LMS/SHP/S06815

Annual Performance Report April 2009 Through March 2010 for the Shiprock, New Mexico, Site

December 2010

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Abbreviations

cfs	cubic feet per second
COCs	contaminants of concern
DOE	U.S. Department of Energy
DVP	Data Validation Package
EPA	U.S. Environmental Protection Agency
ft	feet
GCAP	Groundwater Compliance Action Plan
gpm	gallons per minute
kg	kilogram
lb	pounds
MCL	maximum concentration limit
mg/L	milligrams per liter
N	Nitrogen
NH_3	Ammonia
SDWA	Safe Drinking Water Act
SOARS	System Operation and Analysis at Remote Sites
SOWP	Site Observational Work Plan
UMTRCA	Uranium Mill Tailings Radiation Control Act
USGS	U.S. Geological Survey
VSP	Visual Sampling Plan

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1.0 Introduction

This report evaluates the performance of the groundwater remediation system at the Shiprock, New Mexico, Disposal and Processing Site for the period April 2009 through March 2010. The Shiprock site, a former uranium-ore processing facility under the Uranium Mill Tailings Radiation Control Act (UMTRCA), is managed by the U.S. Department of Energy (DOE) Office of Legacy Management.

The mill operated from 1954 to 1968; mill tailings were contained in an engineered disposal cell in 1986. As a result of milling operations, groundwater in the mill site area was contaminated with uranium, nitrate, sulfate, and associated constituents. In March 2003, DOE initiated active remediation of the groundwater using extraction wells and interceptor drains. At that time, a baseline performance report was developed (DOE 2003). That report established specific performance standards for the Shiprock groundwater remediation system and documented the site conditions that form the basis for comparisons drawn herein.

The Shiprock site is divided into two distinct areas, the floodplain and the terrace; an escarpment forms the boundary between the two areas. The floodplain remediation system consists of two groundwater extraction wells, a seep collection drain, and two collection trenches (Trench 1 and Trench 2). The terrace remediation system consists of nine groundwater extraction wells, two collection drains (Bob Lee Wash and Many Devils Wash), and a terrace drainage channel diversion structure. All extracted groundwater is pumped into a lined evaporation pond on the terrace. Figure 1–1 shows the site layout and the major components of the floodplain and terrace groundwater remediation systems. Figure 1–2 shows the locations of monitoring wells and surface water sampling locations at the site.

A detailed description of the Shiprock site conditions is presented in the Site Observational Work Plan (SOWP) (DOE 2000), and the compliance strategy is presented in the Groundwater Compliance Action Plan (GCAP) (DOE 2002). Since these initial reports were developed, DOE has undertaken additional evaluations, including the *Refinement of Conceptual Model and Recommendations for Improving Remediation Efficiency at the Shiprock, New Mexico, Site* (DOE 2005), and the more recent evaluation of the Trench 2 groundwater remediation system (DOE 2009b). DOE recently issued a midterm evaluation of the remediation strategy for both the floodplain and the terrace (DOE 2010a).

1.1 Remediation System Performance Standards

This performance assessment is based on an analysis of groundwater quality and groundwater level data obtained from site monitoring wells in addition to groundwater flow rates associated with the extraction wells, drains, and seeps. Specific performance standards established for the Shiprock floodplain groundwater remediation system in the Baseline Performance Report (DOE 2003) are summarized as follows:

- Groundwater flow directions in the vicinity of the extraction wells should be toward the extraction wells.
- Pumping on the floodplain should intercept contaminants of concern (COCs) that would otherwise discharge to the San Juan River.

