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MAY 2011

Date: MAY 16 2011
Refer To: EP2011-0062

James Bearzi, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Submittal of the Interim Measures Work Plan for Stabilization of the Sandia Canyon Wetland

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the Interim Measures Work Plan for Stabilization of the Sandia Canyon Wetland.

If you have any questions, please contact Steve Veenis at (505) 667-0013 (veenis@lanl.gov) or Cheryl Rodriguez at (505) 665-5330 (crodriguez2@doeal.gov).

Sincerely,

Michael J. Graham, Associate Director
Environmental Programs
Los Alamos National Laboratory

Sincerely,

George J. Rael, Manager
Environmental Projects Office
Los Alamos Site Office

MG/GR/CD/SV:sm

Enclosures: Two hard copies with electronic files – Interim Measures Work Plan for Stabilization of the Sandia Canyon Wetland (LA-UR-11-2186)

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LA-UR-11-2186
May 2011
EP2011-0062

Interim Measures Work Plan for Stabilization of the Sandia Canyon Wetland

Prepared by the Environmental Programs Directorate

EP2011-0062

Interim Measures Work Plan for Stabilization of the Sandia Canyon Wetland

May 2011

Responsible project manager:

Steve Veenis	[signature]	Project Manager	Environmental Programs	5/12/11
Printed Name	Signature	Title	Organization	Date

Responsible LANS representative:

Michael J. Graham	[signature]	Associate Director	Environmental Programs	13 May 11
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Responsible DOE representative:

George J. Rael	[signature] for	Manager	DOE-LASO	5-16-2011
Printed Name	Signature	Title	Organization	Date

CONTENTS

Figures

Plate

Acronyms and Abbreviations

cfs	cubic feet per second
CMP	corrugated metal pipe
Consent Order	Compliance Order on Consent
DOE	Department of Energy (U.S.)
LANL	Los Alamos National Laboratory
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
SCIR	Sandia Canyon investigation report
SERF	Sanitary Effluent Reclamation Facility
SWMU	solid waste management unit
SWWS	Sanitary Wastewater Systems plant
TA	technical area

1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by Los Alamos National Security, LLC. The Laboratory is located in north-central New Mexico approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers 40 mi^2 of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons containing perennial and intermittent streams running from west to east. Mesa tops range in elevation from approximately 6200 to 7800 ft above mean sea level.

The Laboratory is participating in a national effort by DOE to clean up sites and facilities formerly involved in weapons research and development. The goal of the Laboratory's efforts is to ensure past operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve this goal, the Laboratory is currently investigating sites potentially contaminated by past Laboratory operations.

This "Interim Measures Work Plan for Stabilization of the Sandia Canyon Wetland" is prepared in response to New Mexico Environment Department's (NMED's) "Approval with Modification, Phase II Investigation Work Plan for Sandia Canyon" letter dated January 4, 2011 (NMED 2011, 111518). The approval with modifications letter requires the Laboratory to submit a work plan to stabilize the eastern end of the wetland in Sandia Canyon to prevent further upstream migration of the headcut. The work presented in this work plan is being conducted as an interim measure under section VII.B, Compliance Order on Consent (Consent Order). As described in section VII.B.1 of the Consent Order, interim measures are conducted to reduce or prevent migration of contaminants which have or may result in an unacceptable human or environmental receptor exposure to contaminants while long-term corrective action remedies are evaluated and implemented. The objective of the interim measure described in this work plan is to stabilize the wetland to reduce erosion and subsequent downstream migration of contaminated sediments.

Based on analysis of orthophotographs and field evidence, a small wetland existed near the eastern end of the current extent of wetland in Sandia Canyon before establishment of the Laboratory. The introduction of industrial effluent into Sandia Canyon, along with stormwater and snowmelt inputs, allowed the wetland to expand further upstream and to trap significant volumes of fine-grained organic-rich sediments. Wetland stabilization is considered in the context of active stormwater-related sediment erosion and the potential for a future decrease of effluent volume into Sandia Canyon associated with the Sanitary Effluent Reclamation Facility (SERF) expansion project. SERF expansion is designed to further treat and recycle sanitary wastewater to support various cooling towers associated with Laboratory facilities. As such, outfall volumes released into Sandia Canyon could be reduced but will be maintained at a level sufficient to maintain physical stability and geochemical functioning of the Sandia Canyon wetland.

This work plan presents the preliminary conceptual interim measures to be implemented to stabilize the wetland environment in upper Sandia Canyon and the schedule for implementation of those measures. The goal of the stabilization effort is to maintain and enhance hydrologic and geochemical functioning of the wetland. Hydrologic attributes of the wetland enable dense root-binding vegetation (cattails) to thrive. Dense cattail vegetation has an important role in reducing peak stormwater discharge, minimizing erosion of sediments and adsorbed contaminants and causing deposition of suspended sediments because of high flow-path tortuosity. Geochemical stability maintains the strong reducing condition that keeps contaminants which may be prone to mobility under oxidizing conditions in a reduced and stable state.

