Appendix A

Watershed Conceptual Models

Appendix A
Tables

Table A-1
Los Alamos Canyon and Pueblo Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
Surface Water	Flow	Perennial flow originates from springs and interflow through hillslope soils in the upper watershed. The downcanyon extent of perennial flow is variable, but generally terminates in the upper portions of Los Alamos Canyon west of TA-41. The magnitude of snowmelt runoff is the predominant factor affecting the duration and extent of surface water flow. The remainder of upper Los Alamos Canyon down to its confluence with Pueblo Canyon has intermittent surface water flow. Segments that have persistent flow for most of the year or during periods of extended snowmelt runoff sometimes exhibit interrupted flow. DP Canyon is ephemeral, although some persistent surface water is sometimes observed in small, shallow bedrock pools, generally less than a few meters across, which are filled by runoff originating in the southeastern portion of the Los Alamos townsite. Flow sometimes exists for very short distances in Reach DP-2 because of discharge of groundwater stored within alluvium, and immediately above, in Reach DP-4, where groundwater discharges at DP Spring.	Surface water flow in upper Pueblo and Acid Canyons is generally ephemeral with runoff events caused by summer storms. Locally persistent surface water flow in the upper canyon is associated with townsite runoff and snowmelt runoff. Gage data (E055) are available for 2002 and 2003, showing that surface water rarely flows through the length of upper Pueblo Canyon; only 14 days of this flow occurred in 2002. In the South Fork of Acid Canyon, the channel is bedrock dominated, and storm water runoff and periodic releases of water from the Walkup Center swimming facility result in small pools of water that persist for several weeks or even months in narrow and confined and/or shaded canyon areas. In lower Pueblo Canyon, effluent-dependent flow is present for about 3 km in lower Pueblo Canyon from the discharge from the Los Alamos County Wastewater Treatment Plant (WWTP). The flow extends to the confluence with Los Alamos Canyon. In water year 2002, gaging station E060 below the WWTP measured 357 days of flow (Shaull et al. 2002, 85499).	Surface water flow in lower Los Alamos Canyon is from Basalt Spring and a lesser amount from LA Spring. The flow from Basalt Spring and the downcanyon extent of surface water flow depends on the amount of water that is discharged from the WWTP. At times of high discharge, flow can be continuous for approximately 7.5 km to the confluence with the Rio Grande. During periods of low discharge, flow may only extend from 1 to 3 km. Within approximately 1–2 km of the confluence with the Rio Grande, surface water flow is common and believed to be related to discharge of deep groundwater to the surface.

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
Surface Water (cont.)	Quality	Key contaminants in upper Los Alamos Canyon surface water include nitrate, polycyclic aromatic hydrocarbons (PAHs), strontium-90, and plutonium-239/240. The plutonium-239 is related to outfalls (likely Hillsides 137 and 138) in former TA-01. Strontium-90 originated from the outfall at TA-21, which ceased operation in 1986. PAHs may come from automobile exhaust and other urban combustion sources.	Key contaminants in Acid Canyon surface water include PAHs (e.g., benzo_a_pyrene, dibenz_a_h_anthracene), and radionuclides (plutonium-239/240 and strontium-90). The PAHs are believed to be associated with runoff from developed areas within the Los Alamos townsite. The radionuclides were detected in bedrock pools in the South Fork of Acid Canyon and are consistent with contaminants found in sediment within the canyon from historical releases from TA-45. The radionuclide contamination generally does not extend beyond the Acid/Pueblo Canyon confluence in detectable concentrations, with the exception of plutonium-239/240 in unfiltered samples. Surface water in Pueblo Canyon above the confluence with Acid Canyon also has PAHs that are considered to have a source in townsite runoff. Surface water in Pueblo Canyon below the confluence with Acid Canyon shows organic contaminants (PAHs) that are both likely from townsite, national forest, or Cerro Grande fire sources. Radionuclides include plutonium-239/240.	Key contaminants in surface water and springs in lower Los Alamos Canyon include PAHs (benzo_k_fluoranthene), and, only from unfiltered surface water, strontium-90. Strontium-90 could be from either Los Alamos Canyon or Pueblo Canyon, but based on estimated inventories of strontium-90, it is most likely associated with Los Alamos Canyon, specifically Solid Waste Management Unit (SWMU) 21-011(k).

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
Surface Water (cont.)	Quality (cont.)	Key contaminants in DP Canyon surface water and springs include strontium-90. The radionuclides are contaminants only for the unfiltered samples indicating the potential that the detections are related to the presence of suspended sediment in the samples. DP Spring consistently shows elevated strontium-90 concentrations related to surface water and alluvial groundwater discharge from Reach DP-2 where strontium-90 is present throughout the sediment due to historical releases from SWMU 21-011(k).		
Springs	Flow	Discharge at DP Spring is highly variable, generally ranging from 0 to less than 1 gal./min, and has been observed to respond rapidly to storm water runoff from upper DP Canyon. Surface water flow generally extends for less than 50 ft downcanyon from the point where spring flow joins the stream channel.	There are no springs in Pueblo Canyon.	Basalt Spring is recharged by water from the WWTP in Pueblo Canyon. It has variable estimated discharge rates ranging from 1 to 10 gal./min. LA Spring discharges along the south slope of the canyon approximately 300 m downstream of Basalt Spring.
	Quality	Strontium-90 and gross beta are present above applicable standards.		Nitrate is occasionally present above regulatory standards.

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
Alluvial Groundwater	Extent/Hydrology	Alluvial saturation extends from west of the Laboratory boundary downcanyon for variable distances. During dry years, and especially during years with limited spring snowmelt runoff, saturation may not extend to LAO-4c. Alluvial monitoring wells as far down upper Los Alamos Canyon as LAO-4.5c had water for sampling for the first three of four RFI sampling rounds conducted in 2001 and 2002. LAO-6a, the most downcanyon alluvial monitoring well in upper Los Alamos Canyon, only had water sufficient for sampling during the round of sampling conducted in the spring of 2001. Monitoring well LAO-B, located on U.S. Forest Service (USFS) land approximately 0.7 km west of the Laboratory boundary, shows very consistent water levels throughout the year with little interannual variability.	Alluvial groundwater occurs in two distinct modes. Wells located upcanyon of the WWTP show groundwater level variations closely tied to precipitation and associated flood events and to winter and spring snowmelt. The extent of saturation is seasonally variable, but often extends downcanyon to the portion of the canyon where effluent from the Bayo WWTP is discharged into the canyon. Below the WWTP, saturated conditions occur year-round, but the degree of saturation is variable because of changes in runoff and the volume of effluent released throughout the year. The variation in water level elevations downcanyon of the WWTP is controlled primarily by seasonal routing of effluent for uses such as irrigation for the municipal golf course.	Groundwater saturation in most of lower Los Alamos Canyon down to the area around LLAO-4 is related to infiltration of surface water discharged from Basalt Spring, which is hydrologically linked to surface water discharged from the Bayo WWTP into Pueblo Canyon (LANL 1995, 50290). Groundwater levels in the upper portion of lower Los Alamos Canyon are highly variable and are related to seasonal variations in discharge rates from the WWTP and to floods from upper Los Alamos and Pueblo Canyons. In the lowermost portion of lower Los Alamos Canyon, the water level record from LLAO-5 shows relatively constant saturation with much less variability than is exhibited in the upper portions of lower Los Alamos Canyon. The geochemistry of groundwater from LLAO-5 indicates that alluvial groundwater in the lower-most portion of the watershed represents mixing of waters from Los Alamos Canyon and regional groundwater discharging to the Rio Grande.