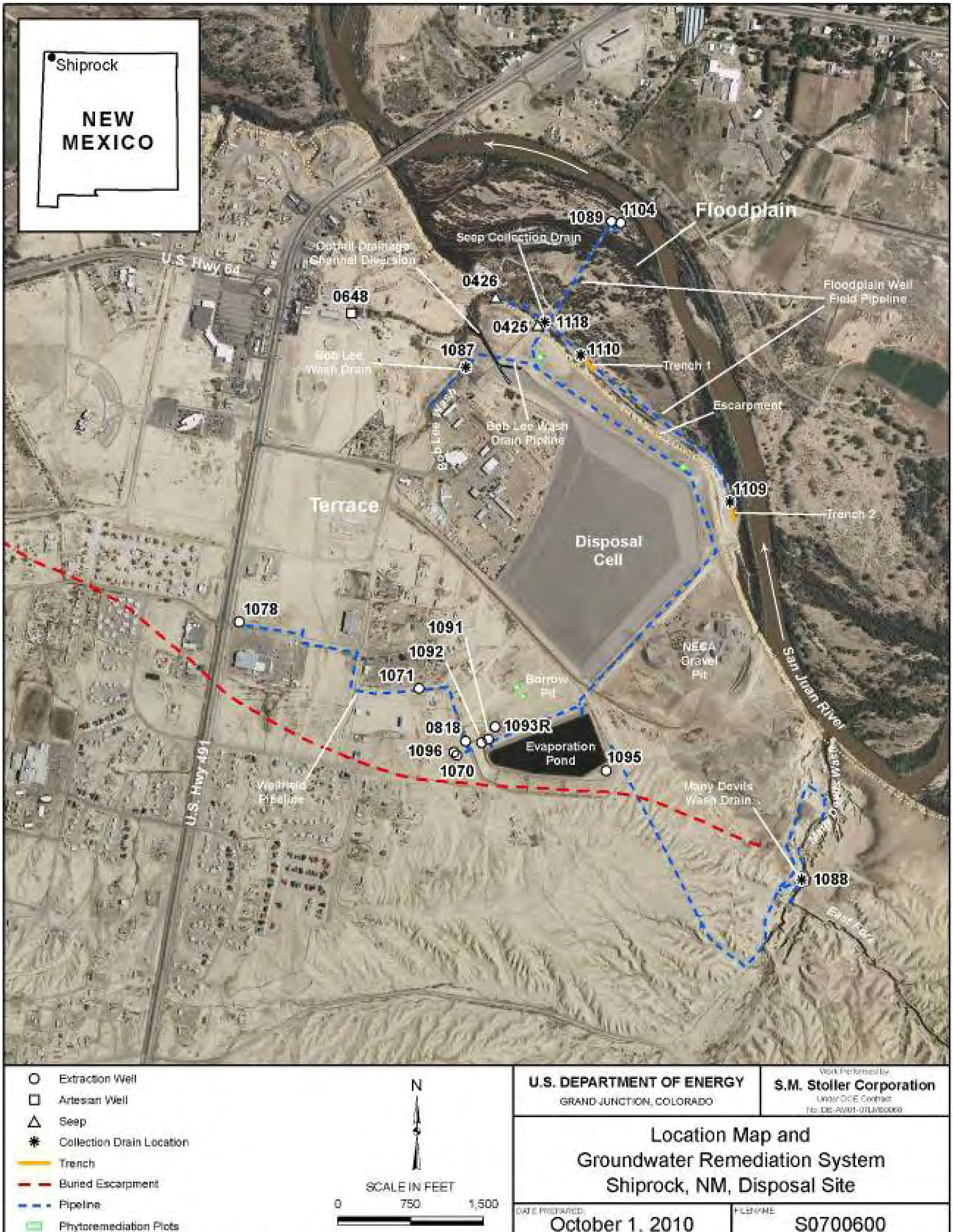

Figure 1–1. Location Map and Groundwater Remediation System

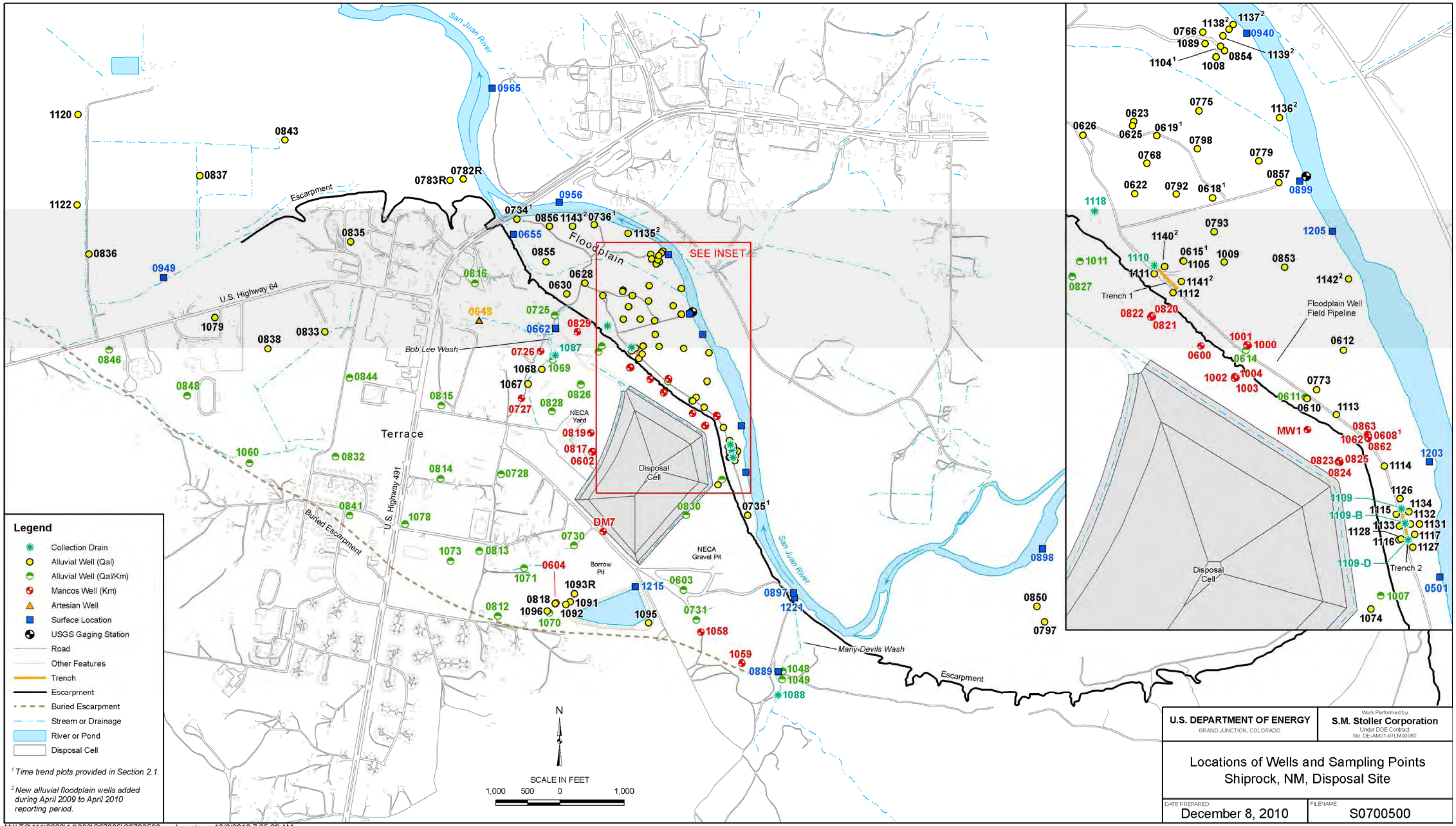

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Figure 1–2. Locations of Wells and Sampling Points at the Shiprock Site

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Performance standards established for the terrace groundwater remediation system in the 2003 baseline report (DOE 2003) are:

- Terrace groundwater surface elevations should decrease as water is removed from the terrace system.
- The volume of water discharging to the interceptor drains located in Bob Lee Wash and Many Devils Wash should decrease over time as groundwater levels on the terrace decline.
- The flow rates of seeps located at the escarpment face (locations 0425 and 0426) should decrease over time as groundwater levels on the terrace decline.

1.2 Contaminants of Concern (COCs) and Remediation Goals

The COCs for both the floodplain and terrace, defined in the GCAP (DOE 2002) are ammonia (total as nitrogen); manganese; nitrate (nitrate + nitrite as nitrogen); selenium; strontium; sulfate; and uranium. These constituents are listed in Table 1–1 along with respective UMTRCA standards and, for comparison, corresponding floodplain background data. Background data are available only for the floodplain because, even after years of investigation and reconnaissance, groundwater reflective of background conditions has not been encountered in terrace areas near the disposal cell.

Table 1–1. Groundwater COCs for the Shiprock Site

Contaminant	40 CFR 192 MCL	SOWP Floodplain Background Value	Historical Range in Floodplain Background[a] (Mean)	Comment
Ammonia, as N (mg/L)	NA	0.045	Not detected (≤0.1)	
Manganese (mg/L)	NA	1.24	0.001–7.2 (1.3)	Maximum background level of 7.2 mg/L measured in March 2006 (well 0797).
Nitrate[b] (mg/L)	10	0.12	0.004–3.3 (0.16)	
Selenium (mg/L)	0.01	<0.001	0.0001–0.018 (0.001)	EPA Safe Drinking Water Act (SDWA) MCL standard is 0.05 mg/L.
Strontium (mg/L)	NA	2.3	1.0–10 (3.0)	Background maximum (10 mg/L) measured in September 2008 (well 0797). EPA risk-based value is 22 mg/L (see discussion at the conclusion of Section 1.2).
Sulfate (mg/L)	NA	1432	427–5200 (1983)	Because sulfate levels have historically been elevated in terrace artesian well 0648 (1870−2340 mg/L), the GCAP proposed an alternate cleanup goal of 2000 mg/L (DOE 2002).
Uranium[c] (mg/L)	0.044	0.007	0.004–0.12 (0.03)	In recent years, levels in both background wells, although variable, have been increasing slightly and have approached or exceeded the 0.044 mg/L standard.

[a] Floodplain background wells 0797 and 0850 (locations shown in Figure 1–2; also see Figure 2–10)
[b] Nitrate + nitrite as nitrogen (N)
[c] Equivalent to 30 picocuries per liter (pCi/L) U-234 + U-238, assuming secular equilibrium
40 CFR 192 = Title 40 *Code of Federal Regulations* Part 192; EPA = U.S. Environmental Protection Agency; MCL = Maximum concentration limit (applies to 40 CFR 192) or maximum contaminant level (EPA SDWA)
mg/L = milligrams per liter
NA = Not applicable (contaminant does not have an MCL in 40 CFR 192)

The compliance standards for uranium and nitrate in the floodplain are their respective 40 CFR 192 standards of 0.044 milligram per liter (mg/L) and 10 mg/L. A secondary standard of 250 mg/L for sulfate has been established under the U.S. Environmental Protection Agency (EPA) Safe Drinking Water Act (SDWA).[1] However, sulfate concentrations in floodplain background wells 0797 and 0850 have consistently been above this standard (427–5200 mg/L). Because sulfate levels have also been elevated in groundwater entering the floodplain from flowing artesian well 0648 (up to 2340 mg/L), the GCAP proposed an alternate cleanup goal for sulfate of 2000 mg/L (DOE 2002). This alternate goal is conservative given the elevated levels in floodplain background wells.

Relatively high selenium concentrations in the floodplain (originating on the terrace) make it unlikely that the 40 CFR 192 standard of 0.01 mg/L for this constituent can be met while contaminated water from the terrace is still providing a source.[2] Therefore, DOE has proposed an interim alternate concentration limit for selenium of 0.05 mg/L (DOE 2002), which is the EPA maximum contaminant level for drinking water.