2.0 CONCEPTUAL MODEL FOR REACH S-2 OF SANDIA CANYON

Sandia Canyon watershed starts from the Pajarito Plateau in Technical Area 3 (TA-03) and extends southeastward approximately 10.9 mi (17.6 km) to the Rio Grande. Effluent from daily Laboratory wastewater releases and periodic storm events support a broad, 3-acre (1.2-hectare) wetland within reach S-2 (Plate 1). Reach S-2 contains post-Laboratory-aged (post-1942) sediment deposits (including fine and coarse deposits) in the canyon floor with interbedded alluvial fan deposits and colluvium along the margins. These deposits overlie the base of unit 3 of the Tshirege Member of the Bandelier Tuff. The canyon-floor sediment deposits vary in width from approximately 82 to 197 ft (25 to 60 m). Cross-sections through the canyon-floor deposits at various locations in reach S-2 are provided in the 2009 Sandia Canyon investigation report (SCIR) (LANL 2009, 107453). The nature, sources, extent, fate, and transport of contaminants associated with sediment, surface water, and groundwater in reach S-2 are discussed in section 7 of the SCIR.

In this section, aspects of a conceptual model for polychlorinated biphenyls (PCBs) and chromium (the primary contaminants associated with sediment in the wetland) that are relevant to stabilization of the Sandia Canyon wetland are discussed. Key aspects of the conceptual model include (1) sources and current distribution of PCBs and chromium in the wetland, (2) wetland hydrology, (3) geochemical functioning and stability in the wetland, and (4) physical stability of the wetland.

2.1 Contaminant Sources and Distribution in Sandia Canyon Wetland

Chromium was released as part of the TA-03 power plant discharge from 1956 to 1972. In particular, potassium dichromate usage for cooling tower water treatment resulted in an estimated total release of approximately 31,000 to 72,000 kg (69,000 to 160,000 lb) of hexavalent chromium [Cr(VI)] into the south fork of upper Sandia Canyon [Solid Waste Management Unit (SWMU) 03-012(b)] (LANL 2007, 098938). PCBs were released primarily from a transformer storage facility [SWMU 03-056(c)] along the south fork of Sandia Canyon (reach S-1S). Remediation for PCB contamination at this SWMU was completed in 2001.

Reach S-2 is the most important part of Sandia Canyon in the context of sediment contamination because of the proximity to contaminant sources, the large volume of sediment deposited during the period of active contaminant releases, the presence of high concentrations of organic matter in the wetland, and the deposition of large amounts of silt and clay. About 80% to 90% of the chromium and PCB contamination within the Sandia Canyon watershed sediment deposits is located within this reach of upper Sandia Canyon.

Approximately 84% of the total chromium in Sandia Canyon sediments is contained within reach S-2, where concentrations are highest and where a large volume of post-1942 sediment exists. The most probable mean estimate of anthropogenic chromium mass in post-1942 sediment deposits in Sandia Canyon is 18,000 kg (40,000 lb), with approximately 70% of the total contained within fine-grained, silt- and clay-sized sediment. Solid organic matter and saturated alluvium in the Sandia Canyon wetland produce geochemically reducing conditions favorable to converting soluble hexavalent chromium [Cr(VI)] released in cooling water to insoluble and less toxic trivalent chromium [Cr(III)], which is particularly stable in this environment. Trivalent chromium concentrations up to 3740 mg/kg occur within organic-rich sediments in reach S-2, and average chromium concentrations in the fine-grained sediment in S-2 (600 mg/kg) greatly exceed those in sediments in any other reach of the canyon. The highest concentration, 3740 mg/kg, was measured in fine-grained sediments in the east part of reach S-2. In reach S-2, Cr(VI) concentrations average <0.1% of the total chromium concentrations. This indicates that the vast majority of the chromium in Sandia Canyon sediment is Cr(III).

Chromium concentrations are slightly higher in surface-water samples collected immediately downstream of the wetland, suggesting some mobilization and transport of chromium from the wetland. Microfiltration experiments comparing water sampled through 0.45-μm filters (typical filter size used for water samples) and 0.02-μm filters, however, suggest that most of the additional chromium released is in the form of Cr(III).

PCBs in reach S-2 sediment are mostly a mixture of Aroclor-1254 and Aroclor-1260, but Aroclor-1248 and Aroclor-1242 also occur in low concentrations. Estimated inventories of PCBs in Sandia Canyon sediment deposits range from approximately 3 kg (7 lb) for Aroclor-1248 to 35 kg (78 lb) for Aroclor-1254. As with chromium, most of the mass is contained within reach S-2, ranging from an estimated 79% for Aroclor-1260 to 99.6% for Aroclor-1248. Most of the PCBs are also associated with fine-grained sediment, ranging from an estimated 68% for Aroclor-1242 to 75% for Aroclor-1260. An estimated 88% of Aroclor-1254 is contained within reach S-2. The highest concentration (2.53 mg/kg) of this Aroclor in Sandia Canyon was measured from a depth-integrated sample (0 to 2.08 m deep) from an auger hole through the c2b unit in the middle of reach S-2. Aroclor-1242 was detected in one sample from reach S-2, a depth-integrated sample through the entire thickness of alluvium in the active cattail wetland. This is a detection frequency of 1% in S-2 (1 of 88 samples). Aroclor-1248 was detected in two samples in reach S-2 (2% detection frequency). For Aroclor-1260, the highest concentration in Sandia Canyon sediments was measured in reach S-2 (2.08 mg/kg) from a sediment deposit that previously had cattails located just east of the current downstream wetland extent.

