatibility with Land transfer parcels and
- compatibility with Hazardous and Solid Waste Amendments (HSWA) Permit PRS consolidation.

The aggregates resulting from the application of these criteria are shown in Figure 4.1-1.

Table 4.1-1 identifies the eight watersheds and the associated aggregates, and lists the number of PRSs within each aggregate.

In total, there are 35 aggregates and 2124 PRSs within the eight watersheds. For all but one watershed, the canyon within each watershed is itself an aggregate, so that Canyons Focus Area investigations can precede aggregate investigations. Depending upon the complexity of the watershed, the canyon aggregate comprises one or more PRSs. The exception is Frijoles Canyon, for which there are no Canyons Focus Area investigations planned (only aggregate investigations).

The Cañon de Valle/S-Site/Upper Canyon aggregate comprises approximately two dozen old buildings located on S-Site in TA-16, which actually are located across the Cañon de Valle, S-Site, and Upper Canyon aggregates.

4.2 Documentation

The results of prioritization of all ER Project work elements and aggregates are documented in the ER Project baseline (LANL 1999, 63448).

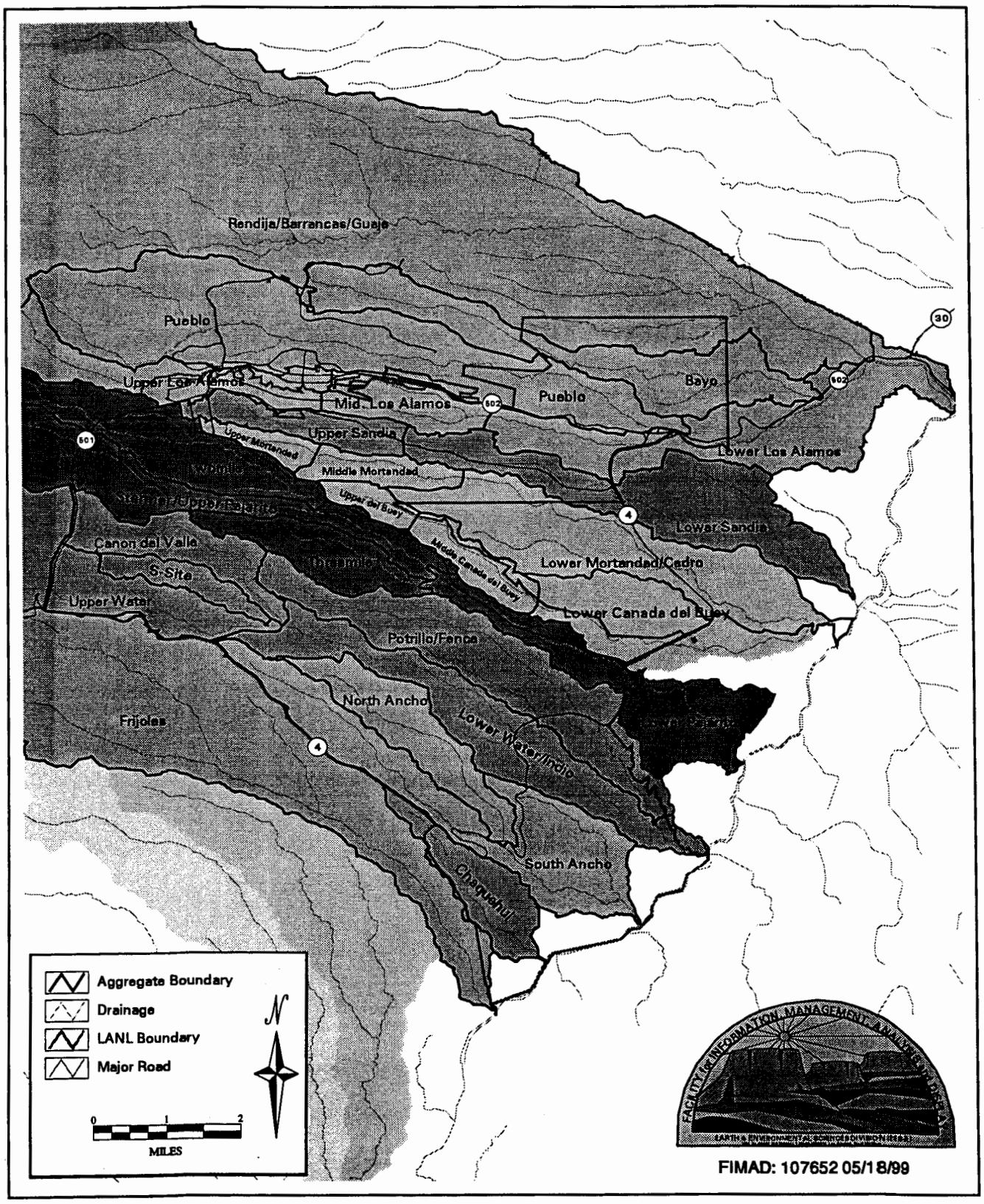


Figure 4.1-1. Watershed and aggregate map

Table 4.1-1
Watersheds, Aggregates, and Associated PRSs

Watershed	Watershed	Number of PRSs in Aggregate
Ancho	Ancho Canyon	1
	North Ancho	30
	South Ancho	6
Chaquehui	Chaquehui	60
	Chaquehui Canyon	1
Frijoles	Frijoles	16
Los Alamos/Pueblo	Bayo	32
	Middle Los Alamos	216
	Los Alamos/Pueblo Canyon	7
	Lower Los Alamos	26
	Pueblo	15
	Rendija/Barrancas/Guaje	29
	Upper Los Alamos	113
Mortandad	Lower Canada del Buey	1
	Lower Mortandad/Cedro	8
	Middle Canada del Buey	38
	Middle Mortandad/Ten-Site	78
	Mortandad/Canada del Buey Canyon	1
	Upper Canada del Buey	86
	Upper Mortandad	140
Pajarito	Lower Pajarito	57
	Pajarito Canyon	3
	Starmer/Upper Pajarito	140
	Threemile	36
	Twomile	163
Sandia	Lower Sandia	76
	Sandia Canyon	1
	Upper Sandia	188
Water/Valle	Cañon de Valle	244
	Cañon de Valle/S-Site/Upper Water	1
	Lower Water/Indio	21
	Potrillo/Fence	43
	S-Site	108
	Upper Water	150
	Water/Valle Canyon	4

4.3 Physical Descriptions of Watersheds

This section describes some of the physical features, events, and processes within the eight watersheds that are likely to impact the conceptual site-exposure model used to develop and implement integrated characterization, analysis, and assessment activities.

4.3.1 Los Alamos/Pueblo Watershed

The Los Alamos/Pueblo watershed contains seven aggregates—Bayo, Upper Los Alamos, Middle Los Alamos, Lower Los Alamos, Pueblo, Rendija/Barrancas/Guaje, and the Los Alamos/Pueblo Canyon itself. Figure 4.3-1 shows the Los Alamos/Pueblo watershed (including subdrainages) and its corrective action aggregates.

Los Alamos Canyon is located in the northern part of the Laboratory. It is an east-trending canyon that originates on US Forest Service land in the Sierra de los Valles at an elevation of 9950 ft (3033 m) asl. The drainage extends about 16 mi (24 km). from the headwaters to its confluence with the Rio Grande at an elevation of 5550 ft (1692 m) asl and drains an area of about 11 mi^2 (25 km^2). Los Alamos Canyon crosses Laboratory land from its western to eastern border. It crosses San Ildefonso Pueblo land for about 3.5 mi (5.3 km) before joining the Rio Grande. The canyon passes through or is adjacent to Laboratory TAs-1, -2, -3, -21, -26, -32, -41, -43, -53, 62, -72, and -73.