Previous reports (e.g., DOE 2009a) have cited a cleanup objective for manganese based on the maximum background concentration for the floodplain. This level is currently 7.2 mg/L, the historical maximum measurement in well 0797 in March 2006.[3] The maximum background concentration of strontium was also detected in well 0797: 10 mg/L in September 2008. A cleanup standard has not been established for ammonia (EPA has not developed any toxicity values upon which to base an associated risk-based standard), and levels measured in background wells have been low (≤0.1 mg/L).

Regulatory standards are also not available for strontium, a constituent typically not associated with uranium milling sites. Strontium was selected as a COC based on the Baseline Risk Assessment (DOE 1994); it was selected primarily because of concentrations measured in sediment (rather than groundwater) and a conservatively modeled agricultural uptake scenario. The form present at the Shiprock site is stable (nonradioactive) strontium, a naturally occurring element, and is distinguished from the radioactive and much more toxic isotope strontium-90, a nuclear fission product (ATSDR 2004). EPA has developed a risk-based screening level for stable strontium in groundwater of 22 mg/L (assuming groundwater is used for drinking water). As discussed later in this report, almost all historical groundwater results at Shiprock have been less than this risk-based value.[4]

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[1] Studies conducted by the Centers for Disease Control in conjunction with EPA have shown that no adverse effects from sulfate ingestion occur at concentrations of up to 1,200 mg/L (EPA 1999). The report notes that other studies have shown that concentrations of sulfate exceeding 2,000 mg/L may have little or no adverse effect on humans and animals.

[2] As acknowledged in the recently issued *Review and Evaluation of the Shiprock Remediation Strategy* (DOE 2010a), although concentrations are clearly elevated in some areas at the site, the extent to which selenium is attributable to former milling processes rather than natural sources is not clear. Selenium concentrations are highest in distal areas (e.g., the paleochannel south of the site and in Many Devils Wash; see Figures 1–6a and 1–6b) and evidence suggests that selenium could have been leached from the Mancos Shale or soils derived from the shale.

[3] At the time the GCAP (DOE 2002) was developed, the maximum background value for manganese was 2.7 mg/L; this 2009–2010 updated annual report reflects the most updated historical background range.

[4] http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/Generic_Tables/index.htm. Last revision May 2010; accessed October 27, 2010.

1.3 Hydrogeological Setting

This section presents a brief summary of the floodplain and terrace groundwater systems. More detailed descriptions are provided in the SOWP (DOE 2000), the refinement of the site conceptual model (DOE 2005), and the recent Trench 2 evaluation (DOE 2009b).

1.3.1 Floodplain Alluvial Aquifer

The thick Mancos Shale of Cretaceous age forms the bedrock underlying the entire site. A floodplain alluvial aquifer occurs in unconsolidated medium- to coarse-grained sand, gravel, and cobbles that were deposited in former channels of the San Juan River above the Mancos Shale. The floodplain aquifer is hydraulically connected to the San Juan River; the river is a source of groundwater recharge to the floodplain aquifer in some areas, and it receives groundwater discharge in other areas. In addition, the floodplain aquifer receives some inflow from groundwater in the terrace area. The floodplain alluvium is up to 20 feet (ft) thick and overlies Mancos Shale, which is typically soft and weathered for the first several feet below the alluvium.

As discussed in the following section, most groundwater contamination in the floodplain lies close to the escarpment east and north of the disposal cell. This plume configuration is best characterized by elevated concentrations of sulfate and uranium. Contamination does not occur along the escarpment base in the northwest part of the floodplain because relatively uncontaminated surface water from Bob Lee Wash discharges to the floodplain, recharging local groundwater and then flowing to the north and west. Surface water in Bob Lee Wash originates primarily as deep groundwater from the Morrison Formation that flows to the land surface via artesian well 0648. Well 0648 flows at approximately 65 gallons per minute (gpm) and drains eastward into lower Bob Lee Wash. Background groundwater quality in the floodplain aquifer is defined by monitoring wells 0797 and 0850 installed in the floodplain approximately 1 mile upriver from the site.

1.3.2 Terrace Groundwater System

The terrace groundwater system occurs partly in unconsolidated alluvium in the form of medium- to coarse-grained sand, gravel, and cobbles deposited in the floodplain of the ancestral San Juan River. Terrace alluvial material is Quaternary in age; it varies from 0 to 20 ft in thickness and caps the Mancos Shale. Though less well mapped, some terrace groundwater also occurs in weathered Mancos Shale underlying the alluvium. The Mancos Shale is exposed in the escarpment adjacent to the San Juan River floodplain.

The terrace groundwater system extends southwestward from the escarpment separating the terrace from the floodplain for up to about 1 mile, where it is bounded by a buried escarpment. Terrace alluvial material is exposed at the terrace–floodplain escarpment, but to the southwest, it is covered by an increasing thickness of eolian silt, or loess. At the southwest edge of the terrace aquifer, along the base of the buried escarpment, up to 40 ft of loess overlies the alluvium; the alluvium in this area consists of coarse ancestral San Juan River deposits.

Mancos Shale in the terrace area is weathered several feet below its contact with the alluvium. Groundwater is known to occur in the weathered shale and, in some areas, appears to flow through deeper portions of the shale, within fractures and along bedding surfaces.

1.4 Contaminant Distributions

This section provides an overview of sitewide contaminant distributions. The floodplain remedial strategy focuses on reduction of COC concentrations and decreased contaminant mass discharging to the San Juan River. Therefore, subsequent discussions of contaminant distributions and temporal trends focus primarily on floodplain wells. Contamination trends on the terrace receive less focus in this annual report because the compliance strategy is based on hydrologic control—active remediation to reduce groundwater elevations, with the ultimate goal of eliminating potential exposure pathways (e.g., in seeps and washes). Therefore, concentration-driven performance standards for the terrace system have not been developed. However, as a best management practice, contaminant concentrations are measured at each extraction well, drain, and seep.

Whereas Section 2 (Section 2.1.2 in particular) focuses primarily on temporal trends for floodplain wells, this section presents a snapshot of current conditions and a comparison of that snapshot with baseline (pre-remediation) conditions.

1.4.1 Data Presentation and Visualization

Concentrations of COCs in terrace and floodplain groundwater, based on results of the most recent sampling event (September 2009 or March 2010), are shown in Figures 1–3 through 1–9. Detailed information and supporting quality assurance documentation is provided in the corresponding Data Validation Package (DVP) reports (DOE 2009c, DOE 2010b).

In Figures 1–3 through 1–9, each figure is presented as a pair (e.g., Figures 1–3a and 1–3b). Figures with an "a" suffix plot contaminant concentrations using graduated symbols defined for discrete categories. Categories (or interval classes) are based on defined increments above or below a regulatory criterion (e.g., 40 CFR 192 MCLs, if available), the floodplain background data listed in Table 1–1, and/or the sitewide contaminant distribution.[5] Companion figures (with a "b" suffix) plot the same data, but in an alternate form, using bar charts that reflect the actual (continuous vs. discrete) distribution of the data, overlying an aerial photograph. In these "b" series figures, each bar denotes the COC magnitude at a given location relative to the maximum detected concentration at the site for all sample types (e.g., alluvial well, Mancos well, surface water location, or treatment system sump locations).[6] The latter (bar chart) data visualization method is provided to facilitate identification of "hot spots" and, more importantly, to better depict the overall distribution of contaminants across the site (and across media).