Aroclor-1254 and Aroclor-1260 are consistently detected in surface-water base flow immediately downgradient of the wetland (gage E123) at concentrations that exceed the human health criterion for perennial water (0.00064 μg/L). In alluvial groundwater, these two PCBs are detected infrequently at well SCA-1 within the wetland, at concentrations below the U. S. Environmental Protection Agency maximum contaminant level of 0.5 μg/L. The detection of these two Aroclors in waters in the immediate vicinity of the wetland is likely from the presence of suspended sediment in these samples.

2.2 Hydrology of the Sandia Canyon Wetland

Sources of surface water in reach S-2 are currently dominated by effluent releases. Sandia Canyon heads on the Pajarito Plateau in the TA-03 area and has little snowmelt runoff. Stormwater runoff is related to precipitation onto paved and other low-permeability surfaces. Effluent releases to Sandia Canyon have occurred since the early 1950s and continue today. The primary sources for the releases are the Laboratory's treated sanitary wastewater and cooling tower blow-down. Currently, three National Pollutant Discharge Elimination System (NPDES) permitted outfalls (001, 03A027, and 03A199) discharge to upper Sandia Canyon in the TA-03 area. These three existing outfalls accounted for 137 million gal. (519 million L) in 2008. The single largest wastewater discharge at the Laboratory is from Outfall 001. Treated sanitary wastewater effluent from the TA-46 Sanitary Wastewater Systems (SWWS) plant accounts for the majority of the Outfall 001 effluent volume, measuring 101 million gal. (382 million L) in 2008. Boiler water blow-down from the TA-03 power plant added an additional 15 million gal. (57 million L) to the Outfall 001 effluent volume in 2008. Cooling tower blow-down from the TA-03 Nicholas C. Metropolis Center for Modeling and Simulation, also known as the Strategic Computing Complex or the Metropolis Center, and blow-down from the Laboratory Data Communications Center discharge the balance of the effluent into the upper reach of Sandia Canyon via Outfalls 03A027 and 03A199, respectively (LANL 2009, 107453).

Stream gage E121 upgradient and stream gage E123 downgradient of the wetland, respectively, have experienced peak flows of no more than 140 cubic feet per second (cfs) and 86 cfs, respectively, during the period of record beginning in 2002 for E121 and 1999 for E123. Data from 2007 and 2008 indicate that industrial outfalls contribute approximately 75% of the total surface-water flow in the canyon, with stormwater runoff and snowmelt contributing the remainder of the water flow (LANL 2008, 102996). Surface water appears to have a short residence time within the wetland, with most of the flow occurring within the active stream channel in the upper third of reach S-2 and passing over the surface of the saturated wetland comprising the lower two-thirds of reach S-2. Persistent, effluent-supported surface-water flow extends approximately 2.5 mi (4 km) further downstream before infiltrating into shallow alluvium in the canyon floor.

Alluvial groundwater occurs in reach S-2, with saturation of alluvial sediments supporting about a 3-acre (1.2-hectare) wetland. Alluvial groundwater monitoring well SCA-1, and its replacement well, SCA-1-DP, are located within the eastern edge of reach S-2. The well is shallow and fully saturated. The water level is effectively the surface-water level because the well is fully saturated to above the ground surface. Also, the water level variations at this location are minor, suggesting that the inputs from daily effluent, seasonal variability, and stormwater runoff do not significantly infiltrate and affect groundwater level fluctuations. Persistent saturated alluvium within the wetland is key to maintaining a healthy functioning wetland, particularly if effluent discharge is reduced in the future. Alluvial water residence times and geochemical heterogeneity are not well constrained, although residence times are expected to be orders of magnitude longer than for surface water.

Despite the presence of alluvial groundwater in reach S-2, a recent study on the surface-water losses along the length of the canyon bottom indicates little infiltration of surface water occurs within or immediately downcanyon of reach S-2 (LANL 2008, 102996; LANL 2009, 107453). Based on surface-water data collected from July 2007 to June 2008, an average water flux of 15,000 m^3/yr (12 acre-ft/yr) is estimated to infiltrate into bedrock beneath the wetland, along an area that includes the Rendija Canyon fault zone. This volume represents approximately 2% of the surface water (both effluent and runoff) flowing into the canyon during the period of the study and indicates that faults and fractures in this area are probably, at best, minimal pathways for deep infiltration. Studies using geophysical techniques are ongoing to assess infiltration within reach S-2.

No perched-intermediate groundwater aquifer has been identified beneath reach S-2. The regional aquifer is separated from the alluvial water in the canyon bottom at reach S-2 by approximately 1100 ft (335 m) of volcanic tuff and older sediments.