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
	Extent/Hydrology (cont.)	Further downcanyon, alluvial groundwater levels show rapid response to heavy precipitation in the summer and fall. Water levels also rise in response to late winter and early spring snow melt runoff. This recharge mechanism is not entirely due to infiltration from the stream bed, but may also be related to underflow within the alluvium. In DP Canyon, two separate alluvial saturated zones exist; one in Reach DP-2 and the other in Reach DP-4. In general, groundwater level variations in DP Canyon are directly related to runoff generated in the Los Alamos townsite throughout the year. Alluvial groundwater monitoring wells in Reach DP-2 consistently show some amount of saturation. The second saturated zone is separated from Reach DP-2 by a bedrock-dominated portion of the canyon. Intermittent flow from DP Spring recharges the alluvium in Reach DP-4. This alluvial groundwater is a component of the groundwater observed in well LAO-2 at the confluence of DP and Los Alamos Canyons. Contaminants unique to the portion of upper Los Alamos Canyon above the confluence with DP Canyon (e.g., molybdenum) are detected in LAO-2, indicating that mixing of groundwater from distinct sources occurs in this area.		
	Depth/Thickness			

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
	Quality	Key contaminants in alluvial groundwater above the confluence with DP Canyon include molybdenum, gross beta, and strontium-90. Molybdenum is related to discharge from National Pollutant Discharge Elimination System (NPDES)-permitted outfalls from TA-53 where sodium molybdate was used as a water treatment chemical in cooling towers (ESP 2002, 73876). The use of molybdate has been discontinued. The strontium-90 is related to contamination in a septic leach field east of the Omega West Reactor at TA-02. Below the confluence with DP Canyon the contaminants include strontium-90. Concentrations of strontium-90 in Los Alamos Canyon initially increase below the confluence with DP Canyon indicating that in DP Canyon SWMU 21-011(k) is a more significant source of strontium-90 than is TA-02.	The key contaminants in Pueblo Canyon alluvial groundwater include nitrate from the WWTP.	No contaminants exceed regulatory standards.
	Quality (cont.)	Key alluvial groundwater contaminants in DP Canyon include strontium-90 from SWMU 21-011(k). Strontium-90 has been present in DP Canyon alluvial groundwater for years and concentrations do not show significant decline.		

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
Intermediate Groundwater	Extent/Hydrology	Intermediate depth perched groundwater beneath Los Alamos Canyon has variable depth and lithology of the saturated zones. Intermediate depth groundwater was encountered near the top of the Puye Formation (below the Guaje Pumice Bed) at approximately 680 ft bgs in R-7 in the Guaje Pumice Bed, at 325 ft in LADP-3, and at 295 ft in LAOI(A)-1.1. Deeper saturation was also encountered at about 317 ft in the Puye Formation in borehole LAOI(A)-1.1 within the Guaje Pumice Bed. Intermediate depth perched groundwater was also encountered during drilling of supply well O-4 near the confluence with DP Canyon (Stoker et al. 1992, 58718). Zones of intermediate depth perched groundwater occur within Cerros del Rio Basalts at approximately 179 ft and 264 ft at well R-9i in the lower portion of upper Los Alamos Canyon.	Intermediate depth groundwater occurs beneath Pueblo Canyon. At Test Well 2A, in the middle portion of Pueblo Canyon, the perched groundwater occurs within the Puye Formation at a depth of approximately 120 ft bgs. In lower Pueblo Canyon, in TW-1A and POI-4 perched groundwater was encountered within Cerros del Rio basalts at a depth of about 188 ft bgs. This intermediate perched zone may be one source of water contributing to the flow from Basalt Spring in Los Alamos Canyon.	.
	Depth/Thickness			
	Quality	No contaminants exceed regulatory standards.	No contaminants exceed regulatory standards.	
Regional Aquifer	Depth/Hydrology	Depth to the regional aquifer in upper Los Alamos Canyon is about 900 ft bgs in the Puye Formation at R-7 in the upper portion of the canyon and 688 ft bgs in Santa Fe Group basalts at R-9 in the lower portion of upper Los Alamos Canyon (LANL 2002, 72717, LANL 2000, 71250).	Depth to the regional aquifer is known from several locations in Pueblo Canyon and ranges from approximately 890 ft bgs at R-2 in upper Pueblo Canyon to approximately 650 ft bgs at TW-1 in lower Pueblo Canyon. Historical data indicates that recharge pathways between alluvial groundwater and deeper zones of saturation exist beneath Pueblo Canyon. A discussion of the data is presented below.	Discussions of regional groundwater beneath lower Los Alamos Canyon are presented in a section of the monitoring plan that addresses San Ildefonso Pueblo and White Rock Canyon.
	Quality	No contaminants exceed regulatory standards.	No contaminants exceed regulatory standards.	
Contaminants	Potential Sources	TA-01, TA-02, TA-41, TA-21	TA-00, TA-01 and TA-45	

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
	Type	TA-01 Hillsides 137, 138, and 140 received discharges from septic tank outfalls from 1943 until the late 1950s. Radionuclides are the primary contaminants at these hillside sites, although some metals contamination is also present. TA-02 housed a series of research nuclear reactors, including the Omega West Reactor, which was a source of tritium releases into alluvial groundwater. Other SWMUs at TA-02 include leach fields for water boiler reactors. Cesium-137 and strontium-90 are the primary contaminants associated with the leach fields, and strontium-90 has historically been detected in alluvial groundwater monitoring wells downcanyon of the site. TA-41 was used for weapons development and long-term studies of weapon subsystems. The primary contaminant sources are a septic system and a sewage treatment plant. Initial data from these SWMUs indicate radionuclides at levels above background, but characterization of TA-41 is incomplete. TA-21 was the site of a plutonium processing plant and polonium and tritium research laboratories. Outfalls were the primary source of radionuclide contaminants in DP and upper Los Alamos Canyons. Radionuclides, particularly cesium-137 and strontium-90, are the primary contaminants discharged from this outfall.		

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
	Type (cont.)	TA-53 includes a proton accelerator and associated experimental and support buildings used for research with subatomic particles; it is the current site of the Los Alamos Neutron Science Center (LANSCE) (LANL 1994, 34756). The accelerator became fully operational in 1974. Occasional releases occurred from three surface impoundments at the east end of TA-53, referred to as consolidated unit 53-002(a)-99. These releases have contributed contamination to an unnamed tributary drainage to Los Alamos Canyon. The impoundments received sanitary, radioactive, and industrial wastewater from various TA-53 buildings as well as septic tank sludge from other Laboratory buildings. The northern impoundments were active from the early 1970s until 1993. The southern impoundment was active from 1985 until 1998. Inorganic chemicals, organic chemicals, and radionuclide contaminants have been identified at the impoundments and in the drainage (LANL 1998, 58841; LANL 2004).		