Figures 1–5a and 1–5b, which plot nitrate concentrations, provide a good example of the two (spot plot vs. bar chart) data presentation methods. In Figure 1–5a, it is apparent that nitrate

[5] In some cases, distinctions between groupings are subtle and not significant. For example, in Figure 1–7a, the red symbols denote any strontium measurement exceeding the historical background maximum of 10 mg/L. However, in some areas (e.g., the area between the evaporation pond and Many Devils Wash), there is very little variability in the data despite differences in symbols (<10 mg/L vs. >10 mg/L), and no indication of contaminant levels significantly above the historical background range.

[6] Data values are not labeled in the "b" series figures because the purpose of these figures is to show the relative magnitude and overall distribution of contaminants rather than specific values. Although bar charts are considered a useful data visualization tool, for some adjacent or colocated data points (e.g., Mancos wells 0602 and 0817, located west of the disposal cell), if one datum (0817) is elevated, its neighbor (0602) may be obscured. In these cases, the reader is referred to the "a" version of the figure pair for clarification.

concentrations are elevated on the terrace in the radon borrow pit area in the paleochannel near the buried escarpment, in Many Devils Wash, and on the floodplain at the base of the escarpment and in the well 1089 area. But only by reviewing Figure 1–5b is it apparent how nitrate concentrations at most site locations (including the disposal cell area) pale in comparison to those measured in the radon borrow pit and paleochannel area. Also, nitrate concentrations in Many Devils Wash are higher than most on the floodplain.

Figure 1–10, a side-by-side comparison of relative contaminant distributions for the primary COCs, represents a compendium of the individual "b" series figures discussed above. Based on the detailed statistical summary provided in Appendix A, Figure 1–11 plots corresponding historical distributions of each COC shown in Figure 1–10 for floodplain wells. Strontium is not plotted in either of these figures because of its uniform distribution (i.e., no spatial variation; see Figures 1–7a and 1–7b).] Whereas Figure 1–10 represents the most recent "snapshot" for all terrace wells, the plots in Figure 1–11 reflect all historical measurements: the longer the box, the more historical variation. Alternatively, tight boxes indicate stable levels (i.e., little variation) and/or a small number of samples (e.g., in the case of the new floodplain wells).

Appendix A, the detailed basis for the summary plot in Figure 1–11, presents a sampling summary and descriptive statistics for site COCs in all floodplain monitoring wells. In this appendix, box plots (also called box-and-whisker plots) are used as a data visualization tool to show the historical distribution of COCs in all floodplain wells, organized by area, where area groupings are based on the categorizations defined in Table A–1 and Figure A–1. Detailed summary statistics are also provided.

As a final data visualization method, Figures 1–12 through 1–18 plot changes in the extent of the floodplain and terrace contaminant plumes and present interpolated data for wells sampled between 2000 and 2003 (representing baseline conditions) and the most recent result for this evaluation period (September 2009 or March 2010).[7] Because these interpolations consist of predicting concentrations of COCs at an unsampled site based on measurements made at the closest surrounding sites, these figures are most useful for examining changes in plume extent for floodplain monitoring wells, given the density of wells in this area. Interpolations for west terrace areas and/or areas where well density is sparse should be reviewed with some caution (and also noting actual data values).

1.4.2 Overview of Findings

As shown in Figure 1–2, the Shiprock well network is dense. For this reporting period, 118 monitoring wells were sampled (62 on the floodplain and 56 on the terrace). Surface water locations (e.g., at seeps and the San Juan River) are also routinely sampled. Given the density of the site sampling network and the distinct COCs evaluated, it is difficult to capture the essence of contaminant distributions both spatially and temporally. However, based on the plots in Figures 1–3 through 1–18, several global trends are apparent.

[7] In previous annual performance reports (e.g., DOE 2008), March 2003 data (corresponding to the onset of active groundwater remediation) were used to generate contaminant plume maps representing baseline conditions. However, because fewer alluvial wells were sampled in 2003 than in 2000–2001, baseline plume maps were developed using the most recent 2000–2003 measurement to optimize the number of wells with a corresponding 2009–2010 measurement and thus comparability of the two (baseline and current) plume snapshots.

As discussed in the recently issued 2010 site remediation strategy review (DOE 2010a; see Section 5.1.4), DOE has considered initiating a pilot groundwater hot-spot remediation study at locations where concentrations of one or more contaminants are elevated. However, as is evident in the figures provided in this section, a factor that confounds such an evaluation is the fact that maximum concentrations of individual COCs do not occur in the same location. Figure 1–10 (the merged version of the bar chart figures) demonstrates the differences in spatial distributions of individual contaminants. For example, uranium is highest around the disposal cell and on the floodplain, at the base of the escarpment and in the Trench 1 and well 1089 areas (also see Figure 1–11). In terms of relative magnitude, uranium concentrations at the remainder of the site are much lower. Alternatively, nitrate, which is most concentrated in the radon cover borrow pit and paleochannel area, has a very different distribution. Nitrate, like sulfate and selenium, is also elevated in Many Devils Wash.

Sulfate, in general the most evenly distributed of site-related contaminants, is most elevated in Many Devils Wash. The inability to find representative background concentrations for the terrace (to date, candidate locations have been dry) further complicates interpretation of these findings. Like uranium, ammonia is highest in wells screened in the Mancos Shale just west of the disposal cell (0602 and 0817). However, ammonia (like manganese) is also elevated in the evaporation pond area. Manganese, which is at or near background concentrations across much of the site, is elevated in the evaporation pond area, and in some of these wells levels have increased (e.g., see Figure 1–13).

Selenium, on the other hand, is most elevated along the buried escarpment on the terrace and is present at much lower concentrations on the floodplain. As mentioned above, selenium levels are also elevated in Many Devils Wash, and the extent to which this is attributable to the site or naturally occurring conditions is the subject of a recently initiated evaluation.

The extent to which the differing distributions discussed above reflect prior milling practices, differences in contaminant chemistry and mobility, and/or influences from background are not clear at this time. To address these unknowns, DOE plans to conduct more targeted characterization to address key issues and site areas, such as Many Devils Wash. Therefore, the current interpretation is likely to continue to evolve as ongoing and planned studies yield additional data.

The plume maps in Figures 1–12 through 1–18 (comparing baseline and current snapshots) demonstrate the success of the floodplain remediation, in particular for the primary COCs (nitrate, sulfate, and uranium). In these figures, an arcuate plume extends northward from the contaminated area at the base of the disposal cell, crosses the floodplain and approaches the San Juan River near the floodplain extraction wells. This plume configuration is best characterized by elevated concentrations of sulfate and uranium. In general, contamination does not occur along the escarpment base in the northwest part of the floodplain (Figure 1–10). Additional discussion of floodplain contaminant trends is provided in Section 2.1.2, which presents time-concentration plots of COCs for a representative subset of floodplain wells.