2.3 Geochemical Functioning and Stability

Mass-balance estimates suggest that the majority of the chromium mass released from Sandia Canyon outfall sources is contained as Cr(III) in the reach S-2 sediment. Reducing wetland conditions promote conversion of mobile Cr(VI) to immobile Cr(III). Data from geochemical studies presented in the 2009 SCIR (LANL 2009, 107453) indicate that the adsorbed and reduced chromium in the sediments are predominantly geochemically stable, indicating that the Cr(III) inventory is not likely to act as a significant secondary source for Cr(VI) under current hydrogeochemical conditions or as a result of drying.

Much of the present-day low-level mobilization of chromium from the wetland is likely associated with colloidal transport of Cr(III) in the form of chromium hydroxide or Cr(III) adsorbed to sediment particles. For example, total dissolved chromium concentrations have been found to decrease in samples filtered through 0.02-μm filters, as opposed to 0.45-μm filters typically used in surface-water or groundwater sampling. In addition, cations concentrated in the SWWS-treated effluent—including calcium, sodium, and magnesium—may enhance desorption of Cr(III) from wetland sediment through cation exchange reactions. The complexing of Cr(III) with dissolved organic carbon, in the forms of humate and fulvate ligands (anions), may also enhance desorption of Cr(III) from the organic-rich solids concentrated within the wetland. It is also possible that some Cr(VI) is released because sulfate, phosphate, and total carbonate alkalinity are competing anions for Cr(VI), which limits adsorption of Cr(VI) onto iron (oxy)hydroxides at or above pH 6. Further details on the stability of Cr(III) in wetland sediments can be found in Appendix J of the SCIR (LANL, 2009, 107453).

Maintenance of reducing conditions, including a reduced effluent discharge scenario, is desirable to ensure contaminant stabilization for redox-sensitive species.

2.4 Physical Stability of Sandia Canyon Sediments

Physical stability of the wetland is important because of the presence of adsorbed contaminants, including PCBs and chromium. Saturated sediment conditions and wetland vegetation in the lower half of reach S-2 help stabilize these contaminants. Rapid geomorphic changes have been observed in the wetland as a result of changes in the routing of outfall discharges and the occurrence of floods.

Before 1998, discharge to upper Sandia Canyon occurred from a hillslope outfall at the head of reach S-2 (Plate 1). This discharge led to alluvial saturation of the southern portion of the upper third of reach S-2. This alluvial saturation resulted in a larger wetland extent than is currently observed. In 1998, the outfall was moved to the south tributary of upper Sandia Canyon. In recent years, the extent of the wetland has decreased because of lowering of the water table in the upper third of reach S-2 when the outfall was rerouted to the upper tributary (Figure 2.4-1).

Currently, the largest contributing drainage area that flows into reach S-2 is conveyed through a 72–in.-diameter corrugated metal pipe (CMP) culvert a short distance upstream of the wetland. Peak stormwater flows have created a scour hole at the culvert outfall into the stream reach. Between the outfall and the upstream extent of the wetland, the stream is unstable and has experienced moderate stream-bank erosion. Along this reach, the stream has become disconnected from its floodplain. Observations in spring 2011 suggest that the channel in the upper third of the reach is approaching stable grade and is beginning to meander and establish an active floodplain surface inset into a higher abandoned terrace (Figure 2.4-1). A narrow, bankfull terrace has begun to form along this reach as the stream seeks equilibrium. In some locations, this bankfull terrace is up to 4 m wide, and wetland vegetation is beginning to opportunistically reestablish and expand upstream on this terrace, creating a more stable environment. These newly vegetated active floodplains are important for managing stormwater runoff by enabling higher discharges to spill out of the channel and by providing roughness and sediment-trapping elements to reduce potential contaminant transport. This natural process of stream widening, therefore, is acting to expand and stabilize the wetland in the upper part of the reach.

In the lower two-thirds of the reach, wetland vegetation is well established across the entire floodplain and the stream and wetlands are very stable. In the downstream portion of the wetland, the defined channel is lost and water is conveyed as sheet flow across the width of the wetland. However, as the water leaves the wetland, there is a large headcut (up to 3 m high) traveling upstream through the wetland (Figures 2.4-2 and 2.4-3). Indirect observations are that this headcut advances upstream associated with effects of stormwater runoff. Between 1998 and March 2007, the headcut migrated upcanyon about 14 m. Between March 2007 and August 2009, it migrated approximately 5 m, and since 2009, the headcut advanced an additional 5 m. Dense willow planting at the headcut in 2010 did not arrest the head advancement.

Erosion of contaminated sediment at the eastern end of the wetland would be expected to continue under current conditions. Long-term erosion could result in a reduction or loss of wetland conditions and increased stream channelization. Erosion and transport of wetland sediments also contribute to elevated contaminant concentrations measured at gage E123 located just downcanyon of the terminus of the wetland (Plate 1).

Reduction of effluent volume to the wetland could reduce the extent of saturated alluvium in the wetland and result in decreased wetland extent and increased mobilization of contaminated sediment, although stormwater and snowmelt would continue to enter the upper end of reach S-2 and may serve to augment alluvial groundwater in the lower portion of reach S-2.

Downstream of the wetland, the stream system enters a narrow floodplain with limited riparian wetlands. The stream is stable, with bedrock exposed along portions of the streambed.