Table A-1 (continued)

Conceptual Model Element	Characteristic	Upper Los Alamos Canyon (including DP Canyon)	Pueblo Canyon (including Acid Canyon)	Lower Los Alamos Canyon
	Type (cont.)	SWMU 21-018(a), Material Disposal Area (MDA) V received liquid waste effluent from laundry operations and includes three absorption beds on the south side of DP Mesa that sometimes overflowed into Los Alamos Canyon (LANL 1991, 07529; LANL 1996, 54969). Sediment sampling in 1946 documented that plutonium from this source was entering the main channel in Los Alamos Canyon (Kingsley 1947, 04186). Additional outfalls that discharged off the south rim of DP Mesa include those from SWMUs 21-023(c), 21-024(b), 21-024(c), 21-024(i), and 21-027(a) (LANL 1991, 07529; LANL 1995, 52350). SWMU 21-029, the DP Tank Farm, was a fuel distribution station with above ground and underground fuel tanks from 1946 to 1985. Diesel range organic (DRO) and gasoline range organic (GRO) hydrocarbon contamination was identified at two areas of bedrock seeps in the DP Canyon channel and observed to periodically form a sheen in surface water adjacent to the site. (LANL 1996, 52270; LANL 2001, 71303; LANL 2001, 73436). The other MDAs at TA-21 are not considered to contribute important releases into the canyons.	Septic tank outfall occurred on the south rim of Acid Canyon in the 1940s and contained plutonium-239/240 and PCBs. Former Pueblo Canyon WWTP operated from 1951 until 1991. Sludge from the Pueblo Canyon WWTP contained metals at levels above background. Former Central WWTP operated from 1947 until 1961. Metals and organic chemicals, including mercury and dichlorodiphenyl-trichloroethane (DDT), were contaminants identified at the outfalls. Outfalls from former TA-01 and former TA-45 were the most significant sources of radionuclide and other contamination in Acid and Pueblo Canyons. TA-45 was the site of the first radioactive liquid waste treatment facility (RLWTF). TA-01 outfalls into Acid Canyon were not treated. Plutonium-239/240 is the primary contaminant, although other radionuclides, metals, and some organic chemicals are also present	

Table A-2
Sandia Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Upper Sandia Canyon (from TA-03 to bottom of State Highway 4 hill, west TA-53)	Middle Sandia Canyon (bottom of Truck Route hill to State Highway 4)	Lower Sandia Canyon (State Highway 4 to Rio Grande)
Surface Water	Flow	Flow is mainly from effluent discharges (about 330,000 gal./day). Flow is perennial for 2 to 2.5 mi from TA-03 (gage E123) to the western edge of TA-53. Intermittent for short reach near bottom of Truck Route hill and stream flow loss pronounced.	Ephemeral at gage stations E124 and E125.	Lower Sandia Canyon is ephemeral except for an intermittent reach of a few hundred yards supported by Sandia Spring approximately 0.5 mile from the Rio Grande.
	Quality	Nitrate is the only contaminant that has occasionally exceeded regulatory standards. Water quality mostly reflects sewage effluent.		
Springs	Name	There are no springs in this reach.	There are no springs in this reach.	Sandia Spring discharges ~1gal./min approximately 0.5 miles from Rio Grande.
	Quality			No contaminants exceed regulatory standards. Contaminant levels at detection or background levels.
Alluvial Groundwater	Extent	No alluvial wells presently in this reach. Alluvial saturation is likely within limited alluvial sediments because of effluent discharges.	Absent in eastern portion of reach. Test drilling in western portion suggests saturation in canyon south of LANSCE, but no alluvial wells are currently located in this portion of the canyon. Several new wells are planned for installation in 2006.	Not known; likely dry except below Sandia Spring.
	Depth/Thickness			
	Quality			

Table A-2 (cont.)

Conceptual Model Element	Characteristic	Upper Sandia Canyon (from TA-03 to bottom of Truck Route hill, west TA-53)	Middle Sandia Canyon (bottom of Truck Route hill to SR-4)	Lower Sandia Canyon (SR-4 to Rio Grande)
Intermediate Groundwater	Extent/Hydrology	No information available. Some intermediate water likely to be present beneath stream channel because of perennial flow conditions.	Lateral extent not certain, however R-11, R-12 and PM-1 encountered an intermediate perched zone. Test drilling suggests limited saturation in Cerro Toledo south of LANSCE at 30 to 60 ft depth.	R-10 and R-10a identified intermediate water in this area.
	Depth/Thickness		Zone in R-12 from 443 to 519 ft depth. Water level stabilized at 424 ft.	Interemediate zone was encountered at approximately 340 ft bgs.
	Quality		No definitive data available.	
Regional Aquifer	Depth/Hydrology	No regional aquifer wells in this reach of canyon.	Penetrated by four wells in this reach: R-12, PM-1, PM-3, and R-11. Encountered at 805 ft in R-12. Higher static water level in PM-1 suggests upward flow near State Highway 4. Large-scale pumping at PM-1 and PM-3 may pull water in from adjacent canyons: Los Alamos or Mortandad.	R-10 and R-10a shows regional groundwater at approximately 671 ft bgs.
	Quality		No contaminants exceed regulatory standards. R-11 shows chromium at approximately 26 ug/L.	
Contaminants	Potential Sources	TA-03 and former TA-20.	TAs-3, 53, -60, -61, and -72, Los Alamos Canyon, Mortandad Canyon	No known surface sources.
	Type	Nitrate, perchlorate, chromium, copper, polychlorinated biphenyls (PCBs) in sediments, high explosives (??) from former TA-20	Tritium, nitrate, perchlorate, chromium, isotopes of uranium and plutonium, lead in surface soils.	

Table A-3
Mortandad Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Description
Surface Water	**Flow**	Mortandad Canyon and its tributaries are ephemeral. With the exception of gaging station E200, which measures flow created by discharge of treated effluent from the TA-50 RLWTF, all other gaging stations measured flow only in response to precipitation. In the period 1995–2002, gage E200 measured flow 64% of the year, where the other gages (E202, E203, E204) measured no flow. Operating NPDES-permitted outfalls associated with Mortandad Canyon include 051 associated with the TA-50 RLWTF; 03A-021 associated with the CMR Laboratory at TA-03; 03A-022 associated with the Sigma Building at TA-03; 03A-045 associated with the Rad Chem Laboratory at TA-48; 03A-160 associated with Antares Target Hall at TA-35; 03A-181 associated with a utility building at TA-55; and 04A-166 associated with water supply well Pajarito Mesa #5. Cañada del Buey within the Laboratory boundary is ephemeral in character, based on flow data from three gages; E218, E230, and E225. In the period from 1995 to 2002, the number of days of flow per year ranged from 38 at the gage near TA-46 to zero near MDA G. Cañada del Buey east of the Laboratory has effluent-supported flow from the Los Alamos County sewage treatment plant in White Rock, which discharges into Cañada del Buey about 2 mi upstream of its confluence with Mortandad Canyon, and results in effluent-supported surface flow that regularly extends to the Rio Grande. Operational NPDES-permitted outfalls associated with Cañada del Buey include 13S associated with the TA-46 Sanitary Wastewater Systems Consolidation (SWSC) Plant (effluent is sampled at 13S but not discharged; all SWSC effluent is routed to TA-03) and 04A-118 associated with water supply well Pajarito Mesa #4.
	Quality	Key contaminants include americum-241, plutonium-238, plutonium-239/240, strontium-90, fluorine, nitrate, and perchorate.
	Name	No springs are present in the Mortandad Canyon.
	Quality	Not applicable
Alluvial Groundwater	**Extent**	Based on water levels observed in Mortandad Canyon alluvial wells, a saturated zone in the alluvium extends downstream from the TA-50 RLWTF outfall for approximately 2.2 mi. The easternmost extent of saturation in the alluvium is estimated near wells MCO-8 and MCO-8.2. In Cañada del Buey, nine alluvial wells were installed, but only two occasionally contain groundwater.
	Depth/Thicknes s	The saturated portion of the Mortandad Canyon alluvium is generally less than 10 ft thick and there is considerable variation in saturated thickness depending on the amount of precipitation and runoff in any particular year. Groundwater flow velocity in the alluvium varies from about 60 ft/day in the upper canyon to about 7 ft/day in the lower canyon and has been estimated to be 30 to 40 ft/day between MCO-5 and MCO-8.2.
	Quality	Key contaminants include americum-241, gross alpha, gross beta, plutonium-238, plutonium-239/240, strontium-90, H-3, fluorine, nitrate, and perchlorate. Effluent releases have had a major impact on water quality.