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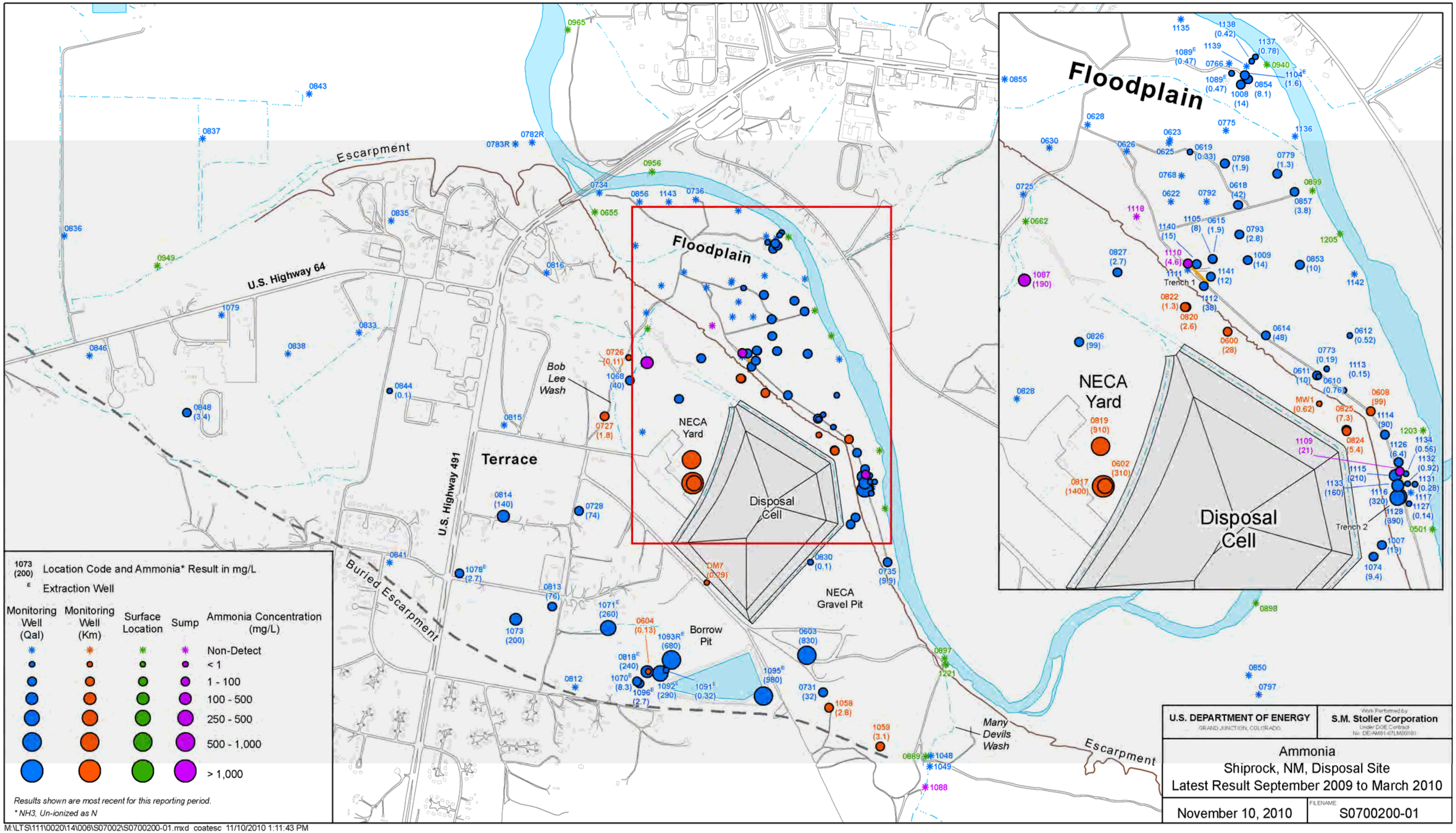

Figure 1–3a. Concentrations of Ammonia in Groundwater and Surface Water, September 2009–March 2010

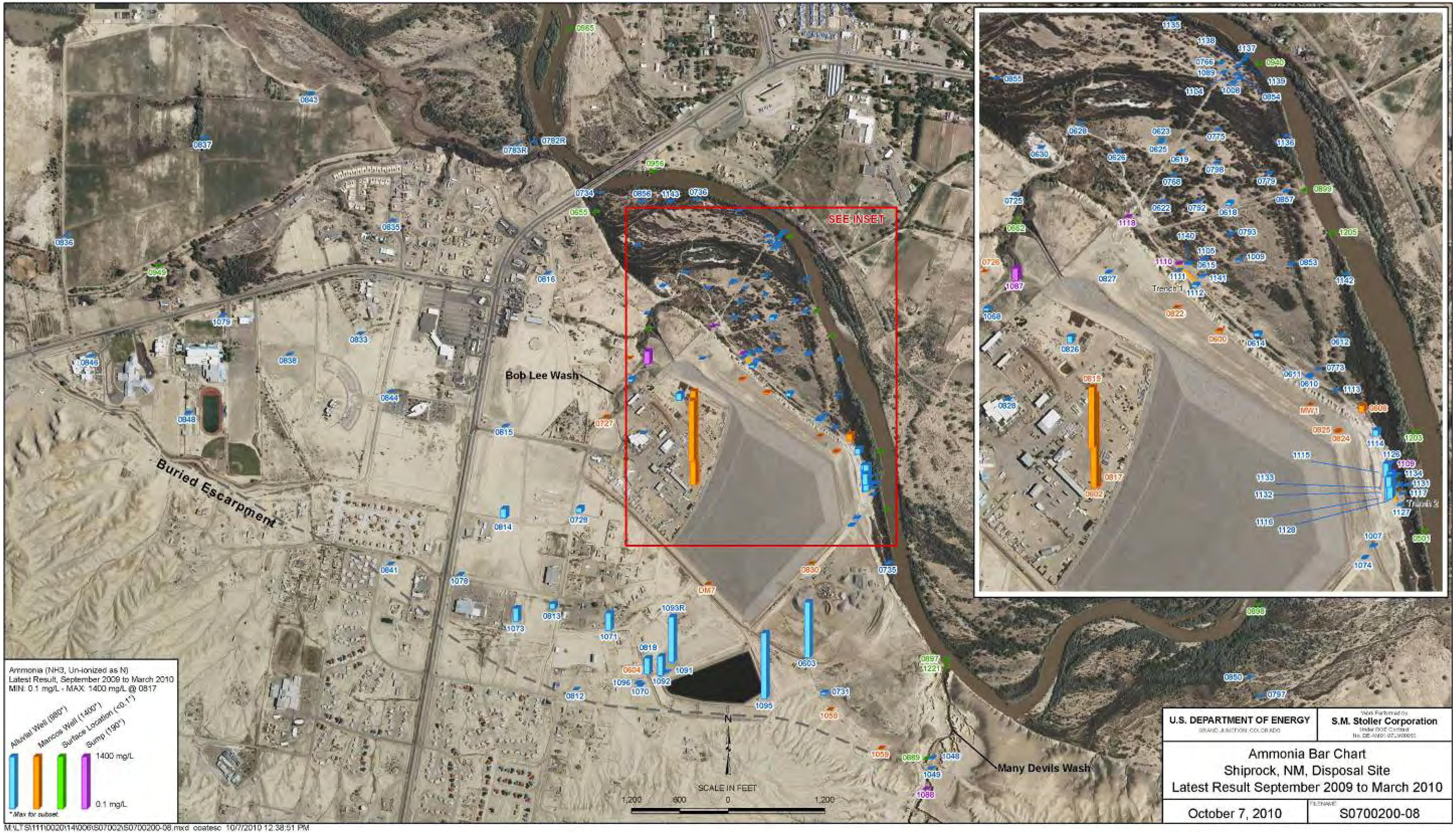

Figure 1−3b. Relative Distribution of Ammonia in Groundwater and Surface Water, September 2009–March 2010