Los Alamos Canyon is 600 to 2500 ft (183 to 762 m) wide at the top and from 360 to 800 ft (110 to 244 m) deep. The canyon cuts into the Tschicoma Formation in the Sierra de los Valles, Bandelier Tuff across Laboratory land, and the Puye Formation before it reaches the Rio Grande. The canyon floors are relatively flat and filled with alluvium and colluvial soils eroded from the canyon walls, and vary in width from a few tens of feet to 2000 ft (610 m). The sides of these canyons are steep, rocky, and partially covered by trees, particularly on the south sides (the north-facing slopes).

On a regional scale, Los Alamos Canyon is an interrupted stream. Small streams characterized by extremely variable flow are located on the floor of the canyon. Two springs in upper Los Alamos Canyon, Quemazon Spring and Reservoir Spring, support a perennial reach to within a few to several hundred yards west of the Los Alamos reservoir. The Los Alamos reservoir provides a relatively constant source of surface water to the stream in upper Los Alamos Canyon except during late spring and early summer (after snowmelt and before summer storms refill the reservoir). In most years, snowmelt adds enough water to the reservoir to that it overflows and supports flow onto the western portion of the Laboratory. Skating rink spring, west of the county-operated skating rink, flows intermittently and provides a small component of surface water to the stream.

On Laboratory lands, surface-water flow is mainly ephemeral until its confluence with Pueblo Canyon, where sanitary effluent from the Los Alamos County/Bayo Canyon sewage treatment plant (STP) typically supports surface flow to the Laboratory's eastern boundary. Two springs just east of the Laboratory boundary, Basalt Spring and Los Alamos Spring, and one spring in the lower canyon, Indian Spring, flow intermittently and provide surface water to the stream and saturation in the alluvium. Springs, effluent flow, and precipitation, combined with seasonally variable saturated alluvial conditions in the lower canyon can support surface flow to the Rio Grande several days of the year. During the summer months, effluent discharge from the treatment plant is reduced or discontinued because it is used to irrigate the county golf course and athletic fields.

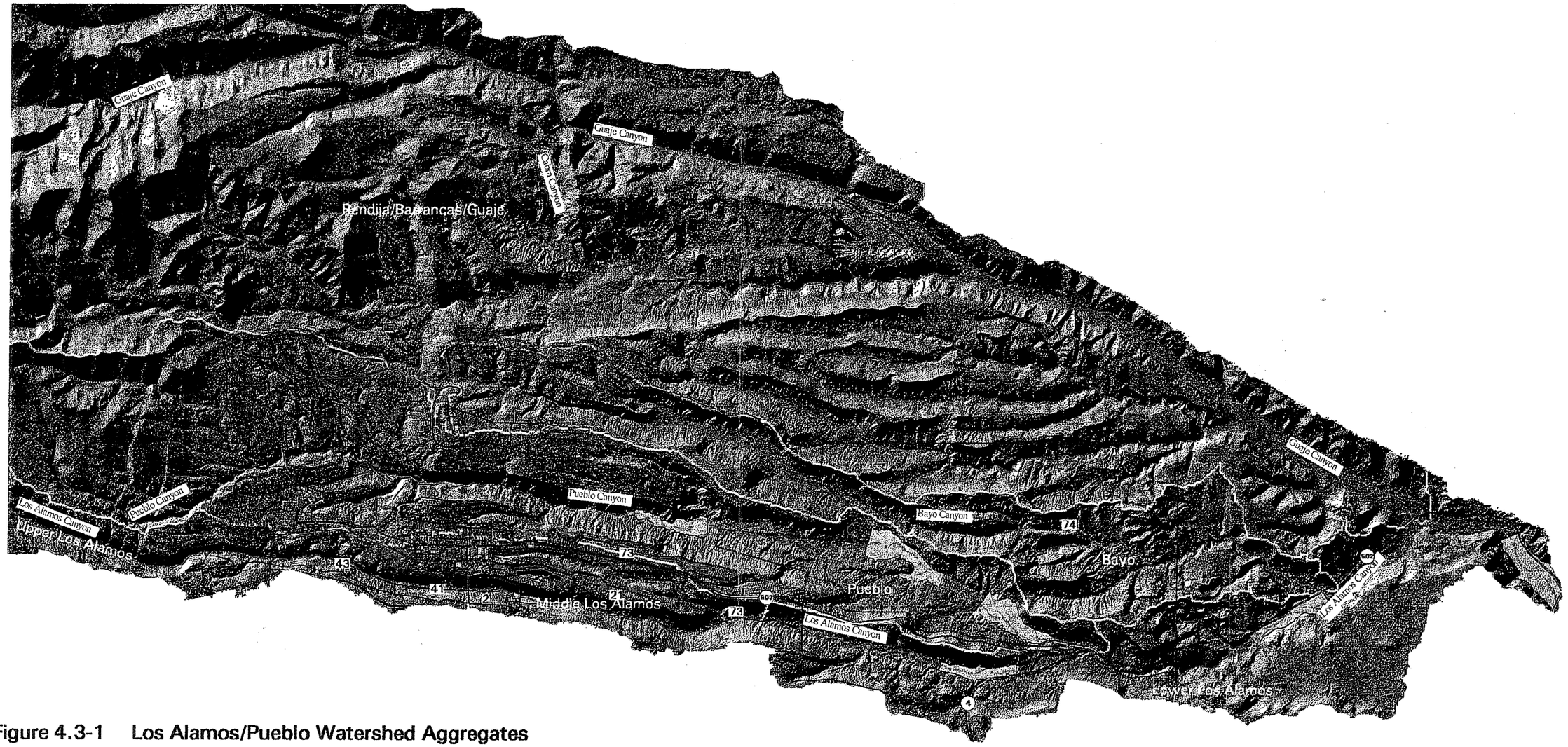


Figure 4.3-1 Los Alamos/Pueblo Watershed Aggregates

Los Alamos Watershed Aggregates

- Aggregate Boundary
- Paved Road
- Potential Release Site (PRS)
- Technical Area (TA) Boundary
- Potential Sampling Reach
- Structure
- Wetland

0 0.50 1.50
MILES

1983 North American Datum
Projection and Grid Ticks:
New Mexico State Plane Coordinate System,
Central Zone (Transverse Mercator)

Notice: Information on this map is provisional and has not been checked for accuracy.

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Operating NPDES-permitted outfalls associated with Los Alamos Canyon and adjacent mesa tops draining into the canyon include 03A-040, which is associated with the Health Research Laboratory at building 43-1; 03A-047, 03A-048, 03A-049, and 03A-113, which are associated with the cooling towers at TA-53; 02A-129 and 03A-158, which are associated with the steam plant (Building 21-357) and the tritium science and technology building (21-209); and 04A-161 and 04A-186, which are associated with water supply wells Otowi #1 and Otowi #4.

Pueblo Canyon originates on US Forest Service land, and has a total drainage area of about 6.5 mi^2 (14.6 km^2). It extends across northern Los Alamos County and into the northeastern part of the Laboratory, where it joins Los Alamos Canyon. The Pueblo Canyon drainage contains most of the townsite. The canyon passes through or is adjacent to TAs-0, -19, -31, -45, and -73. The lower, broad portion of the canyon remains on Laboratory-controlled land.

Pueblo Canyon is 500 to 3000 ft (152 to 914 m) wide at the top and varies in depth from 200 to 500 ft (60 to 152 m). No source of water to sustain perennial flow is present in upper Pueblo Canyon, though small streams with extremely variable flow are found on the canyon floor. Snowmelt from the upper reaches occasionally extends downstream as far as the townsite, but does not normally reach Laboratory land. A small tributary known as Acid Canyon received contaminated liquid wastes in the early years of Laboratory operation. The Los Alamos County/Bayo Canyon STP located between Bayo Canyon and Pueblo Canyon releases a substantial flow of treated water into the lower half of Pueblo Canyon. One spring located near the STP, Hamilton Bend Spring, rarely flows. There are no NPDES-permitted outfalls in Pueblo Canyon.