3.0 INTERIM MEASURES TO STABILIZE WETLAND

Interim measures will be implemented to stabilize the wetland geomorphically as described conceptually below. Final design elements, locations, and elevations will be determined during final design after additional surveying data is collected and hydrologic evaluations are conducted. These will not be provided in this work plan.

There are two general types of interim measures proposed in this work plan: installation of grade control to stabilize the headcut at the terminus of the wetland, and a flood management action to reduce potential erosion during stormwater runoff by installing a stilling basin, as described below. In addition, future stormwater mitigations carried out under the NPDES Individual Permit may also provide flood management benefits to the Sandia Canyon wetland.

3.1 Grade-Control Structure and Fill

In order to arrest the headcut at the terminus of the wetland in reach S-2, a grade-control structure is proposed approximately 30 m downstream of the current headcut (Figure 2.4-2). The grade-control structure will be designed to create and fix an optimal channel and floodplain grade that will mitigate potential channel incision and continued headcutting. The grade-control structure design will incorporate an impervious or low-permeability material to maintain sufficiently high alluvial groundwater levels to maintain or enhance upcanyon wetland conditions.

The proposed location for the grade-control structure is on competent bedrock just upcanyon from the location of gage station E123. The transition from the wetland above the grade-control structure and the stream channel below the grade-control structure will be designed to prevent erosive flows that could scour and destabilize the stream reach below the structure.

Fill will be placed upstream of the grade-control structure to replace the area of the wetland that has been eroded. This area will be filled to the elevation of the existing wetland area to prevent the formation of a pool behind the grade-control structure and to facilitate rapid reestablishment of the eroded area of the wetland. Native wetland vegetation may be planted on the fill to accelerate the stabilization process.

3.2 Stilling Basin

At the exit of the 72-in.-diameter CMP culvert, a stilling basin will be excavated and armored to reduce the energy and velocity of peak stormwater events before entering into the stream in the location shown in Figure 2.4-1. The stilling basin will be excavated to provide a sufficient area for a plunge pool from the culvert and align the outflow with the current stream elevation. The base of the basin will be armored with riprap to reduce the potential for erosion.

The outlet of the stilling basin will release base flows and flows resulting from smaller storm events directly into the stream at the elevation of the main stream channel. The overflow structure will also be designed to release the peak flows from higher storm events over a wider area, reducing the concentration of high-velocity flows into the stream channel. This overflow will be placed at the elevation of the inset bankfull floodplain, allowing it to convey high flows and reduce erosion potential within the stream channel.

4.0 MONITORING

Stormwater monitoring at locations E121, E122, and E123 will continue. A poststabilization monitoring approach to determine the effectiveness of the stabilization measures will be developed and provided to NMED for approval before implementation. In addition, a network of alluvial monitoring points will be established within the wetland. This network will provide spatial and temporal information on variations in hydrologic and geochemical conditions associated with potential changes in the effluent volume in Sandia Canyon. A series of repeat cross-section locations will also be established in the upper portion of reach S-2 and in the vicinity of the current headcut location to document geomorphic changes. These data will collectively enable an adaptive management strategy to be used in the event that changes in the effluent volume result in detrimental impacts to wetland performance.

5.0 SCHEDULE FOR IMPLEMENTATION

The following schedule is proposed for implementation of the measures outlined in this plan:

Activity	Completion Date
Collection of additional design data	July 2011
Final design	90 d after NMED approval of this interim measures work plan
Completion of construction activities	April 2012
Submittal of a completion report and poststabilization monitoring plan	July 2012

6.0 REFERENCES

The following list includes all documents cited in this plan. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), September 2007. "Fate and Transport Modeling Report for Chromium Contamination from Sandia Canyon," Los Alamos National Laboratory document LA-UR-07-6018, Los Alamos, New Mexico. (LANL 2007, 098938)

LANL (Los Alamos National Laboratory), July 2008. "Fate and Transport Investigations Update for Chromium Contamination from Sandia Canyon," Los Alamos National Laboratory document LA-UR-08-4702, Los Alamos, New Mexico. (LANL 2008, 102996)

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NMED (New Mexico Environment Department), January 04, 2011. "Approval with Modifications, Phase II Investigation Work Plan for Sandia Canyon," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2011, 111518)