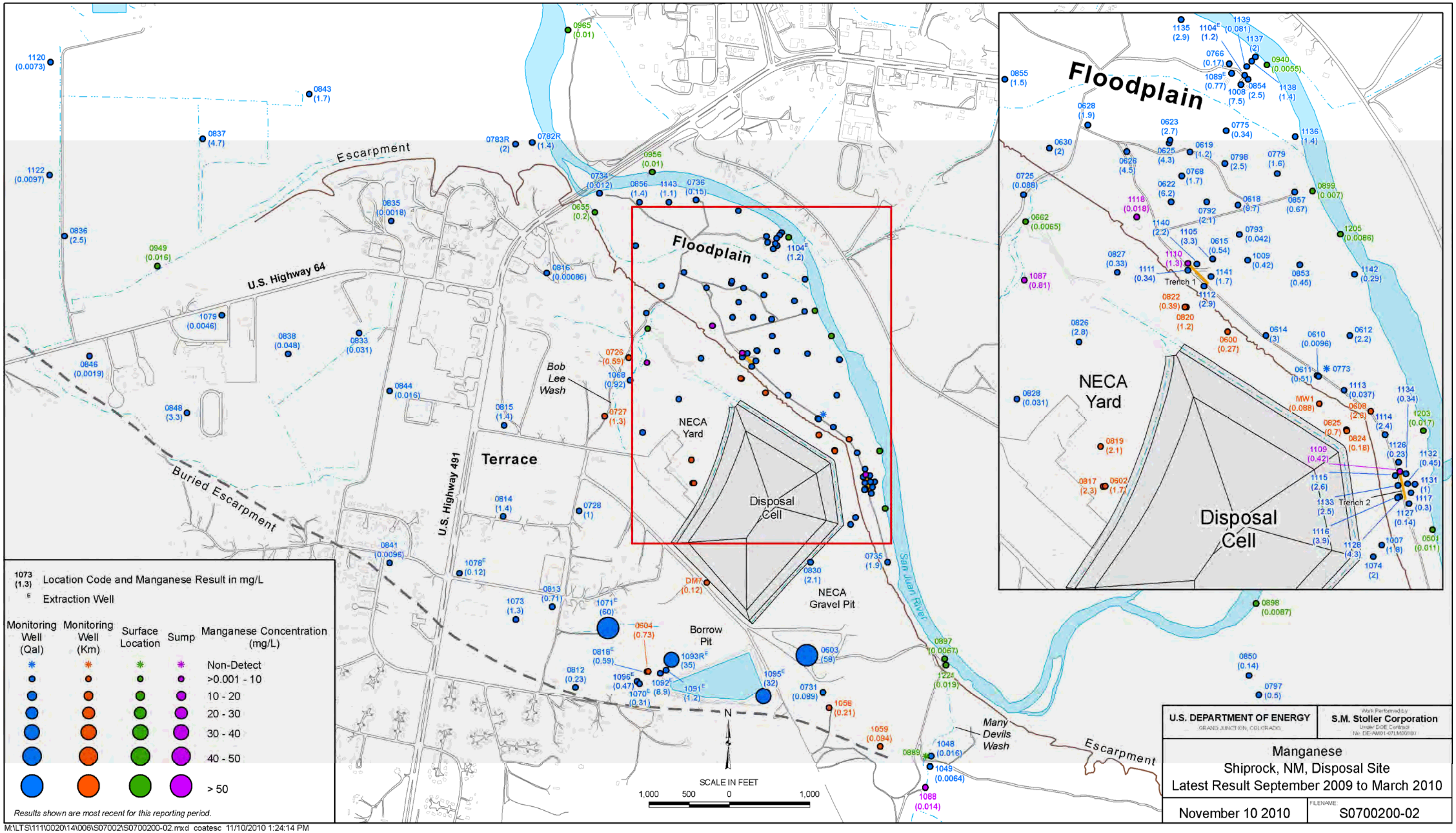

Figure 1–4a. Manganese Concentrations in Groundwater and Surface Water, September 2009–March 2010

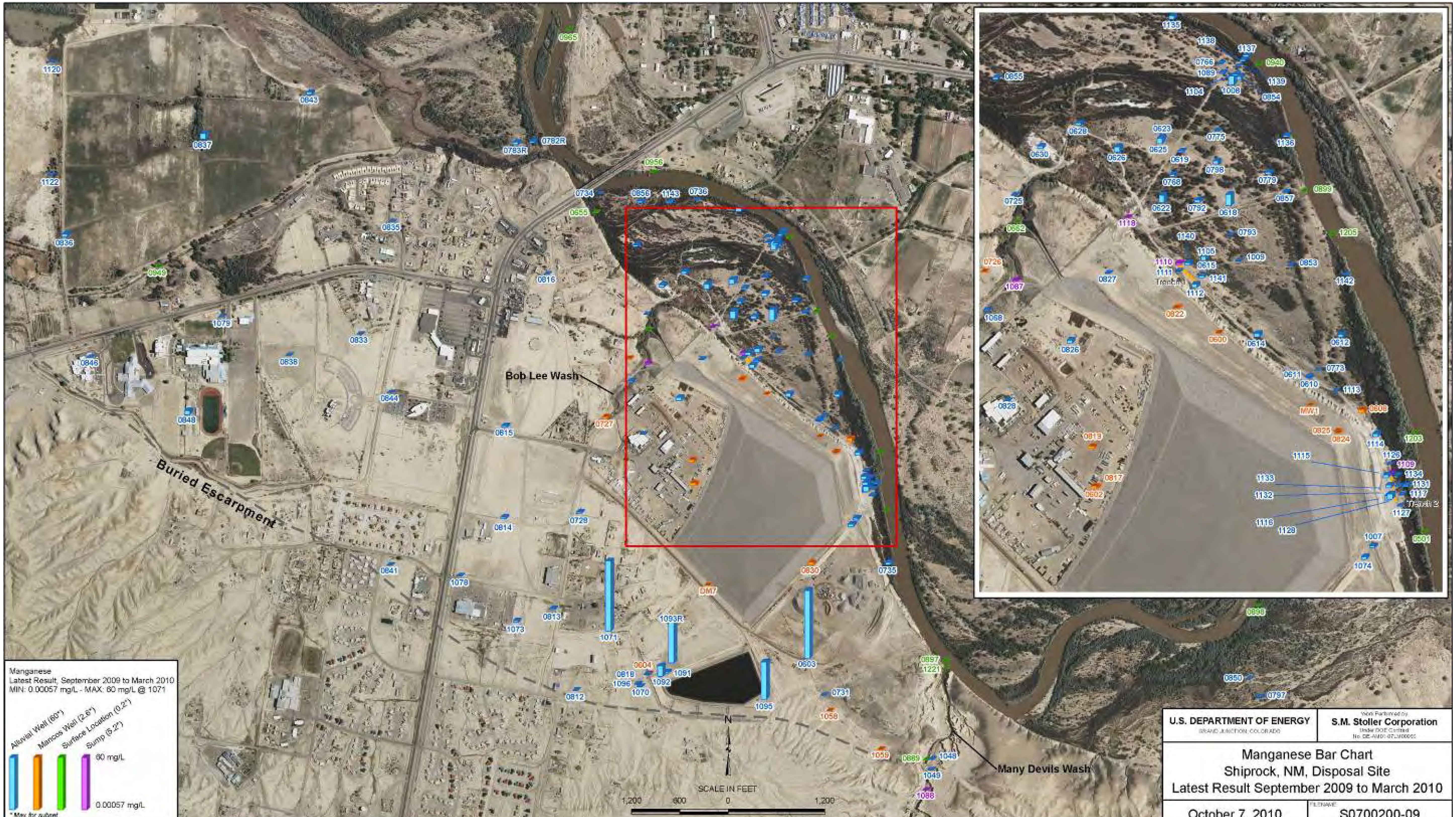

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Figure 1−4b. Relative Distribution of Manganese in Groundwater and Surface Water, September 2009–March 2010