4.3.2 Mortandad Watershed

The Mortandad watershed contains seven aggregates for the purposes of integrated characterization and remediation—Lower Cañada del Buey, Lower Mortandad/Cedro, Middle Cañada del Buey, Middle Mortandad/Ten-Site, Upper Cañada del Buey, Upper Mortandad, and the Mortandad/Cañada del Buey Canyon itself. Figure 4.3-2 shows the Mortandad watershed (including subdrainages) and its corrective action aggregates.

Mortandad Canyon is an east-to-southeast trending canyon that heads on the Pajarito Plateau near the main Laboratory complex at TA-3, at an elevation of 7380 ft (2249 m) asl. The drainage extends about 9.6 mi (14.4 km) from the headwaters to its confluence with the Rio Grande at an elevation of 5440 ft (1658 m) asl and drains an area of about 4.6 mi^2 (10.4 km^2). The canyon crosses San Ildefonso Pueblo land for several miles before joining the Rio Grande. The canyon passes through or is adjacent to Laboratory TAs-3, -5, -35, -46, -48, -50, -51, -52, -54, -55, -59, -60, and -63.

Mortandad Canyon is cut into Bandelier Tuff, with steep walls that are near vertical in some places. The canyon floor is narrow from the head to approximately TA-35, where it widens eastward. One tributary, Effluent Canyon, joins Mortandad Canyon in this segment. This section of the canyon is filled with underbrush, shrubs, pine, fir, box elder, and oak trees. The stream channel is entrenched in this portion of the canyon.

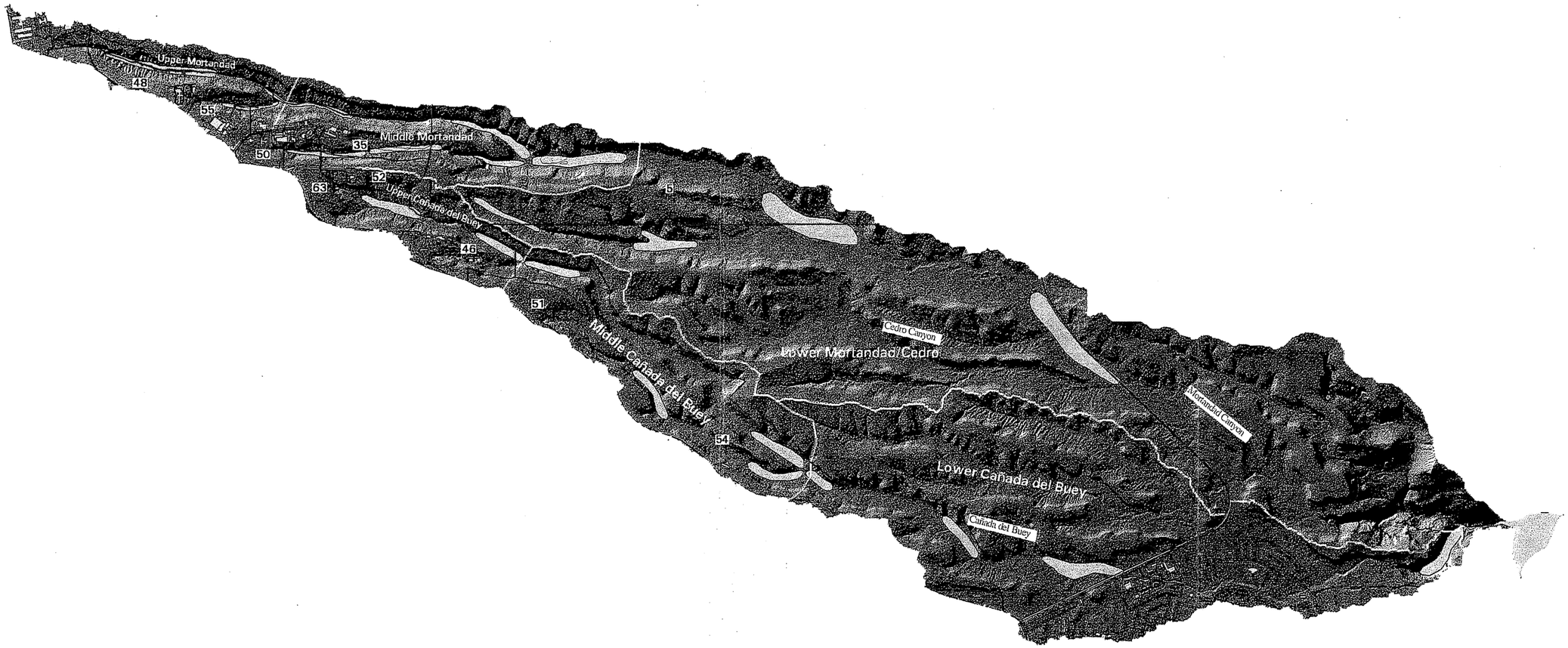

Figure 4.3-2 Mortandad Watershed Aggregates

Mortandad Watershed Aggregates

- Aggregate Boundary
- Paved Road
- Potential Release Site (PRS)
- Technical Area (TA) Boundary
- Potential Sampling Reach
- Structure
- Wetland

0 0.50 1.50
MILES

1983 North American Datum
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Figure 4.3-3 Water/Cañon de Valle Watershed Aggregates

Water/Cañon de Valle Watershed Aggregates

- Aggregate Boundary
- Paved Road
- Potential Release Site (PRS)
- Technical Area (TA) Boundary
- Potential Sampling Reach
- Structure
- Wetland

0 0.50 1.00
MILES

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From TA-35 downstream, the canyon widens and the stream channel is well defined. This portion of the canyon has been channelized and a portion of the stream has been diverted to prevent wash-out of the roads and well heads. The number of pine trees decreases eastward from TA-35 and there is a transition to a scattered piñon-juniper community. Small wetland areas that support cattails are associated with the active outfalls in Mortandad Canyon near TA-35.

Mortandad Canyon is an ephemeral stream with no known springs. It does not receive significant snowmelt. Treated effluent from the Los Alamos County/White Rock STP, located at Overlook Park, enters Mortandad Canyon from Cañada del Buey and generally flows to the Rio Grande. During the summer months, effluent discharge is reduced or discontinued because it is used to irrigate the soccer and softball fields at Overlook Park.

Operating NPDES-permitted outfalls associated with Mortandad Canyon include 051, which is associated with the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF); 03A-021, which is associated with the Chemistry and Metallurgy Research laboratory at TA-3; 03A-022, which is associated with the Sigma Building at TA-3; 03A-045, which is associated with the radiochemistry laboratory at TA-48; 03A-160, which is associated with Antares Target Hall at TA-35; 03A-181, which is associated with a utility building at TA-55; and 04A-166, which is associated with water supply well Pajarito Mesa #5.

Ten-Site Canyon is a major tributary to Mortandad Canyon on Laboratory property, with a surface area of about 0.3 mi^2 (0.7 km^2). It lies south of Mortandad Canyon and parallels the canyon for a distance of about 1.5 mi (2.25 km). A small tributary to Ten-Site Canyon is informally referred to as "Pratt Canyon" in the Mortandad Canyon work plan (LANL 1997, 56835). Pratt Canyon received discharges of liquid and sludge from the TA-35 wastewater treatment plant that operated from 1951 to 1963.