Table A-3 (cont.)

Conceptual Model Element	Characteristic	Description
Intermediate Groundwater	**Extent/Hydrology**	Perched groundwater was encountered during drilling of R-15 and MCOBT-4.4 in two different stratigraphic levels within the Cerros del Rio basalt. The lateral extent of these intermediate depth perched zones is unknown.
	Depth/Thickness	At MCOBT-4.4, a single screen set in a perched zone within the upper Puye Formation/Cerros del Rio basalt at a depth of 524 ft below ground surface (bgs). In R-15, perched groundwater was encountered at a depth of 646 ft bgs in the lower portion of the Cerros del Rio basalt.
	Quality	Key contaminants include nitrate, chromium, and perchlorate. Water quality shows the impact of historical effluent releases.
Regional Aquifer	**Depth/Hydrology**	The regional water table occurs within the Puye Formation in the Mortandad Canyon watershed. In Ten Site Canyon, approximately 3700 ft west of the confluence with Mortandad Canyon, the regional aquifer was encountered at a depth of 1182 ft in well R-14. In Test Well 8, located in Mortandad Canyon approximately 1300 ft west of the confluence with Ten Site Canyon, the regional aquifer occurs at a depth of 994 ft. The regional aquifer was encountered at a depth of 964 ft in R-15, located in Mortandad Canyon approximately 2000 ft east of the confluence with Ten Site Canyon. In well R-13, located approximately 5800 ft east-southeast of R-15, the regional aquifer was encountered at a depth of 833 ft. Flow in the regional aquifer is generally west to east with some deviation due to pumping the Pajarito Mesa well field. However, the flow tends to come back toward the east due to pumping of other wells. Average flow velocity for the regional aquifer in the vicinity of Mortandad Canyon is estimated to be about 95 ft/yr.
	Quality	Wells R-13 and R-14 have not shown contamination in the regional aquifer during drilling and/or subsequent characterization sampling. Key contaminants include perchlorate in well R-15.
Contaminants	**Potential Sources**	A description of potential release sites (PRSs) in the Mortandad watershed is provided in Work Plan for Mortandad Canyon. The canyon passes through or is adjacent to current Laboratory Technical Areas (TAs) 03, 05, 35, 46, 48, 50, 51, 52, 54, 55, 59, 60, and 63. PRSs in Cañada del Buey are provided in the "Work Plan for Sandia Canyon and Cañada del Buey." Cañada del Buey has been a buffer zone for surface and subsurface material disposal areas at TA-54 and for effluent disposal, mostly from former TA-04. It also received discharges from TA-46, -51, and -52. Outfall discharges into Mortandad Canyon are described in the "Work Plan for Mortandad Canyon." Mortandad Canyon and its tributaries have received effluent from the Laboratory since the early 1950s. Outfall discharges into the Cañada del Buey drainage are described in the Work Plan for Sandia Canyon and Cañada del Buey. Cañada del Buey received effluent from the Laboratory from the 1950s to the 1990s.

Table A-3 (cont.)

Conceptual Model Element	Characteristic	Description
	Type	TA-03 activities include administrative offices and support facilities plus various division laboratories and technical shops. TA-05 contains some physical support facilities, tests wells, and environmental monitoring and buffer areas. TA-35 activities include research laboratories for nuclear safeguards research and development, reactor safety, laser fusion, optical sciences, pulsed-power systems, high energy physics, tritium fabrication, metallurgy, ceramic technology, and chemical plating. TA-46 activities include research laboratories for applied photochemistry and organic and materials chemistry plus environmental management operations and the Sanitary Wastewater System Facility. TA-48 activities include research on nuclear and radiochemistry, geochemistry, biochemistry, and actinide chemistry. TA-50 activities include management and processing of industrial liquid and radioactive liquid wastes and it houses the RLWTF. TA-51 activities include environmental research and experimental studies for radioactive waste storage. TA-52 activities include research on nuclear reactor performance and safety. TA-54 activities include radioactive solid and hazardous chemical waste management and disposal operations. TA-55 activities include plutonium processing and research on plutonium metallurgy. TA-59 activities include occupational health and safety management, environmental management, and emergency management. TA-60 contains physical support and infrastructure facilities including the Test Fabrication Facility and Rack Assembly and the Alignment Complex. TA-63 contains physical support facilities and activities include environmental and waste management functions and facilities. The effluent discharged from TA-03, TA-35, TA-48, and TA-50 has contained a variety of contaminants, including nitrate, perchlorate, chromium, tritium, cesium-137, strontium-90, americium-241, and several isotopes of uranium and plutonium.

Table A-4
Pajarito Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Pajarito Canyon	Twomile Canyon	Threemile Canyon
Surface Water	Flow	Surface water occurs in Pajarito Canyon mostly as intermittent flow. Short reaches of perennial flow occur downstream of spring discharges in Starmers Gulch and below the 4-series springs in White Rock Canyon. Surface water flow is ephemeral in central Pajarito Canyon between the confluences with Twomile and Threemile Canyons. Flow is also ephemeral through White Rock.	Flow is ephemeral west of TA-03 and is possibly intermittent from TA-03 to the confluence with Pajarito Canyon.	Threemile Canyon is ephemeral except for a possibly intermittent reach supported by springs above the confluence of Threemile and Pajarito Canyons.
	Quality	Key contaminants include RDX and possibly mercury and nitrate.	There are no surface water chemistry results for Twomile Canyon except for a small tributary below building SM-30 in TA-03. Samples from the tributary show elevated mercury in unfiltered samples.	Contaminants include RDX .
Springs	Name	In the western portion of Pajarito Canyon, springs issue from canyon slopes above the alluvium. The probable source of these springs is the upper part of the Tshirege Member of the Bandelier Tuff. Typical discharge rates are approximately 1 to 15 gal./min. Springs include PC, Homestead, Upper Starmer, Charlies, Garvey, Perkins, Starmer, and Josie Springs, Keiling and Bulldog Springs.	Springs issue from the canyon floor of upper Twomile Canyon in TA-03 and 58. These springs include Hanlon, Anderson, SM-30, SM-30A, and TW-1.72 Springs.	There are two springs on the floor of Threemile Canyon. These springs include Threemile and TA-18 Springs.
	Quality	Contaminants include RDX and perchlorate, which have been detected in spring water at TA-08 and TA-09.	There are no screening data for springs in Twomile Canyon.	No contaminants exceed regulatory standards.

Table A-4 (cont.)

Conceptual Model Element	Characteristic	Pajarito Canyon	Twomile Canyon	Threemile Canyon
Alluvial Groundwater	Extent	There are no alluvial wells in western Pajarito Canyon, so information about the nature and extent of alluvial groundwater is limited. Most likely, infiltration of surface water creates a saturated zone where alluvium is present from the Pajarito fault zone across the Laboratory to White Rock. Alluvial wells have been installed between TA-18 and State Highway 4. These wells demonstrate the presence of alluvial groundwater in this part of Pajarito Canyon. The drilling of seven test holes in 1985 showed that the saturation in lower Pajarito Canyon does not extend laterally under Mesita del Buey near MDAs G and L (Devaurs 1985, 7416; Devaurs 1985, 07415). Three of the alluvial test holes were completed as groundwater monitoring wells (PCO-1, -2, and -3). An additional 20 alluvial wells were installed between 1990 and 1998 by the Environmental Restoration Project as part of the RCRA facility investigation (RFI) for TA-18.	There are no alluvial wells in Twomile Canyon and the extent of alluvial groundwater, if present, is unknown.	Alluvial groundwater has been documented in lower Threemile Canyon at 18-BG-1 and 18-MW-8.
	Depth/Thickness	Wells PCO-1, -2, and -3 are probably representative of alluvial groundwater between TA-18 and State Highway 4. When installed, depth to water was 1.3 ft in PCO-1, 6.3 ft in PCO-2, and 3.1 ft in PCO-3 (Purtymun 1995, 45344). Assuming continuous saturation in the alluvium, the saturated thickness is about 9.7 ft in PCO-1, 2.7 ft in PCO-2, and 8.9 ft in PCO-3. The saturated thickness varies seasonally, with no water present in dry years.	No Data.	In well 18-BG-4, the water level was 2.5 ft bgs.
	Quality	Contaminants include hexahydro-1,3,5,trinitro-1,3,5-triazine (RDX) and possibly beryllium, lead, and plutonium-239/240.	No Data.	No contaminants exceed regulatory standards.