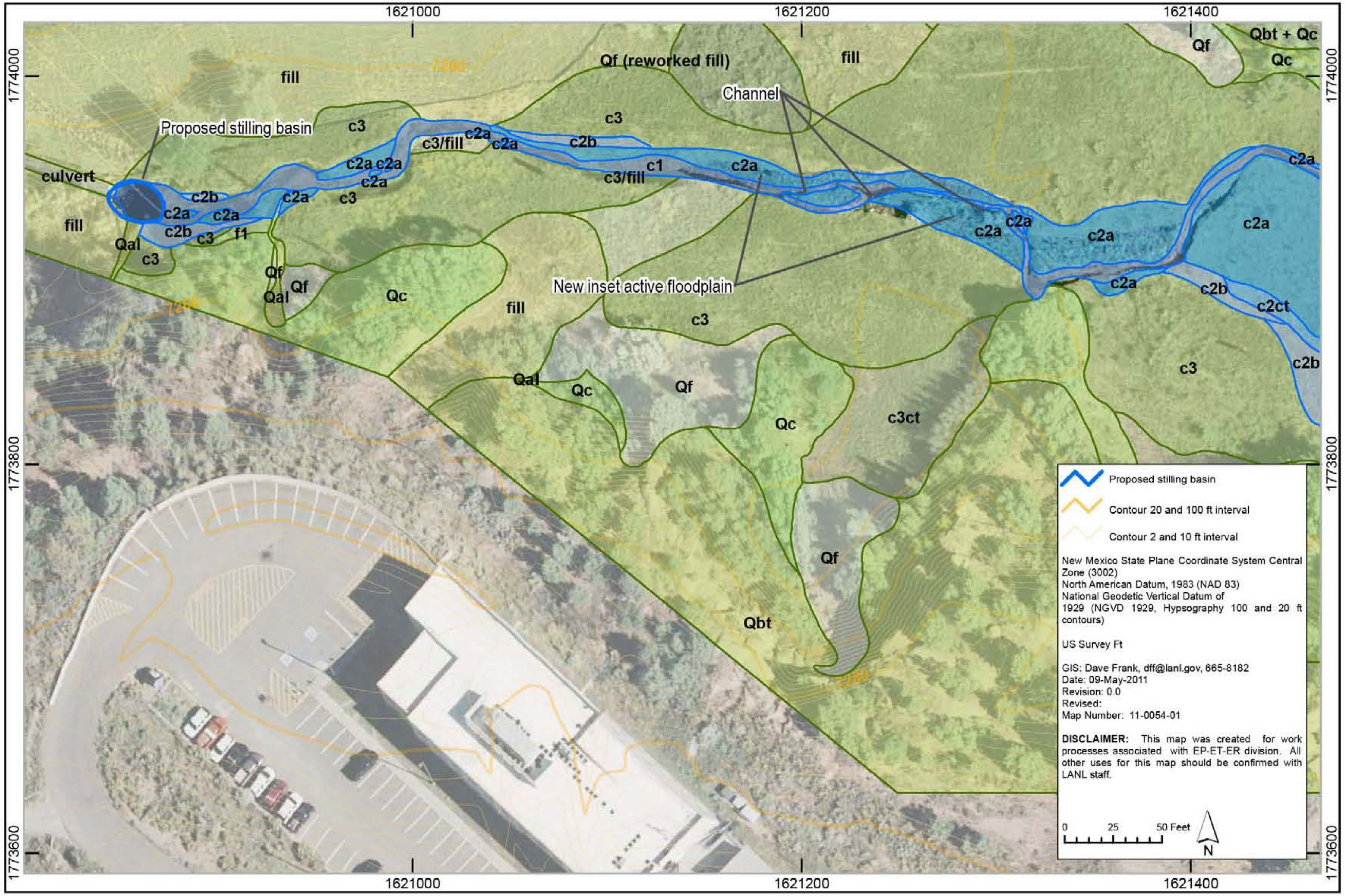


Figure 2.4-1 Upper portion of reach S-2 showing proposed mitigation and location of new inset active floodplains