No active NPDES-permitted outfalls are associated with Ten-Site Canyon. They have been eliminated.

Cañada del Buey covers a surface area of about 4.3 mi^2 (9.7 km^2). It extends about 7 mi (10.5 km) to the southeast along the north side of TA-54 through the north part of White Rock and joins Mortandad Canyon about 0.5 mi (0.75 km) upstream of the Rio Grande. Cañada del Buey is entirely ephemeral in character. The county-operated STP in White Rock discharges into Cañada del Buey about 2 mi (3 km) upstream of its confluence with Mortandad Canyon. This discharge results in effluent-supported surface flow that regularly extends to the Rio Grande.

NPDES-permitted outfalls associated with Cañada del Buey include 13S, which is associated with the TA-46 sanitary wastewater system consolidation (SWSC) plant (effluent is sampled at 13S but not discharged; all SWSC effluent is routed to TA-3); and 04A-118, which is associated with water-supply well Pajarito Mesa #4.

The TA-50 RLWTF outfall has the highest impact on the quality of water in Mortandad Canyon.

4.3.3 Water/Cañon de Valle Watershed

The Water/Cañon de Valle watershed contains seven corrective-action aggregates for the purposes of integrated characterization and remediation: Cañon de Valle, Cañon de Valle/S-Site/Upper Water, Lower Water/Indio, Potrillo/Fence, S-Site, Upper Water, and Water/Valle canyon in its entirety. Figure 4.3-3 shows the aggregate boundaries in the Water/Cañon de Valle watershed.

Figure 4.3-4 Sandia Watershed Aggregates

Sandia Watershed Aggregates

- Aggregate Boundary
- Paved Road
- Potential Release Site (PRS)
- Technical Area (TA) Boundary
- Potential Sampling Reach
- Structure
- Wetland

0 0.50 1.00
MILES

1983 North American Datum
Projection and Grid Ticks:
New Mexico State Plane Coordinate System,
Central Zone (Transverse Mercator)

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Water Canyon, which heads on the flanks of the Sierra de Los Valles, drains a total area of about 6 mi^2 (13.5 km^2). It originates on US Forest Service lands and extends across the southern portion of the Laboratory to its confluence with the Rio Grande in White Rock Canyon.

On a regional scale, Water Canyon is an interrupted stream attributable to several perennial springs in the upper reaches of Water Canyon, including Armistead, American, and other springs in the upper reaches of Cañon de Valle (the major subdrainage to Water Canyon).

As it cuts across the southern half of Laboratory property, the Water Canyon drainage passes near numerous sites that have been used for testing and development of weapons components, including Tas-8, -9, -11, -14, -15, -16, -36, and -49. While several of these sites have been inactive since the early 1950s, others are still in use. Potential contaminant releases into the Water Canyon drainage as a result of these operations include high explosives (HE), radionuclides, and metals.

The Water Canyon drainage encompasses land managed by the Laboratory and land owned by the US Forest Service. Currently, hiking trails provide recreational access to the portion of the drainage west of the Laboratory boundary on US Forest Service land. Local residents and Laboratory employees use this area for activities such as hiking, biking, jogging, and camping.

Frequently, some regular anthropogenic flow occurs in part of Water Canyon in a reach that extends from near the southwest corner of the Laboratory boundary to a point slightly downstream of the confluence with its tributary, Cañon de Valle. This water is spring water from the Water Canyon gallery that is piped through TA-16 where it was once used for industrial supply. This water is released from TA-16 and flows through stormwater drainages back into the Water Canyon drainage.

Snowmelt in Water Canyon seldom extends downstream as far as the Laboratory boundary. However, on one occasion in the early 1970s, it extended all the way to the Rio Grande. NPDES-permitted outfalls associated with Water Canyon include 03A-028, which is associated with a power control building and cooling tower at TA-15; and 03A-185, which is associated with the dual-axis radiographic/radiography hydrotest (DARHT) facility at TA-15.

Cañon de Valle originates on US Forest Service lands west of the Laboratory, and extends for 7.8 mi (11.7 km) to its confluence with Water Canyon. On this route it covers a drainage area of about 4.2 mi^2 (9.5 km^2), and passes through the south-central part of the Laboratory, in or near TAs-9, -11, -14, -15, -16, -37, and -67. It drains a surface area of approximately 4.2 mi^2 (9.5 km^2).

Cañon de Valle contains perennial springs on US Forest Service land west of the Laboratory's west boundary. Peter Spring, SWSC Spring, Burning Ground Spring, Fish Ladder Spring, and Hollow Spring have been identified in Cañon de Valle. Three of these springs currently measure flow at established stations. Cañon de Valle contains one NPDES-permitted outfall: 05A-055, which is associated with the HE wastewater treatment facility.

S-Site Canyon originates on Laboratory land at TA-16. It covers a drainage area of approximately 0.8 mi^2 (1.8 km^2), and extends for 2.5 mi (3.8 km) to its confluence with Cañon de Valle, just above Cañon de Valle's confluence with Water Canyon. It contains one spring, Martin Spring. NPDES-permitted outfalls associated with S-Site Canyon include 03A-130, which is associated with the vibration test building at TA-11; and 05A-097, which is associated with a shed at TA-11.