Table A-4 (cont.)

Conceptual Model Element	Characteristic	Pajarito Canyon	Twomile Canyon	Threemile Canyon
Intermediate Groundwater	Extent/Hydrology	Intermediate perched water is likely to occur beneath Pajarito Canyon, but knowledge of its extent and quality is incomplete. Perched water was indicated during the drilling of PM-2 and SHB-4 in the vicinity of TA-18. At PM-2, a "show of water at 335 ft" was noted in the Otowi Member of the Bandelier Tuff during the cable-tool drilling (Cooper et al. 1965, 8582). In SHB-4, the core tube and core from the top of the Otowi Member from about 125 ft to 145 ft came out of the hole wet (Gardner et al. 1993, 12582). Test Holes 5 and 6 were drilled in 1950 to detect perched groundwater in Pajarito Canyon south of TA-54. Test Hole 5 was drilled through the Bandelier Tuff and into basalts at a total depth of 263 ft. Test Hole 6 was also drilled through the tuff and into basalts to a total depth of 300 ft (Griggs 1955, 08795). These dry test holes indicate that perched water does not occur in the upper part of the vadose zone in this part of the canyon. Between 2000 and 2002 regional wells R-20, R-22, R-23, and R-32 were installed in lower Pajarito Canyon. Perched intermediate water was not identified during the drilling of wells R-20, R-22, and R-32. However, at R-23, near the eastern Laboratory boundary, there were indications that perched intermediate water may be present in Cerros del Rio basalt. However, R-23 is only screened in the regional aquifer.	Well 03-MW-1 is a 28-ft-deep mesa top well that samples shallow intermediate perched water near building SM-30 at TA-03. A thin zone of saturation occurs in tuffs of the upper Tshirege Member.	Characterization well R-19, located on the mesa south of Threemile Canyon, had indications of possible perched water at depths of 834 to 840 ft and 894 to 912 ft (Broxton et al. 2001, 71253). Both zones were screened in the completed well, but only the 894 to 912 ft interval (screen 2) in the Puye Formation yields water.
	Depth/Thickness	See above	Depth to water in well 03-MW-1 is 20 ft.	See above

Table A-4 (cont.)

Conceptual Model Element	Characteristic	Pajarito Canyon	Twomile Canyon	Threemile Canyon
	Quality	No Data.	Characterization sampling for 03-MW-1 found elevated concentrations of mercury, tritium, and volatile organic compounds (VOCs). A Groundwater Investigation Work Plan is being prepared to determine the extent of this perched zone.	No contaminants exceed regulatory standards. Samples from well R-19 indicate there are impacts to the intermediate perched water from Laboratory operations.
Regional Aquifer	Depth/Hydrology	Based on Laboratory water level maps, the general direction of groundwater flow in the regional aquifer is east to southeast in the vicinity of Pajarito Canyon. Depth to the regional aquifer is known in Pajarito Canyon at supply well PM-2 and in characterization wells R-20, -22, -23, and -32. The nonpumping water level for PM-2 in 2001 was at a depth of 855 ft. In 2002, the top of the regional water table was at a depth of 826 ft in R-20, 890 ft in R-22, 828 ft in R-23, and 776 ft in R-32. R-23 is completed with a single well screen, R-20 and R-32 have three well screens, and R-22 has five well screens. The upper portion of the regional aquifer probably discharges at Spring 4A in White Rock Canyon.	There are no regional aquifer wells associated with Twomile Canyon.	Well R-19 is located on the mesa south of Threemile Canyon. It is downgradient from firing site IJ in TA-36 and is upgradient of TA-18. In addition to two screens in the vadose zone (described above), R-19 has five screens in the regional aquifer.
	Quality	No contaminants exceed regulatory standards. Water quality of the regional aquifer beneath eastern Pajarito Canyon shows little, if any, impacts from LANL operations. Sampling at R-22 above background tritium in several screens. Routine surveillance sampling of PM-2 shows the groundwater meets regulatory standards.	No data.	No contaminants exceed regulatory standards . Sampling at R-19 indicates no impacts to the regional groundwater from Laboratory operations.
Contaminants	Potential Sources	TAs -08, -09, -15, -22, -36, -36, -40, and -54	TAs -03, -06, -40, -48, -55, -59, -64, and -69	TAs -15, -18, and -36
	Type	Metals, radionuclides, high explosives, VOCs, and anions	mercury, tritium, and VOCs	HE, VOCs

Table A-5
Water Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Upper Water Canyon & Cañon de Valle	Middle Water Canyon	Lower Water, Fence, and Potrillo Canyons
Surface Water	Flow	*Water Canyon*: Perennial from State Highway 501 to the eastern edge of TA-28. Intermittent surface water occurs in upper Water Canyon (gage E252) primarily in the spring. *Cañon de Valle:* Perennial from Peter Seep to gage E256. Intermittent surface water exists from natural and anthropogenic sources to gage E262.	Ephemeral at gage station E265.2.	Lower Water Canyon is ephemeral, except for a perennial reach supported by Spring 5AA near the confluence of Water and Potrillo canyons. Potrillo Canyon and Fence Canyon are entirely ephemeral.
	Quality	*Cañon de Valle*: Contaminants include barium (2–3 ppm) and the high explosive RDX (>100 ppb), trinitrotoluene[2,4,6-], perchlorate, and possibly mercury	Surface water chemistry results show contaminant levels at detection or background levels.	No contaminants exceed regulatory standards. Uranium is significantly greater than background in surface water (11.9 ppb) near the firing sites, yet no significant elevation in concentrations at State Highway 4.
Springs	Flow	Armistead Spring and American Spring, west of LANL, and SWSC, Burning Ground, Martin, and the Hollow (on LANL property) and others in the upper reaches of Cañon de Valle	There are no springs in the vicinity of TA-49, except for the seep near the Beta hole.	Spring 5AA in lower Water Canyon. No springs in Potrillo Canyon or in Fence Canyon.
	Quality	Contaminants include RDX, barium, dichloroethane[1,2-], tetrachloroethene, trichloroethene, perchlorate, and possibly mercury.		
Alluvial Groundwater	Extent/Hydrology	*Water Canyon*: Some alluvial groundwater may be present near the headwaters. Because of the limited addition of water, lack of springs and seeps, and rare discharge from tributary canyons, the occurrence and duration of alluvial groundwater likely decreases downcanyon. *Cañon de Valle*: Alluvial groundwater system near SWSC and Burning Ground Springs is perennial. Alluvial water in Martin Canyon and the Fishladder drainage is intermittent.	Alluvial groundwater is in WCM-1 and WCM-2, but no water is present in WCO-1, WCO-2, and WCO-3, though water was found in WCO-2 in 2005. In most years, the downstream extent of alluvial groundwater may be between the WCM-2 and WCO-1.	*Potrillo*: one known occurrence of alluvial groundwater in Potrillo Canyon in moisture access hole POTM-2. Several other boreholes have been drilled near this area to define the extent of the groundwater found in POTM-2 but all are dry. *Fence:* No occurrences of alluvial groundwater have been documented for Fence Canyon. However, only one well was installed, well FCO-1, located near State Highway 4. Based on physiography, no alluvial water is expected.