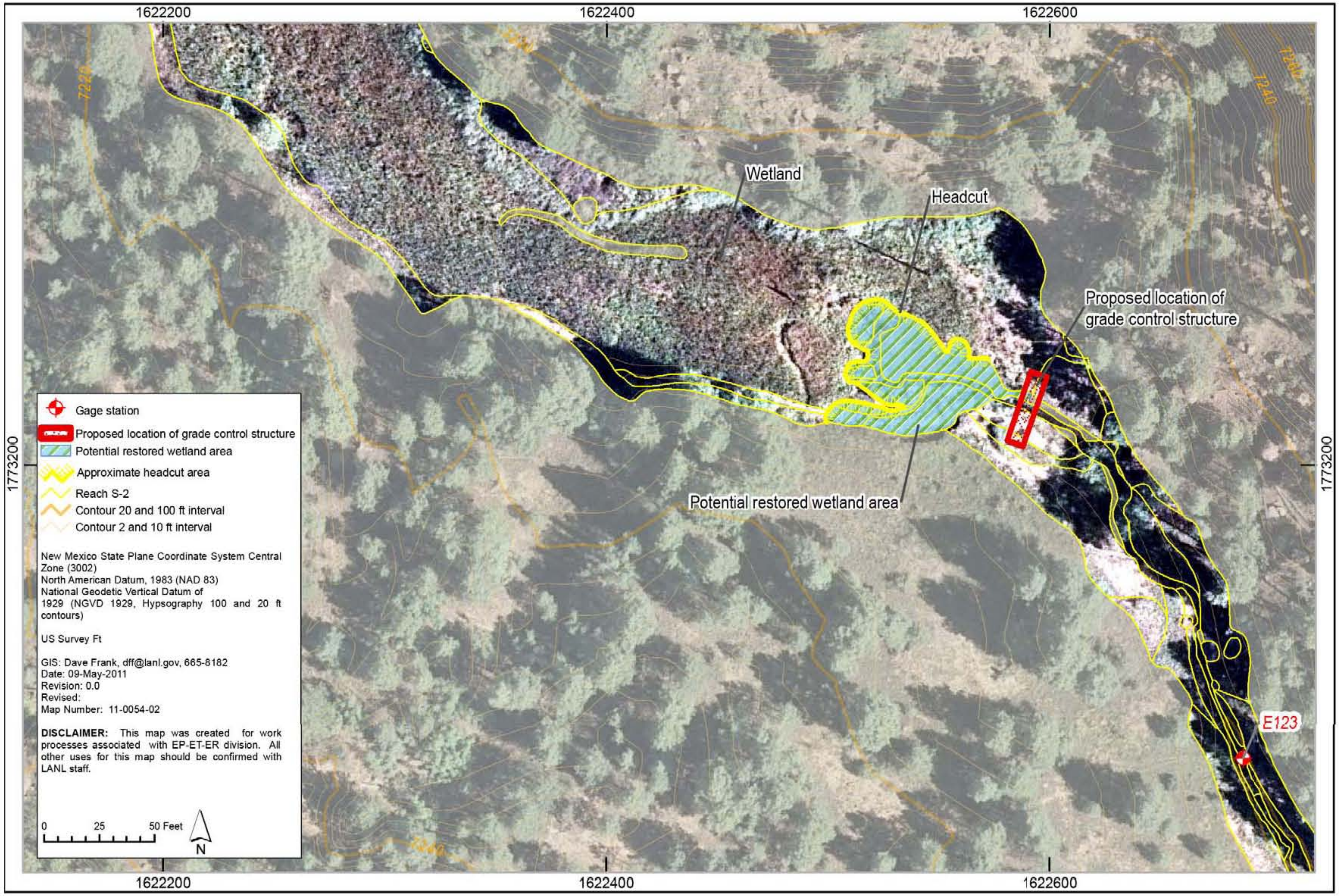


Figure 2.4-2 Lower portion of reach S-2 showing proposed location of grade-control structure