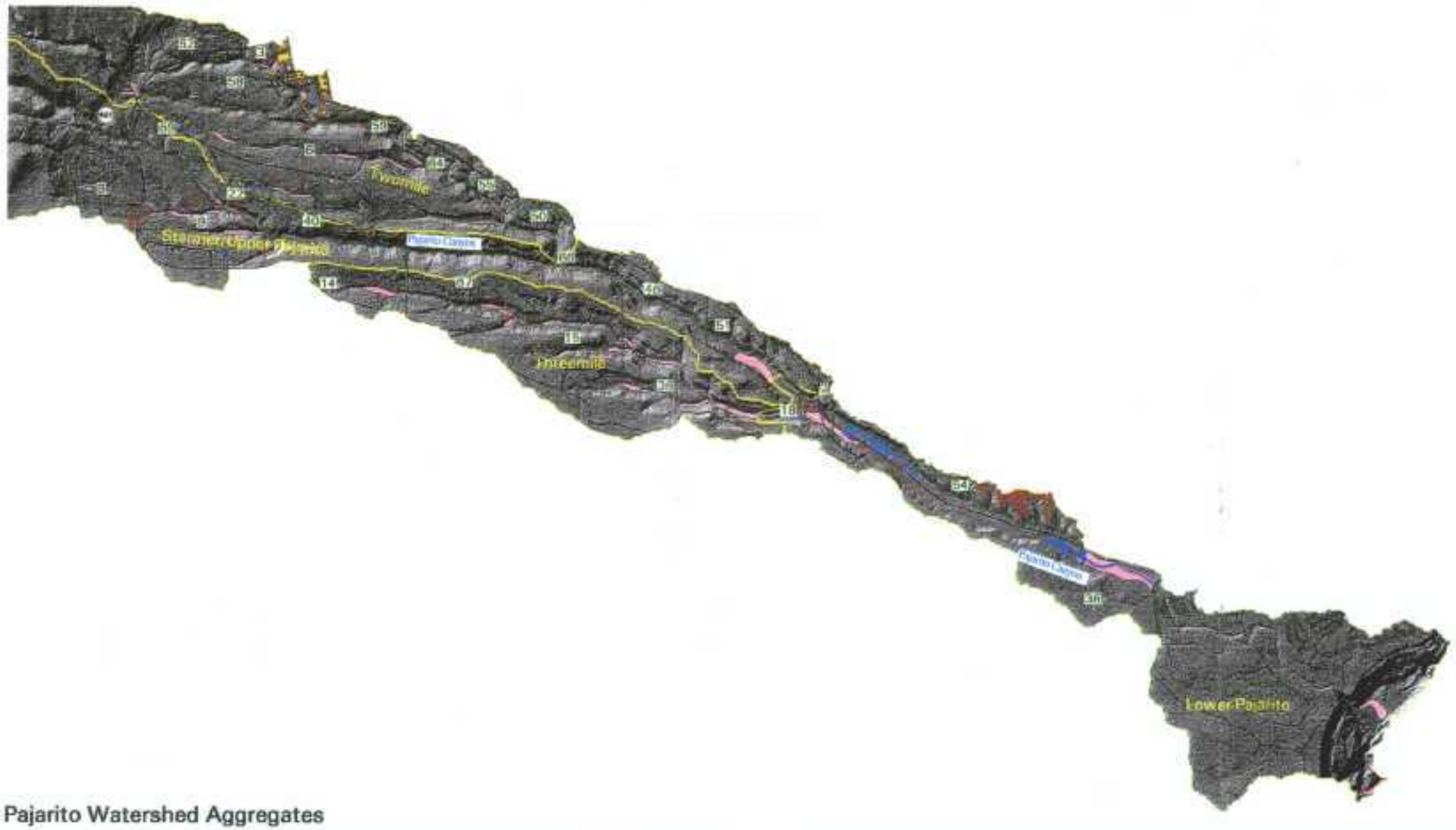

Figure 4.3-5 Pajarito Watershed Aggregates

Pajarito Watershed Aggregates

- Aggregate Boundary
- Paved Road
- Potential Release Site (PRS)
- Technical Area (TA) Boundary
- Potential Sampling Reach
- Structure
- Wetland

0 0.50 1.00
MILES

1983 North American Datum
Projection and Grid Ticks:
New Mexico State Plane Coordinate System,
Central Zone (Transverse Mercator)

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Potrillo Canyon originates on Laboratory lands and extends for 6.9 mi (10.4 km) to its confluence with Water Canyon. On this route it passes through the southeastern part of the Laboratory, in or near TAs-14, -15, -36, and -67. It drains a surface area of approximately 3.4 mi^2 (7.7 km^2).

Potrillo Canyon is entirely ephemeral in character. A special study determined that the broad portion of the canyon below TA-36 forms a significant sink for surface-water flow. There are no NPDES-permitted outfalls.

Fence Canyon originates on Laboratory lands and extends for 3.1 mi (4.7 km) to its confluence with Potrillo Canyon. On this route it passes through the southeastern part of the Laboratory, in or near TAs-36, -68, and -71. It drains a surface area of approximately 1.1 mi^2 (2.5 km^2). Fence Canyon is entirely ephemeral in character. It has no NPDES-permitted outfalls.

Indio Canyon originates on Laboratory lands and extends for 1.2 mi (1.8 km) to its confluence with Water Canyon. On this route it passes through the southeastern part of the Laboratory, in or near TAs-39, -49, and -70. It drains a surface area of approximately 0.7 mi^2 (1.6 km^2). Indio Canyon is entirely ephemeral in character. It has no NPDES-permitted outfalls.

4.3.4 Sandia Watershed

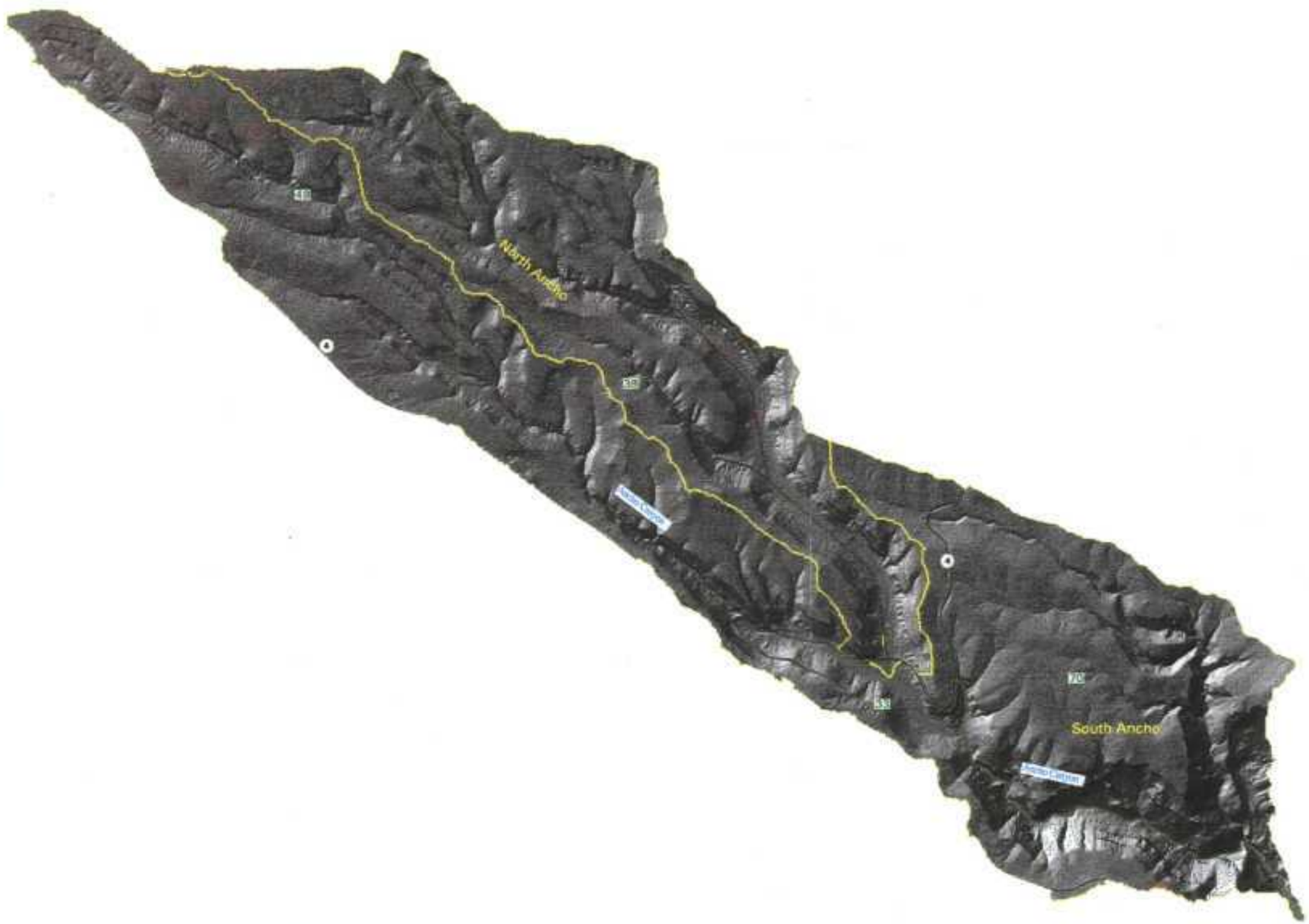
The Sandia watershed is a relatively simple physical system, divided into three corrective-action aggregates—Upper Sandia, Lower Sandia, and Sandia Canyon itself. Figure 4.3-4 shows the aggregate boundaries within the Sandia watershed.

Sandia Canyon heads on the plateau within the Laboratory boundary. It has a total drainage area of about 5.5 mi^2 (12.4 km^2). The small drainage extends for about 10 mi (15 km) across the central part of the Laboratory, through or near TAs-3, -53, -60, -61, and -72. It crosses San Ildefonso Pueblo land for about 3 mi (4.5 km) before joining the Rio Grande.