Table A-5 (cont.)

Conceptual Model Element	Characteristic	Upper Water Canyon & Cañon de Valle	Middle Water Canyon	Lower Water, Fence, and Potrillo Canyons
	Depth/Thickness	Alluvium is typically less than10 ft thick, however, saturation does extend into the tuff		
	Quality	*Cañon de Valle* : contaminants include barium, RDX, dinitrobenzene[1,3-], trinitrotoluene[2,4,6-], and perchlorate.		
Intermediate Groundwater	Extent/Hydrology	Lateral extent of the deep perched zone has not been determined, however in R-25 and SHB-3 a thick perched zone was encountered. Shallower, disconnected, and transient zones of perched saturation have been identified elsewhere within the TA-16 mesa.	No perched water was encountered in any of the holes and all holes have remained dry with the exception of core hole CH-2. DT-5, DT-5P, and four core holes (CH-1, CH-2, CH-3, and CH-4) were drilled to depths of 300 to 500 ft at the main experimental area and more than 50 experimental holes were drilled as deep as 142 ft in Areas 1, 2, 2A, 2B, 3, and 4 from 1959 to 1961. CH-2 may have an undetected natural perched zone; however, this seems unlikely because this recharge pathway apparently developed more than a decade after the hole was completed.	*Water*: None found in the two existing CDV wells (CDV-R-15 and CDV-R-37). *Potrillo and Fence*: The presence of perched water can not be determined from available data.
	Depth/Thickness	R-25: 711-1132 ft		
	Quality	Contaminants include RDX, trinitrotoluene[2,4,6-], trichloroethene, and possibly lead.		
Regional Aquifer	Depth/Hydrology	R-25 encountered the regional aquifer at 1286 ft.		Water supply well PM-2: 730 ft below the bottom of Potrillo Canyon and 620 ft below the bottom of Fence Canyon.
	Quality	RDX has been detected,, although this may have been from cross contamination from the perched zone above. HE concentrations are decreasing in the regional aquifer with time, while they are remaining relatively constant in the perched zone.		
Contaminants	Potential Sources	TAs -08, -09, -11, -14, -15, and -16	TA-49	TAs -14, -15, -36

Table A-5 (cont.)

Conceptual Model Element	Characteristic	Upper Water Canyon & Cañon de Valle	Middle Water Canyon	Lower Water, Fence, and Potrillo Canyons
	Type	HE, barium, solvents	Isotopes of uranium and plutonium, lead, beryllium, and explosives such as TNT, RDX, HMX, and barium nitrate	Nitrated organic compounds such as TNT, nitrocellulose, trinitramines, and pentaerythritol tetranitrate (PETN). Metals may also be associated with the explosives (uranium, barium, beryllium, lithium hydride, lead, mercury, copper, and zinc). Soils in several of these operational areas have high levels of uranium contamination.

Table A-6
White Rock Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Description
Surface Water	Flow	Flow from regional aquifer springs supports perennial surface water flow in several canyons just above where they reach the Rio Grande: Sandia, Pajarito, Ancho, and Chaquehui Canyons. Except for Sandia Canyon, these flows reach the Rio Grande. A municipal sanitary treatment plant discharges effluent into Mortandad Canyon just above the river at the northern county boundary.
	Quality	Barium is the only constituent that has been detected above regulatory standards in surface water (in 2 of 28 samples). Water quality of the other streams is mainly determined by the chemistry of their contributing springs (summarized in the regional aquifer description below). The discharge from the municipal sanitary treatment plant is the primary surface water source and has a strong impact on the chemistry of the water that enters the Rio Grande from Mortandad Canyon, leading to higher total dissolved solids (TDS), nitrate, chloride, sulfate, and some metals.
Springs	Name	Springs near the Rio Grande represent natural discharge from the regional aquifer. Regional aquifer springs are present just above the Rio Grande in Sandia, Pajarito, Ancho, and Chaquehui canyons. Los Alamos Canyon and Water Canyon do not have significant springs in their lower reaches. A small seep (Otowi Spring) emerges along the Rio Grande bank south of Los Alamos Canyon. A small seep (Spring 5AA) issues from the Totavi Lentil in lower Water Canyon, but seldom has sufficient water for sampling. Springs discharge from two geologic units: the Tesuque Formation and the Totavi Lentil (the lower part of the Puye Formation). The Tesuque Formation consists of sandstones, siltstones, and interbedded basalts. The Totavi Lentil is a channel-fill deposit made up of grain sizes ranging from gravel to boulders. Purtymun divided the springs into four groups based on geologic unit and chemistry. Group I springs discharge from the Totavi Lentil on the west side of the river. Water is dominated by calcium bicarbonate with sulfate and chloride of about 4 mg/L and TDS averages 163 mg/L. These springs follow the outcrop of the Totavi Lentil, increasing their elevation above the river in a downstream direction. These higher elevation springs generally occur on the flanks of or in the bottom of canyons where erosion has exposed the Totavi Lentil. Group II springs discharge from coarse-grained Tesuque Formation sediments on both sides of the river. These springs have sodium bicarbonate water with about 3 mg/L of sulfate and chloride, and TDS averages 183 mg/L. Group III springs discharge from fine-grained Tesuque Formation sediments on the west side of the river. These springs also have sodium bicarbonate water with about 10 mg/L of sulfate, 3 mg/L of chloride and TDS averages 215 mg/L. Group IV springs discharge from fine-grained Tesuque Formation sediments on the east side of the river near faults and basalt flows. These springs have varied chemistry with higher TDS than the other springs, of 270 to 500 mg/L. Most of the springs discharge close to the elevation of the Rio Grande, though some springs discharge at elevations several tens of feet above the Rio Grande. There are different hypotheses about the meaning of the elevation of springs above the river. One hypothesis is the elevations could reflect channeling of discharge from the regional aquifer along the higher-permeability Totavi Lentil, combined with the increase in elevation of the water table with distance west of the river. Another hypothesis of spring occurrence is that the elevation of springs above the river could reflect local variations in permeability and geology related to numerous landslides along the canyon walls. A third hypothesis is that the elevation of some springs above the river indicates that they discharge from perched groundwater located above the regional aquifer.

Table A-6 (cont.)