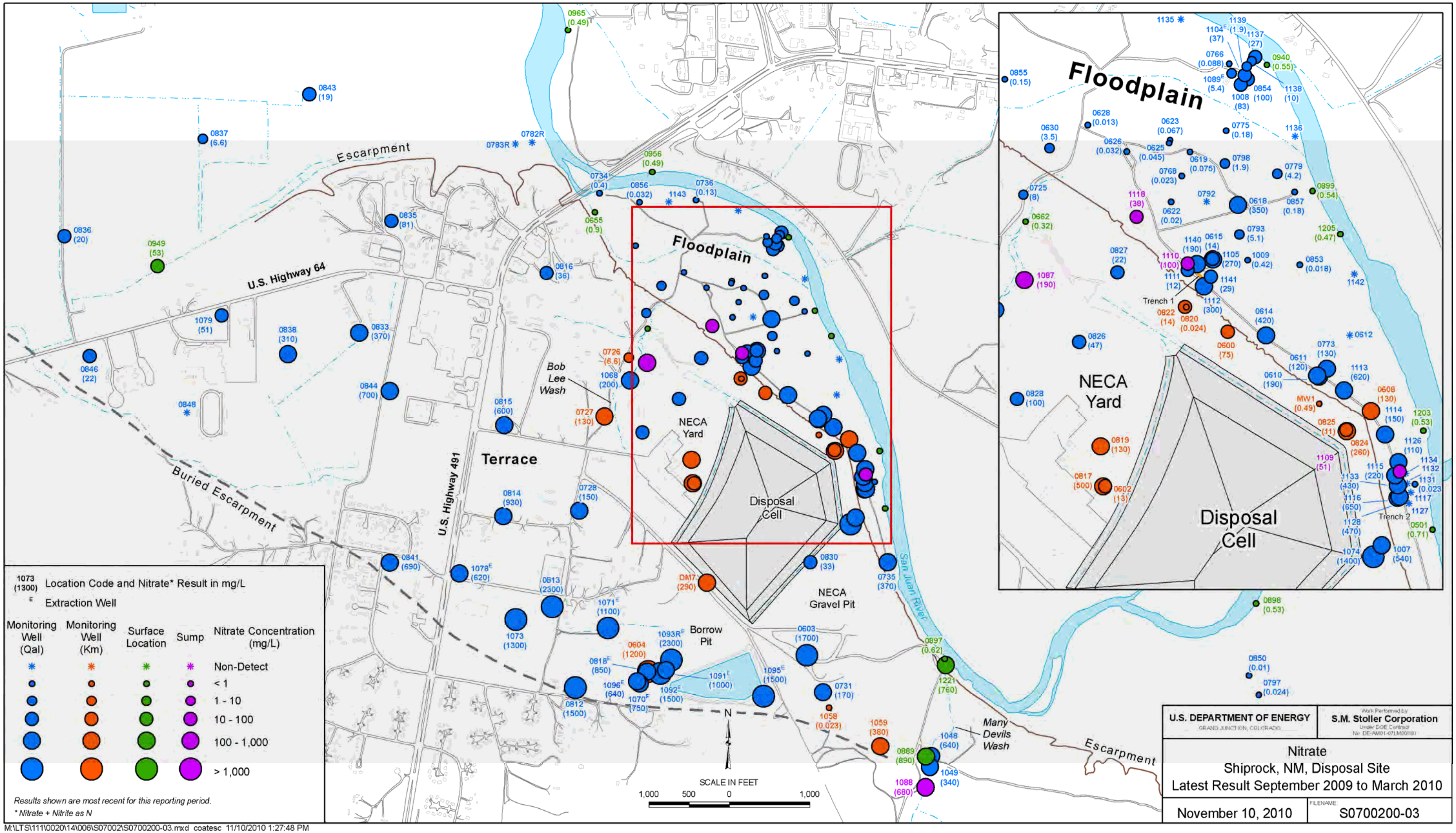

Figure 1–5a. Nitrate Concentrations in Groundwater and Surface Water, September 2009–March 2010

Figure 1−5b. Relative Distribution of Nitrate in Groundwater and Surface Water, September 2009–March 2010

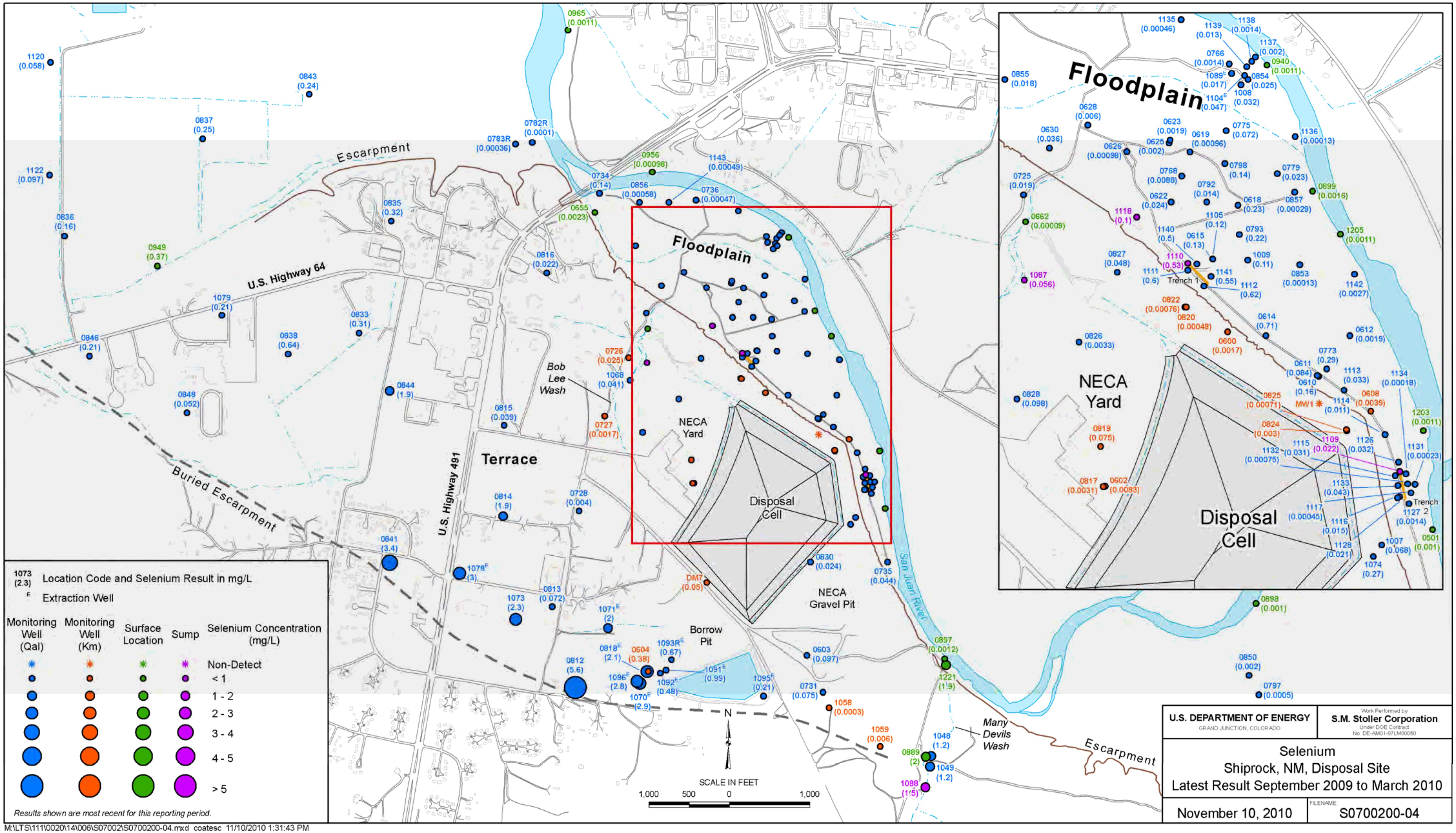

Figure 1–6a. Selenium Concentrations in Groundwater and Surface Water, September 2009–March 2010