Sandia Canyon is ephemeral to a point about 3 mi (4.5 km) east of the Laboratory's eastern boundary where Sandia Spring supports perennial flow for a few hundred yards. This flow does not normally reach the Rio Grande. Sandia Canyon receives no significant snowmelt. In the upper canyon, an effluent-supported reach arising from discharge of treated sanitary effluent supports a significant wetland and typically extends about 3 mi (4.5 km) before infiltrating the canyon bottom alluvium.

NPDES-permitted outfalls associated with Sandia Canyon include 01A-001, which is associated with the steam plant at TA-3; 03A-024 and 03A-027, which are associated with the cooling towers at TA-3; and 04A-163 and 04A-165, which are associated with water supply wells Pajarito Mesa #1 and Pajarito Mesa #3.

The Laboratory made active use of Sandia Canyon lands during the 1940s. The former TA-20, today located partly within TA-53, was used during the Manhattan Project to test initiators (devices that generate neutrons to initiate nuclear explosions). Later, it was for other types of implosion tests. The site, near the west end of Sandia Canyon, consisted of a series of firing areas that were spaced along a small road heading west from state road New Mexico (NM)4. Though there have been few official Laboratory activities in Sandia Canyon since 1948, the canyon has been potentially impacted by outfalls and run-off from mesa-top activities, in particular the treated effluents from the TA-3 sanitary STP and cooling tower blow-down from the TA-3 power plant. Currently, the Laboratory security force active firing range is located in Sandia Canyon.



Ancho Watershed Aggregates

- Aggregate Boundary
- Paved Road
- Potential Release Site (PRS)
- Technical Area (TA) Boundary
- Potential Sampling Reach
- Structure
- Wetland

0 1000 2000 3000
FEET

1983 North American Datum
Projection and Grid Ticks:
New Mexico State Plane Coordinate System,
Central Zone (Transverse Mercator)

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Figure 4.3-6 Ancho Watershed Aggregates

4.3.5 Pajarito Watershed

The Pajarito watershed contains five corrective-action aggregates (Figure 4.3-5.) They are Lower Pajarito, Starmer/Upper Pajarito, Threemile, Twomile, and the Pajarito canyon.

Pajarito Canyon heads on the flanks of the Sierra de los Valles, on US Forest Service lands. It extends eastward for a length of approximately 15 mi (23 km) across the south-central part of the Laboratory before entering Los Alamos County lands in White Rock. On this course it passes through numerous Laboratory technical areas. It covers a drainage area of approximately 8 mi^2 (18 km^2).

On a regional scale, Pajarito Canyon is an interrupted stream attributable to several perennial springs in its upper reaches. These springs support flow in a perennial reach of the canyon, followed by an intermittent reach to within about 0.5 mi (0.75 km) west of the Laboratory boundary. At about 1.0 mi (1.5 km) east of the western Laboratory boundary, Homestead Spring supports another perennial reach for at least several hundred yards, followed by an intermittent and/or ephemeral reach that may extend almost to its confluence with Threemile Canyon.

East of this confluence, Pajarito Canyon is ephemeral across Laboratory land and Los Alamos County land through White Rock, down to a point about 0.4 mi (0.6 km) upstream from its confluence with the Rio Grande. There a large perennial spring fed by the main aquifer, commonly called Pajarito Spring, supports perennial flow for the remainder of the distance to the Rio Grande.

In most years, snowmelt extends onto Laboratory lands for periods ranging from a few days to a few weeks, and may extend down to or below the confluence with Threemile Canyon. Snowmelt occasionally extends downstream as far as the confluence with the Rio Grande.

NPDES-permitted outfalls associated with Pajarito Canyon include 04A-164, which is associated with water supply well Pajarito Mesa #2; and 06A-106, which is associated with the laboratory and office building 36-1 at TA-36.

Twomile Canyon begins in US Forest Service land west of the Laboratory, and extends for about 5 mi (7.5 km) to its confluence with Pajarito Canyon near the center of Laboratory land. Its drainage area is about 2.5 mi^2 (5.6 km^2). It passes through or near numerous Laboratory technical areas. Twomile Canyon contains ephemeral and/or intermittent flow due to groundwater run-off of alluvial water recharged by snowmelt. No operating NPDES-permitted outfalls discharge into the Twomile Canyon drainage.

Commencing on centrally located Laboratory property, Threemile Canyon extends approximately 2.5 mi (3.75 km) to its confluence with Pajarito Canyon and covers a drainage area of approximately 1.7 mi^2 (3.8 km^2). It passes through Laboratory TAs-14, -15, -18, -36, and -67. Like Twomile Canyon, Threemile Canyon experiences only ephemeral or intermittent flow. No operating NPDES-permitted outfalls discharge into the Threemile drainage.

The Laboratory's primary use of Pajarito Canyon has been as the location of the Los Alamos Critical Experiments Facility at TA-18 and surface and subsurface MDAs; as a buffer zone for mesa-top firing site activities; and to a lesser degree, for liquid waste disposal. These operations have been conducted in and have possibly discharged to Pajarito Canyon and its tributaries since the Laboratory began operation in 1943. These early discharges were associated with outfalls, surface runoff, and dispersion from firing sites located at TAs-6, -7, -8, -9, -12, -15, -18, -22, -27, and -69. Additional discharges began with the continued expansion of Laboratory operations to new sites in the 1950s through the 1970s, specifically at TAs-3, -36, -48, and -59.

Chaquehui Watershed

- Paved Road
- Potential Release Site (PRS)
- Technical Area (TA) Boundary
- Potential Sampling Reach
- Structure
- Wetland

0 1000 2000 3000
FEET

1983 North American Datum
Projection and Grid Ticks:
New Mexico State Plane Coordinate System,
Central Zone (Transverse Mercator)

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Figure 4.3-7 Chaquehui Watershed

Frijoles Watershed

- Paved Road
- Potential Release Site (PRS)
- Technical Area (TA) Boundary
- Potential Sampling Reach
- Structure
- Wetland

0 2000 4000 6000
FEET

1983 North American Datum
Projection and Grid Ticks:
New Mexico State Plane Coordinate System,
Central Zone (Transverse Mercator)

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Figure 4.3-8 Frijoles Watershed

The Pajarito Canyon drainage encompasses land managed by the Laboratory, land owned by the US Forest Service, Los Alamos County land, and privately owned land. Currently, hiking trails provide recreational access to the portion of the canyon on Laboratory and Los Alamos County land. Local residents use a portion of the canyon east of the Laboratory boundary, including White Rock Canyon, for activities such as hiking, jogging, and rock climbing.

A significant portion of the residential community of White Rock, including portions of the La Senda and Pajarito Acres subdivisions, is located within the Pajarito Canyon drainage downgradient of the Laboratory boundary. Residents have unrestricted access to the main Pajarito Canyon channel.

4.3.6 Ancho Watershed

The Ancho watershed contains three corrective-action aggregates: Ancho Canyon, North Ancho, and South Ancho. Figure 4.3-6 shows the aggregate boundaries in the Ancho watershed.

Ancho Canyon, which heads on the plateau within the Laboratory near the middle of the southern Laboratory boundary, has a total drainage area of about 4.6 mi^2 (10.4 km^2). It extends for about 7.3 mi (11 km) across Laboratory land to its confluence with the Rio Grande.

Ancho Canyon is ephemeral within active Laboratory TAs-33, -39, and -49, and to the east past state road NM4, to a point about 0.8 mi (1.2 km) upstream from its confluence with the Rio Grande. At that point, a perennial spring, fed by the main aquifer and known as Ancho Spring, supports a perennial flow to its confluence with the Rio Grande. No significant snowmelt occurs in Ancho Canyon. No NPDES-permitted outfalls are associated with Ancho Canyon.