Conceptual Model Element	Characteristic	Description
	Quality	The U.S. Geological Survey and the Laboratory have monitored chemistry of the White Rock Springs since the 1960s; the springs show no clear impact of Laboratory contamination. One sample of 67 from all springs (and 1 of 8 from this spring) showed RDX, trinitrotoluene[2,4,6-], and HMX above regulatory standards.
Alluvial Groundwater	Extent	Alluvial groundwater is not present in the White Rock Canyon area. However, household wells in Los Alamos Canyon (Halladay and Otowi) and household wells nearer the Rio Grande probably draw their water from Santa Fe Group sediments but may draw water in part from alluvium in these drainages.
	Depth/Thickness	Not applicable.
	Quality	Not applicable
Intermediate Groundwater	Extent/Hydrology	Perched intermediate groundwater may not be present in the White Rock Canyon area. However, an alternative hypothesis about White Rock Canyon spring origin is that the elevation of some springs above the river indicates that they discharge from perched groundwater located above the regional aquifer.
	Depth/Thickness	Not applicable.
	Quality	Not applicable.
Regional Aquifer	Depth/Hydrology	The Rio Grande is the major groundwater discharge point for the regional aquifer underlying the Pajarito Plateau. The river gains flow through White Rock Canyon (Purtymun 1995, 45344) indicating that the local water table lies above the river. The Buckman well field lies adjacent to the Rio Grande on the east bank and includes eight pumping wells. These wells draw their water from Santa Fe Group sediments. Water in these wells is quite old, having passed through the deeper portion of the basin fill sediments where it acquired a higher load of dissolved solutes. San Ildefonso Pueblo draws water from more than 10 community and household wells located on both sides of the Rio Grande. Little information on depth or geology for these wells is available. Many of these wells probably draw their water from Santa Fe Group sediments. At least two of the San Ildefonso wells are uncapped artesian wells.
	Quality	Except for naturally occurring constituents, no constituents exceed regulatory standards. Some Buckman wells have exceptionally high uranium (up to 230 ppm, compared to the new EPA MCL of 30 ppm). Such naturally occurring uranium is common in the Pojoaque and Tesuque area. The Buckman wells also have high sodium, alkalinity, and total dissolved solids. San Ildefonso Pueblo household wells also produce older water from deep within the basin, and have high sodium, chloride, alkalinity, and TDS, as well as uranium, arsenic, and boron.
Contaminants	Potential Sources	TA-33 borders the Rio Grande, a site where tritium activities formerly occurred. The low- to moderate-density residential area of White Rock borders the Rio Grande to the north of the Laboratory boundary in White Rock Canyon. A municipal sanitary treatment plant discharges effluent into Mortandad Canyon just above the river at the northern county boundary.

Table A-6 (cont.)

Conceptual Model Element	Characteristic	Description
	Type	TA-33 was used as a firing site and for production of tritium. PRSs include landfills, septic systems, and burn areas It is situated on a mesa top and is being investigated by the Environmental Restoration (ER) Project as Operable Unit (OU) 1122. If contaminants are released from TA-33, they may impact Ancho Canyon, Chaquehui Canyon, or the Rio Grande. The discharge from the municipal treatment plant is the primary surface water source and has a strong impact on the chemistry of the water that enters the Rio Grande from Mortandad Canyon, leading to higher TDS, nitrate, chloride, sulfate, and some metals.

Table A-7
Guaje Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Description
Surface Water	Flow	Guaje Canyon heads in the Sierra de los Valles and is part of the Los Alamos Canyon watershed. Guaje Canyon contains an interrupted stream with a perennial reach extending from springs located upstream of Guaje Reservoir to some distance downstream of the reservoir. An intermittent reach extends farther downstream to the confluence with lower Los Alamos Canyon. Snowmelt runoff does not reach the Rio Grande. Guaje Canyon crosses San Ildefonso Pueblo land and continues to its confluence with lower Los Alamos Canyon approximately a mile west of the Rio Grande. Rendija Canyon heads on the flanks of the Sierra de los Valles and contains an ephemeral stream. Barrancas Canyon heads on the Pajarito Plateau and has intermittent and ephemeral flow. No springs have been found in any of these canyons. Base flow has been monitored at the station Guaje Canyon located below the reservoir for several decades. Gaging stations in these canyons include Guaje above Rendija, Rendija above Guaje, and Guaje at SR-502. For many gages, flow information is not available. These gages do not yet have an established rating curve.
	Quality	No constituents exceed regulatory standards.
Springs	Name	none
	Quality	N/A
Alluvial Groundwater	Extent	Only two alluvial wells have been installed in Guaje Canyon to investigate the presence of alluvial groundwater. These wells were completed in the perennial reach of the canyon and alluvial groundwater was encountered near the stream level. For Rendija and Barrancas Canyons, no alluvial wells have been installed and no alluvial groundwater is known.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable
Intermediate Groundwater	Extent/ Hydrology	No intermediate groundwater wells have been installed and no groundwater is known to exist in these canyons. Drilling of the water supply wells in Rendija and Guaje canyons has not found any intermediate groundwater.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable.

Table A-7 (continued)

Conceptual Model Element	Characteristic	Description
Regional Aquifer	Depth/ Hydrology	The regional aquifer occurs in the Puye Formation and the Santa Fe Group near Guaje Canyon. The regional aquifer probably includes rocks of the Tschicoma Formation in the western part of the canyons. The regional aquifer supplies water to the wells of the Guaje well field. Groundwater flow in the regional aquifer is from the northwest, so no Laboratory contaminant sources are located upgradient of Guaje Canyon sites. The aquifer lies at depths of about 230 to 570 ft in the Guaje well field.
	Quality	No constituents exceed regulatory standards except for high levels of naturally occurring arsenic up to 40 µg/L in older, now-abandoned wells. The EPA maximum contaminant level (MCL) for arsenic is 10 µg/L.
Contaminants	Potential Sources	These canyons are north of the Laboratory and likely not affected by contamination. However, Rendija Canyon contained a small arms firing range and several sites used as mortar impact areas.
	Type	Metals, high explosives (HE)

Table A-8
Bayo Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Description
Surface Water	Flow	Bayo Canyon is part of the Los Alamos Canyon watershed. Bayo Canyon heads on the Pajarito Plateau on land owned by Los Alamos County and extends across the northeast portion of the Laboratory (TA-74), crosses San Ildefonso Pueblo land to the east, and terminates at its confluence with lower Los Alamos Canyon near Totavi. Surface water flow in Bayo Canyon is ephemeral and intermittent and there are no springs in the vicinity. Stream loss caused by infiltration into the underlying alluvium and evapotranspiration typically prevents surface flow from discharging to Los Alamos Canyon. The only gaging station in Bayo Canyon is Bayo below TA-10.
	Quality	None.
Springs	Name	None.
	Quality	N/A
Alluvial Groundwater	Extent	No alluvial groundwater was encountered during drilling of about 90 boreholes at the TA-10 site in upper Bayo Canyon.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable
Intermediate Groundwater	Extent/ Hydrology	None known.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable.
Regional Aquifer	Depth/ Hydrology	The regional aquifer occurs in the Puye Formation and the Santa Fe Group in the vicinity of Bayo Canyon. The regional aquifer probably includes rocks of the Tschicoma Formation in the western part of the canyons. The regional aquifer supplies water to the wells of the Guaje well field. The aquifer lies at depths of about 230 to 570 ft in the Guaje well field.
	Quality	No constituents exceed regulatory standards except for high levels of naturally occurring arsenic up to 40 µg/L in older, now-abandoned wells.
Contaminants	Potential Sources	Former radiochemistry laboratory and firing sites at Bayo Canyon Site, TA-10
	Type	Strontium-90 and other constituents

Table A-9
Ancho Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Description
Surface Water	Flow	Ancho Canyon heads on the Pajarito Plateau and for the most part has ephemeral flow. The canyon has two main branches, the northern one known as North Ancho Canyon. Gaging stations include Ancho above north fork Ancho, Ancho north fork below SR-4, and Ancho below SR-4. These stations have shown little flow. The average discharge for Ancho below SR-4 from seven years of record is 0.005 cfs or 3.6 ac-ft/yr. No other information on surface water quality or flows is available. The only perennial section of the canyon is near the Rio Grande.
	Quality	No constituents exceed regulatory standards.
Springs	Name	Beginning less than a mile above the Rio Grande, Ancho Canyon is perennial, with flow fed by Ancho Spring, a regional aquifer spring.
	Quality	N/A
Alluvial Groundwater	Extent	Little is known about the presence of alluvial groundwater in Ancho Canyon. Ancho Canyon contains thick alluvium that could host perched groundwater, and three boreholes (ASC-15, ASC-16, and ASC-18) drilled by the ER Project encountered 4 ft to 9 ft of saturation in alluvium below MDA Y. Several boreholes drilled downgradient of MDA Y encountered no alluvial groundwater, suggesting the occurrence of alluvial groundwater in this area is limited in extent.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable.
Intermediate Groundwater	Extent/ Hydrology	No intermediate perched zones have been found beneath Ancho Canyon, although further borehole information may change this. ER borehole DMB-1, drilled between Building 69 and the administrative area at TA-39, penetrated 119 ft of Bandelier Tuff and 5 ft of Cerros del Rio basalts. No intermediate-depth perched water was encountered in this hole, but clay-lined fractures and vesicles in the basalt suggest that periodic passage of groundwater through these rocks may occur. A test hole (TH-7) drilled 10 ft into basalts in Ancho Canyon below State Highway 4 was dry. The hole was drilled in 1950 and has since been plugged. R-31 was drilled in TA-39 in the north fork of Ancho Canyon. A screen was placed from 439 to 454 ft at a possible perched zone, based on water seen in a borehole video. The zone has been dry since and no water samples have been collected from it.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable.