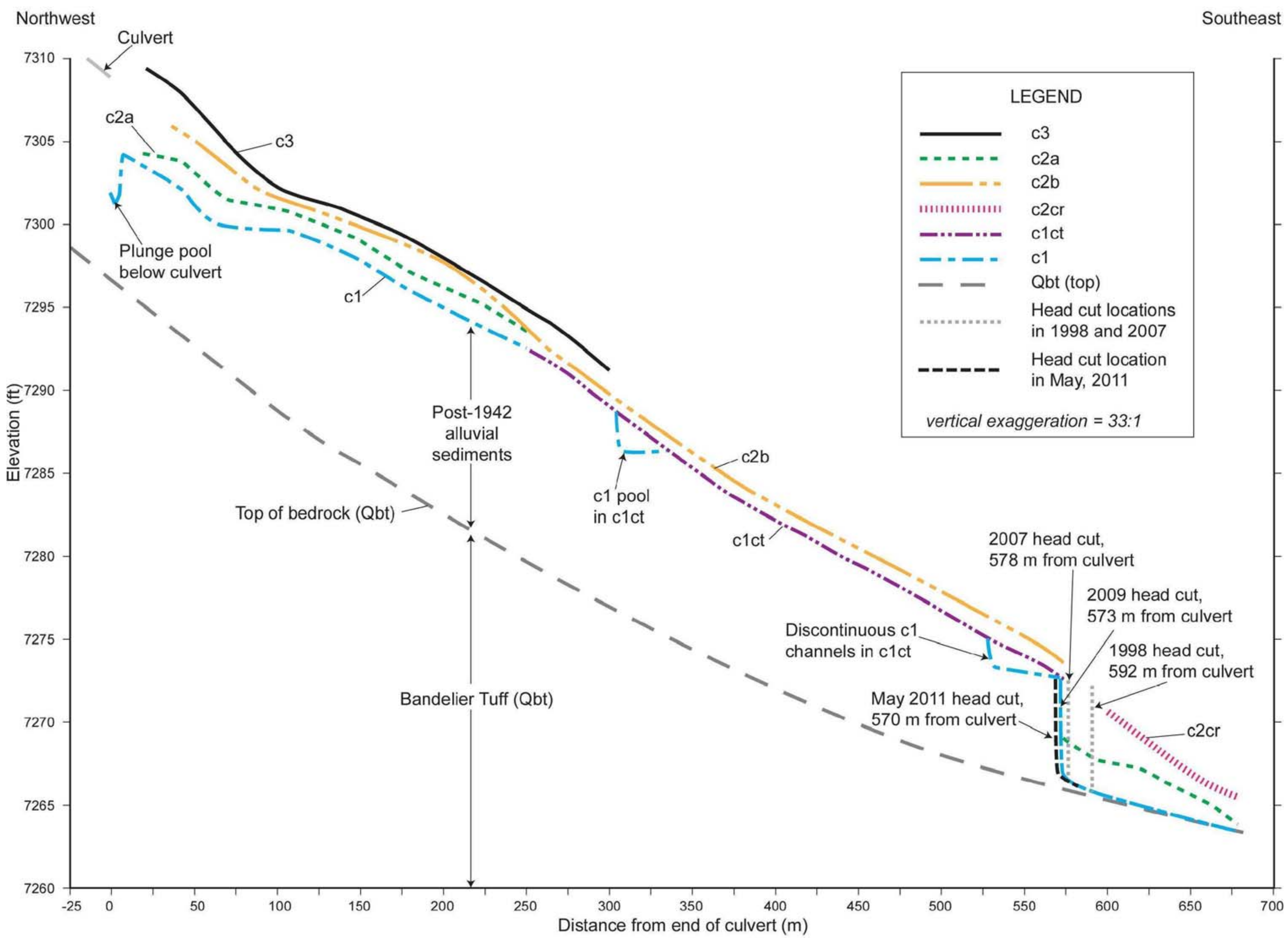


Figure 2.4-3 Longitudinal profile through reach S-2 showing elevations of geomorphic surfaces and depicting time-series of headcut retreat

Plate 1. Sandia Canyon Geomorphology Reach S-2

- Canyons sample location
- Other sample location
- Stratigraphic description location
- Control point
- Gaging station or surface water sample location
- Well
- Headcut location, 3/27/07
- Fence
- Dirt road
- Paved road

Topographic Contour
- 10 ft contour
- 20 ft contour
- 100 ft contour

Type of Contact
- estimate
- headcut
- normal
- Structure
- SWMU or AOC
- Technical area boundary

Geomorphology
- boulder
- c1
- c1br
- c1ct
- c2a
- c2b
- c2cr
- c2ct
- c2w
- c3
- c3ct
- concrete
- f1
- fill
- Qal
- Qbt
- Qc
- Qf

DATA SOURCES

Title; Owner, ID; Intended Scale; Publication Date.
2000 LIDAR Hypsography; Los Alamos National Laboratory, Earth and Environmental Sciences GISLab; 1:1,200; Draft.

Boundary, Technical Areas (index map); Los Alamos National Laboratory, SSMO Site Planning and Project Initiation Group; Unknown; December 4, 2008.

Drainage (index map); Los Alamos National Laboratory, Environment and Remediation Support Services, ER2002-0591; 1:24,000; 2002.

Fences; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating, and Mapping Section; Unknown; March 4, 2008.

Gaging Station or Surface Water Sample Locations; Los Alamos National Laboratory, Environmental Stewardship Division Water Quality and Hydrology Group; Unknown; June 13, 2005.

Geomorphology and Related Spatial Features; Los Alamos National Laboratory, Environment and Remediation Support Services; 1:200; Work in progress.

Hillshade (index map); Los Alamos National Laboratory, Earth and Environmental Sciences GISLab; Unknown; 2002.

Location IDs; Los Alamos National Laboratory, Environment and Remediation Support Services, EP2008-0426; 1:2,500; February 13, 2009.

Potential Release Sites; Los Alamos National Laboratory, Environment and Remediation Support Services; ER2007-0682; 1:2,500; December 19, 2008.

Roads, Surfaced; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating, and Mapping Section; Unknown; August 20, 2008.

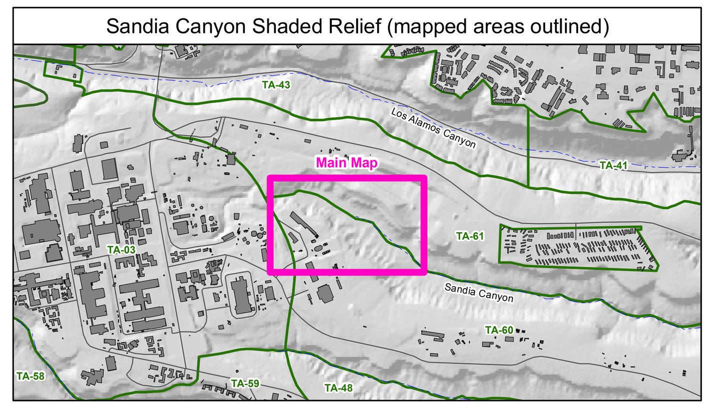
Roads, Unsurfaced; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating, and Mapping Section; Unknown; July 15, 2008.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating, and Mapping Section; Unknown; September 8, 2007.

Watershed (index map); Los Alamos National Laboratory, Environment and Remediation Support Services, ER2006-0942; 1:2,500; October 27, 2006.

SWMU 03-056(c) remediation area; LANL EES-9 GISLab; digitized from report hardcopy, July, 2008.

Sandia Canyon Shaded Relief (mapped areas outlined)



Sandia Canyon Investigation Report, LA-UR-09-06450

Cartography by: Doug Walther
Request #: 14151
Revised by: Liz Miller
GISLab Map #: m201893
Date: June 9, 2009

State Plane Coordinate System, New Mexico Central Zone, 1983 North American Datum. Units Feet.

Grid displays New Mexico State Plane coordinates in feet.

1:600

0 50 100 150
Feet

0 15 30 45
Meters

DISCLAIMER: This map was created for work processes associated with the Sandia Canyon Investigation Report. All other uses for this map should be confirmed with LANL Environmental Programs Directorate.

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