North Ancho aggregate Is a small ephemeral drainage with an area of about 2.2 mi^2 (5 km^2). It passes through TA-39 and may receive runoff from TA-33 and TA-49. No NPDES-permitted outfalls are associated with North Ancho.

The eastern sector of Ancho Canyon defines the northern boundary of TA-33, which was established in 1947 as a test site for weapons components experiments. Three MDAs are located at TA-33: MDA D at East Site, MDA E at South Site, and MDA K at Main Site. In addition, several storage bunkers are located at TA-33. Experiments conducted at TA-33 involved testing beryllium-containing initiators.

Further northwest is TA-39, which is bordered on the south by Ancho Canyon, and which is dissected by North Ancho. TA-39 was established in 1953 as a remote HE-experimentation center. TA-39 contains five outdoor firing sites, four of which remain active. All facilities at TA-39 are located on the North Ancho Canyon bottom.

Both Ancho Canyon and North Ancho originate within the boundaries of TA-49, also known as the Frijoles Mesa site. TA-49 has been used from the mid-1940s to the present as a buffer zone for firing sites in adjacent TAs-15 and -39. A period of intense experimental activity at TA-49 took place from late 1959 through mid-1961, during which hydronuclear and related experiments took place in underground shafts.

Ancho Canyon east of state road NM4 is used considerably for hiking access to the Rio Grande.

5.0 LONG-TERM SURVEILLANCE AND MAINTENANCE

Long-term surveillance monitoring and maintenance are likely components of final remedies for PRSs, groups of PRSs, aggregates, and watersheds where potentially mobile inventories may be left in place. Surveillance monitoring of environmental media provides assurance of continued acceptable risk, or indicates the need for further risk mitigation. Maintenance ensures that the conditions and assumptions under which risk-based decisions were made remain applicable. The design and duration of specific surveillance and maintenance programs generally will reflect the risk-limiting pathways for a site, or will measure the performance of engineered features. Monitoring is necessary to assess the longer-term impacts of residual contaminant inventories and remedial measures. Performance is often associated with determining that contaminant signatures are persistently at or below a criterion. Demonstrating performance typically requires a combination of monitoring and modeling. Modeling will take the form of statistical models when conceptual model components are measurable and mathematical models when mechanisms cannot be measured directly.

Surveillance monitoring entails collecting periodic measurements over time to assess status and trends. Developing an effective monitoring program depends upon sufficiently understanding the system to be monitored so as to anticipate which data will be useful for the analysis. The process of characterizing a site, assessing potential risks, and making corrective action decisions implies that the project has identified what is important about the site, at least from a contamination and transport perspective. The results of these activities will form the design basis for the integrated technical strategy monitoring program.

The integrated technical strategy will rely on existing Laboratory efforts such as the hydrogeologic work plan, the final watershed management plan, and the threatened and endangered species habitat management plan. If the ER Project identifies specific needs that fall outside the scope of Laboratory programs, the project may design additional long-term

surveillance and maintenance programs, which the Laboratory will adopt and implement as necessary to meet Permit requirements. In particular, points of compliance, compliance thresholds, contingencies, and times of compliance will be specified in the conditions of Permit modifications pursuant to completion of corrective actions.

5.1 Strategy

Monitoring design for the watersheds and aggregates will be a combination of site-specific criteria and a program-level strategic approach. Specific criteria will be developed as the aggregate approach matures in each watershed. The monitoring program design team will take the project-level actions below to ensure consistency across the watersheds.

- Identify the specific goals of the monitoring plan. This step is especially important for hydrologic system components, like the springs, where contaminant concentrations change with discharge and the system has several time scales of response to storm events. The measured concentration values will be influenced by the period of integration for the samples. This also means that performance criteria for contaminant concentrations need to be associated with time-integration periods.

- Measure both quantity and quality of water. Dynamic nonlinear hydrologic systems often require estimates of contaminant flux in order to assess trends. Discharge measurements are necessary for these calculations.

- Monitor at multiple geographic scales. The watershed boundaries are designed to include all fate and transport processes within a watershed. The monitoring program will be designed to include empirical estimates of the watershed components and to estimate transport across conceptual model elements.

- Coordinate surface water and alluvial groundwater monitoring. The separation of surface water and groundwater is more a convenience than a system reality, especially for the alluvial aquifer. Groundwater sampling will correspond to surface water monitoring events to support data comparisons.

- Collect water quality parameters. Having information on parameters such as pH, temperature, and charge balance in addition to contaminant concentrations is important to support mixing models and estimating transport across conceptual model elements. These estimates are necessary for modeling contaminant transport.

- Include biological monitoring in the program. Cost efficiencies for monitoring programs often take the form of restricted analyte lists to reduce analytical costs. One way to assess the overall quality of the monitored waters is to conduct toxicity testing with documented test organisms. If persistent toxic effects occur without changes in the monitored contaminants, the waters will be evaluated for additional toxicants.

- Establish a monitoring baseline and then evaluate the program for effectiveness and relevance. Monitoring programs are often susceptible to inertia. Once a program is initiated, the design is rarely revisited. A periodic review will be scheduled as part of the plan implementation. Criteria will also be established that allow reduced monitoring after a stated duration of results without exceeding performance criteria. Criteria are provided in the state water quality regulations.

- Integrate the monitoring design with other monitoring programs. Organizations other than the ER Project are conducting monitoring programs at the Laboratory. Coordinating these programs can reduce costs and enhance data usability.

- Commit to a reporting schedule and decision framework. Each measurement in the monitoring program will have an intended use. Periodic reports of data and interpretations are necessary in order to move information to the stakeholders. The program design will include documenting decision options that the data and interpretations are likely to support. The lag between sample collection and reporting will be considered carefully.

5.1.1 Surface Water

The integrated technical strategy assumes that an institutional watershed management plan will be developed and implemented. Once the final plan is in place, the ER Project will explicitly identify surface water sampling and gaging stations that will be used to fulfill long-term surface water surveillance monitoring needs for PRSs, aggregates, and watersheds.

5.1.2 Vadose Zone

Some form of long-term monitoring probably will be required for sites where a residual contaminant inventory will be left in place, even if no significant releases have been measured within the vadose zone. The ER Project may propose a modification to traditional monitoring approaches, based on statistical procedures designed to compare measured contaminant concentrations to observed background concentrations. Low contaminant-migration rates indicate continuous monitoring for contaminants would be both ineffective and costly; virtually no contaminant transport is expected under most scenarios.

The ER Project will consider the following steps in a probabilistic approach to optimize a vadose-zone monitoring based on field data and computational model results.

- Develop and document flow and transport conceptual models at contaminated sites.
- Evaluate site performance relative to the regulatory performance objectives.
- Conduct sensitivity analyses to identify the site parameters that most strongly affect the identified failure scenarios. The hydrogeologic setting of contaminated sites involves complex systems with multiple interacting processes and significant uncertainty.
- Develop probability distribution functions (pdf) for parameters identified from the sensitivity analysis.
- Carry out a second stage of simulation modeling using a probabilistic code that represents/abstracts system performance (e.g., RIP) to establish confidence limits for key parameters that can be measured through site monitoring.
- Design and implement a monitoring system to obtain required site data.

This optimized, probabilistic approach to monitoring has multiple advantages. First, monitoring is designed to provide early warning before contamination levels reach regulatory sensitivity. Second, monitoring can be designed to measure hydraulic properties (e.g., water content) that are sensitive indicators of significant changes in the vadose zone. This approach to monitoring can be considerably less expensive because it does not require extensive sampling and resampling to detect suites of possible contaminants. Third, monitoring is optimized for specific site conditions and performance objectives; monitoring results are compared to site-specific confidence limits established through simulation modeling.