Table A-9 (continued)

Conceptual Model Element	Characteristic	Description
Regional Aquifer	Depth/ Hydrology	Groundwater flow in the regional aquifer beneath Ancho Canyon is to the east and southeast, towards the Rio Grande. The regional aquifer lies at about 1000 to 1170 ft beneath the mesa at TA-49, and is within the Cerros del Rio basalt, the underlying Puye Fanglomerate, “Totavi” gravels, and possibly the Santa Fe Group. Regional aquifer characterization well R-31 in TA-39 found the regional aquifer at about 530 ft within the Cerros del Rio basalt, the underlying Puye Fanglomerate, and “Totavi” gravels. Postdrilling water quality sampling has not been completed at this well.
	Quality	No constituents exceed regulatory standards. Three regional aquifer wells at TA-49 have been sampled since the 1960s to monitor for effects of testing at that site. In general no effects have been found. High metal concentrations (lead, zinc, iron, manganese) in samples are related to metal well casing and fittings. Occasional detections of organic compounds are not supported by follow up sampling. Analysis of water at Ancho Spring by the Environmental Surveillance Program indicates occasional presence of explosives and trace levels of depleted uranium. Because the spring issues from the canyon floor, it is uncertain whether these contaminants are being transported by groundwater or if they are being mobilized from sediments in the canyon. Ancho Spring is downgradient of explosives testing sites. Spring sampling is covered in a separate part of the monitoring plan.
Contaminants	Potential Sources	Firing sites and underground testing sites at TA-49 and TA-39.
	Type	HE, radionuclides, metals.
	Quality	N/A
	Quality	N/A
	Depth/ Thickness	Not applicable.
	Quality	Not applicable
	Depth/ Thickness	Not applicable.
	Quality	Not applicable.

Table A-10 Chaquehui Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Description
Surface Water	Flow	Chaquehui Canyon heads on the Pajarito Plateau and contains an ephemeral stream in its upper portion. About 0.5 mi above the Rio Grande, Doe Spring, a regional aquifer spring, maintains a short perennial reach. Farther down the drainage, Springs 9 and 9A maintain perennial flow that extends 0.25 mi to the Rio Grande. Gaging stations in Chaquehui Canyon include Chaquehui at TA-33 and Chaquehui tributary at TA-33. No flow data were available in 2002. The gaging stations have insufficient data to establish flow-rating curves.
	Quality	No constituents exceed regulatory standards.
Springs	Name	Springs issue from basalts near the Rio Grande in the area of Chaquehui Canyon (Springs 8A, 9, 9A, 9B, and Doe). These springs are located 130–200 ft above the Rio Grande, and they may represent discharge points for intermediate depth perched water bodies. Alternatively, these springs may represent discharge from the regional aquifer in White Rock Canyon. Spring sampling is covered in the White Rock Canyon spring portion of the Interim Plan.
	Quality	No particular contamination has been found in these springs. Spring sampling is covered in the White Rock Canyon spring portion of this plan.
Alluvial Groundwater	Extent	Little is known about the presence of alluvial groundwater in Chaquehui Canyon. Much of Chaquehui Canyon is unlikely to contain perched alluvial groundwater because most of its course forms a steep narrow drainage through basalts that are swept free of alluvium by runoff. Purtymun reported that there was water perched locally in the alluvium but provided no basis for this statement. Purtymun probably refers to alluvium downstream of Doe Spring and Springs 9 and 9A.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable
Intermediate Groundwater	Extent/ Hydrology	No intermediate groundwater is known in Chaquehui Canyon; however there has been no drilling in the area.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable.

Table A-10 (continued)

Conceptual Model Element	Characteristic	Description
Regional Aquifer	Depth/ Hydrology	Characterization well R-31 in TA-39 (Ancho Canyon) found the regional aquifer at about 530 ft within the Cerros del Rio basalt, the underlying Puye Fanglomerate, and "Totavi" gravels.
	Quality	Post-drilling water quality sampling has not been completed at R-31.

Table A-10 (continued)

Conceptual Model Element	Characteristic	Description
Contaminants	Potential Sources	TA-33 was used as a firing site and for production of tritium. PRSs include landfills, septic systems, and burn areas.
	Type	Tritium

Table A-11
Frijoles Canyon Watershed Conceptual Model

Conceptual Model Element	Characteristic	Description
Surface Water	Flow	Frijoles Canyon lies south of Laboratory land and heads within the Sierra de los Valles. Rito de los Frijoles is a perennial stream that originates in the upper canyon and extends to the Rio Grande. The stream originates from springs in upper Frijoles Canyon. A gaging station in Frijoles Canyon is Rito de los Frijoles at Bandelier. In 2002 there were 365 days with flow, a total volume of 439 acre-feet, and a maximum flow of 19 cfs.
	Quality	No constituents exceed regulatory standards. The Laboratory has monitored surface water quality at two locations for several decades, one near the Bandelier National Monument headquarters, and one just above the Rio Grande. In general, sampling shows no Laboratory-derived contamination in Rito de los Frijoles. The National Park Service has monitored surface water quality extensively in Frijoles Canyon. Fecal coliform count and other constituents related to septic systems are a major issue in surface water quality. Some hints of HE compounds were found in samples in upper Frijoles Canyon in the late 1990s but these results have not been repeated.
Springs	Name	One regional aquifer spring, Spring 10, discharges at the edge of the Rio Grande south of Frijoles stream. The spring has a very low discharge and is difficult to sample separately from river water.
	Quality	Spring 10 chemistry has not shown any LANL impact. No constituents exceed regulatory standards.
Alluvial Groundwater	Extent	No wells have been drilled into the alluvium in Frijoles Canyon. Purtymun and Adams note that the alluvium is probably thin, on the order of 6 m or less. The presence of perennial surface flow suggests a large extent of alluvial saturation.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable.
Intermediate Groundwater	Extent/ Hydrology	No intermediate groundwater is known to exist in the area of Frijoles Canyon, however no wells have been drilled.
	Depth/ Thickness	Not applicable.
	Quality	Not applicable.

Table A-11 (continued)

Conceptual Model Element	Characteristic	Description
Regional Aquifer	Depth/Hydrolog y	No regional aquifer wells are located in Bandelier National Monument. The nearest wells are in Ancho Canyon and are described in that part of the plan.
	Quality	No regional aquifer wells are located in Bandelier National Monument. The nearest wells are in Ancho Canyon and are described in that part of the plan.
Contaminants	Potential Sources	Septic systems at Bandelier National Monument
	Type	Fecal coliform.

REFERENCES

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