5.1.3 Groundwater

The Laboratory in general and the ER Project in particular have placed a high priority on protecting the regional aquifer as a permanent source of drinking water. Ultimately, through the installation of 32 regional aquifer wells in accordance with the hydrogeologic work plan, the Laboratory will understand the current cumulative impact of environmental releases on groundwater quality. Equally important, information gained from the monitoring-well installation program will be used to develop models of the hydrologic system, which in turn will be used to understand the potential cumulative future impact of past releases. It is assumed that the long-term groundwater monitoring program implemented through the hydrogeologic work plan will be sufficient to meet ER Project requirements in completing corrective actions at the watershed scale.

5.2 ER Project Closeout Plan

The Laboratory closeout plan discusses the role of landlord organizations in long-term surveillance and monitoring at sites where residual contamination may be left in place (LANL 1998, 62472). The plan commits the ER Project to designing long-term surveillance and monitoring programs for sites that require such programs, and to communicating the need for and the details of those designs to landlord organizations. Two landlord organizations identified as having overall responsibility for surveillance and monitoring in support of ER Project completion are the Facilities Engineering (FE) Division and ESH Division. The FE and ESH Divisions together ensure that risk due to residual contamination left in place at ER Project completion remains low by controlling the use of contaminated sites and by monitoring releases to the environment.

The FE Division will assume responsibility for maintaining ER sites that have residual contamination after ER Project completion. The FE Division is responsible for developing future land use plans for the Laboratory. At the closeout, the ER Project will transfer records describing residual contamination and associated risk to the FE Division. The FE Division will be responsible for physical maintenance of former ER Project sites, and for ensuring that land use and development plans remain compatible with those conditions. Should development plans require corrective actions to further mitigate the risk associated with residual contamination, the FE Division will be responsible for implementing those actions.

After ER Project completion, the ESH Division will assume~~s~~ responsibility for monitoring and evaluating sites containing residual contamination to ensure that conditions do not exceed acceptable risk thresholds. The ESH Division will recommend~~s~~ maintenance or corrective actions if thresholds are exceeded and will administer~~s~~ Permit conditions following ER Project completion and closeout.

The requirements for long-term maintenance and monitoring will be included in the final corrective action report for an aggregate or a watershed, depending upon the nature, extent, and potential mobility or accessibility of residual contamination. In addition, a master management plan for long-term maintenance and monitoring environmental media within and across watersheds will be prepared. The master plan will discuss

- authorities and responsibilities for long-term maintenance and monitoring;
- residual contaminant levels and associated risk assessments;
- action levels and decision criteria for determining when and what responses may be required; and
- schedules for reporting in accordance with the final RCRA/HSWA Permit and DOE orders.

Action levels will be determined from trend analysis of monitoring data and/or fate and transport modeling, depending upon the persistence, mobility, and toxicity of contamination.

6.0 ER PROJECT PLANS AND REPORTS

Work will continue to be reported by in a timely manner to track progress in corrective actions undertaken by the MDA, Canyons, and Remedial Actions Focus Areas. In addition, documents will be written to reflect investigations and assessments that occur across the operational focus areas within aggregates.

6.1 Integrated Sampling and Analysis Plans

A major component of the integrated watershed strategy is the development and application of SAPs that support an integrated conceptual model—a conceptual model that recognizes the mobility, toxicity, persistence, and potential interactivity of contaminants from multiple PRSs. To the extent necessary to support specific risk decisions at appropriate assessment scales, integrated SAPs will be developed.

A pilot application of integrated SAPs will be completed in FY1999 for TA-35. This application will integrate investigation and assessment activities across 52 PRSs. Because this site is relatively complicated, it provides an opportunity to develop and test the integrated approach at a site that requires multiple assessment scales, and an opportunity to develop and apply an industrial-contaminant baseline.

6.2 Integrated RFI Reports

Progress in the corrective action process for watershed aggregates will be documented in RFI reports written by the operational focus areas and submitted to the NMED. Integrated RFI reports will report data and decisions after multiple field campaigns, and will summarize results from VCA/VCMs. Simple RFI reports may be written as intermediate deliverables to integrated RFI reports when no further action (NFA) decisions are clear.

One Canyons Focus Area RFI report for surface-based investigations will be written for each watershed except the Los Alamos Canyon, Mortandad Canyon, and Water Canyon watersheds, each of which will be addressed in two reports. Those reports will contain

- results of sediment, alluvial ground-water, and surface water investigations as described in the Canyons core document (LANL 1997, 62316) and implemented through work plans;
- descriptions of nature and extent of contamination in sediment, alluvial groundwater, and surface water;
- assessments of the human health and ecological risk posed by the contamination in all three media, as appropriate;
- recommendations for remediating (or taking other corrective action) sediment or alluvial groundwater to avert imminent risk, as appropriate;
- identifications of key PRSs or PRS aggregates within the watershed that are suspected of significant historical or ongoing contaminant contribution to canyon-floor sediment and surface and alluvial groundwater;
- a conceptual model of contaminant fate and transport within canyons comprising the watershed; and
- recommendations for future monitoring.

One or more MDA Focus Area RFI reports will be written for each watershed. The MDA RFI reports will include

- descriptions and results of site-specific RFI sampling campaigns and relevant environmental surveillance activities;
- characterizations of contaminant nature and extent in air, surface, and subsurface media;
- assessments of present-day and potential future risk to ecological and human receptors;
- recommendations for stabilization measures to avert imminent risk, as appropriate;
- assessments of future risk to ecological and human receptors through the approach that will be described in the MDA core document; and
- recommendations for conditional-remedy, focused Phase 2 investigations or streamlined CMSs, through the application of the decision logic in the MDA core document, which is in preparation.

6.3 Corrective Actions Reports

As appropriate to document progress at a PRS or at an aggregate, the following reports will be submitted to the NMED to document VCAs, VCMs, interim measures, CMSs and CMIs.

6.4 Watershed Completion Reports

A watershed report will be developed for all watersheds except the Frijoles watershed, for which a corrective actions RFI report will contain all completion activities. For all other watersheds, reports will be written at the completion of corrective actions for all affected aggregates. These reports will include

- cumulative risk assessment of residual contamination on the watershed scale;
- development of formal agreements with Laboratory facilities, including operations and maintenance activities after CMI and deferred actions;
- plans for integration with decontamination and decommissioning (D&D) activities; and
- the long-term surveillance and maintenance plan for that watershed.

Watershed-specific reports also will summarize

- the results of characterization and remedial activities undertaken at all PRSs and D&D structures within the watershed, resulting in a complete picture of ER Project activities and information for that watershed; and
- all field characterization, sample analysis, and remediation conducted in the watershed by the ER Project since its inception.

If necessary, additional data will be collected through a SAP and associated fieldwork to fill identified data gaps. All available data will be combined for cumulative risk assessment. Data evaluation will include compiling data within watershed, checking data quality, and assembling a watershed data set. A

geospatial analysis of the field and analytical data will be performed to identify areas in which contaminants are concentrated. An analysis of contaminant migration pathways and migration rates will be performed.

Watershed-specific completion reports will contain at least the following elements:

- summary of status for all PRSs in the watershed;
- resolution of any remaining PRSs addressed by the ER Project (e.g., recommendation for NFA), including additional risk/data analysis, sampling points, and residual contamination discussion, if necessary;
- summary of cumulative risks associated with residual contamination in the watershed;
- surveillance and maintenance requirements to ensure protectiveness and effectiveness of corrective actions within the watershed;
- action thresholds and actions associated with surveillance and maintenance activities;
- proposed time- and trend-based endpoints for monitoring; and
- list of responsible institutional parties for final PRS hand-off at project closeout (e.g., long-term surveillance and maintenance, active sites, and/or facilities).

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