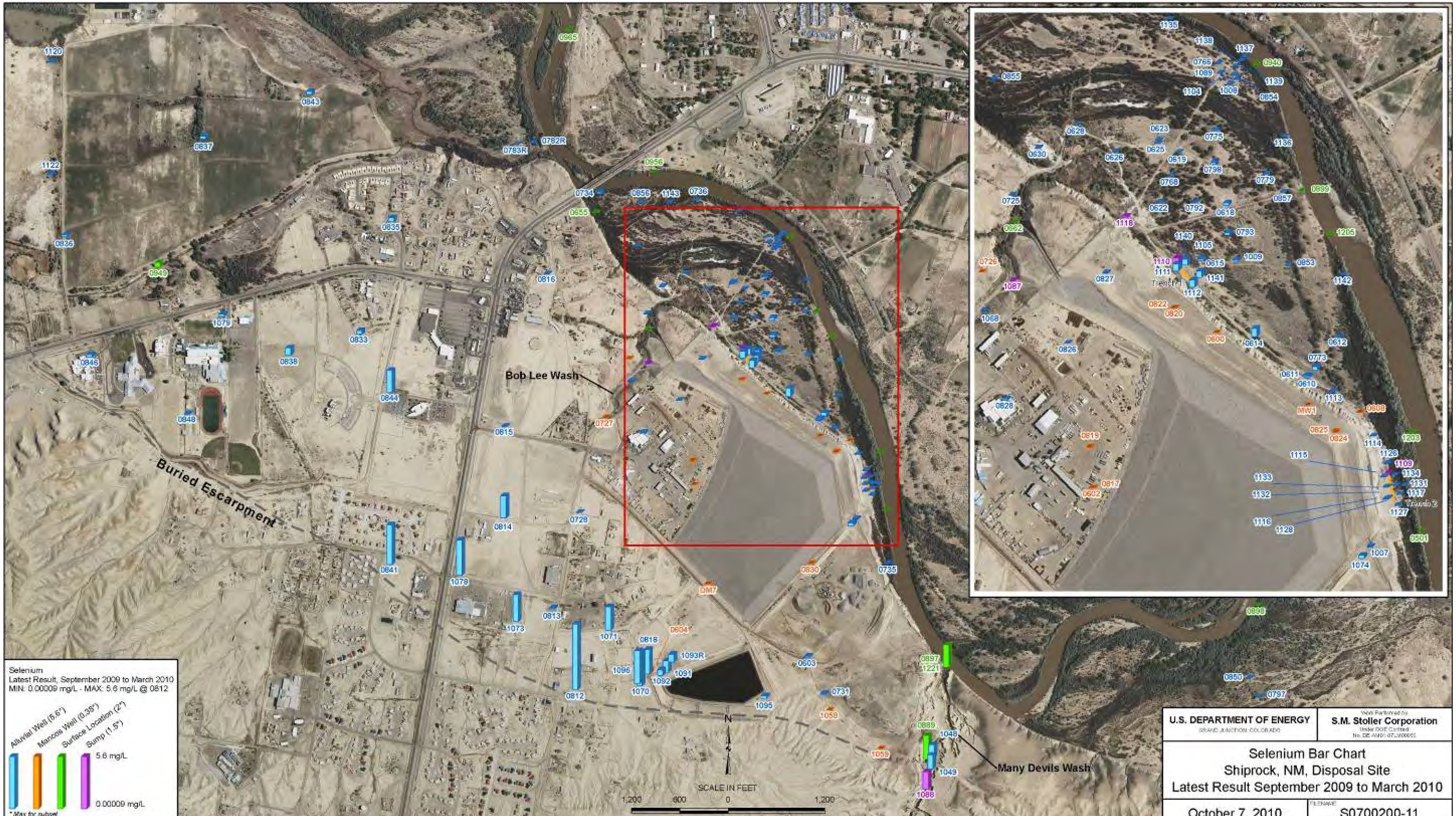

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Figure 1−6b. Relative Distribution of Selenium in Groundwater and Surface Water, September 2009–March 2010

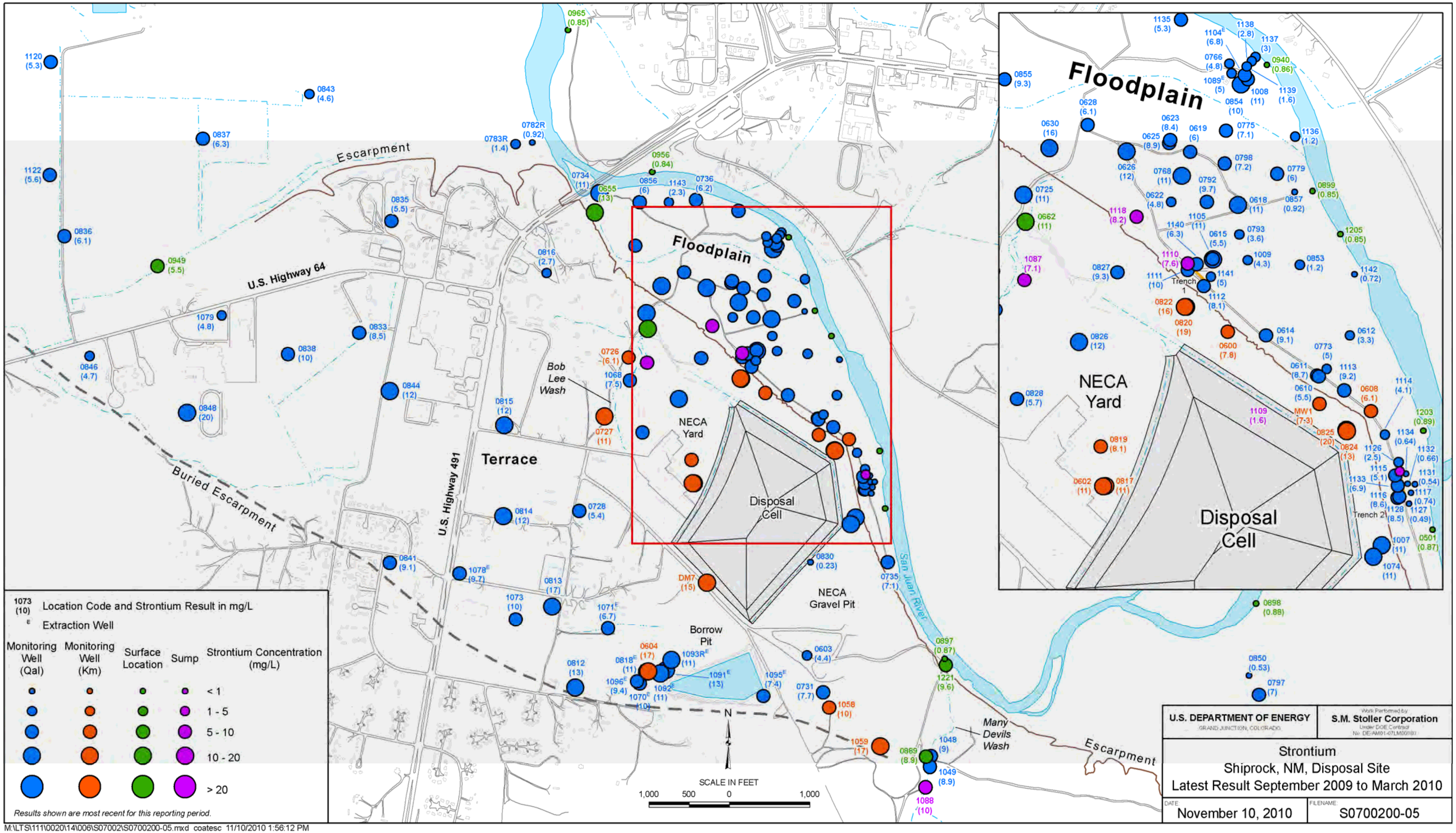

Figure 1–7a. Strontium Concentrations in Groundwater and Surface Water Samples, September 2009–March 2010

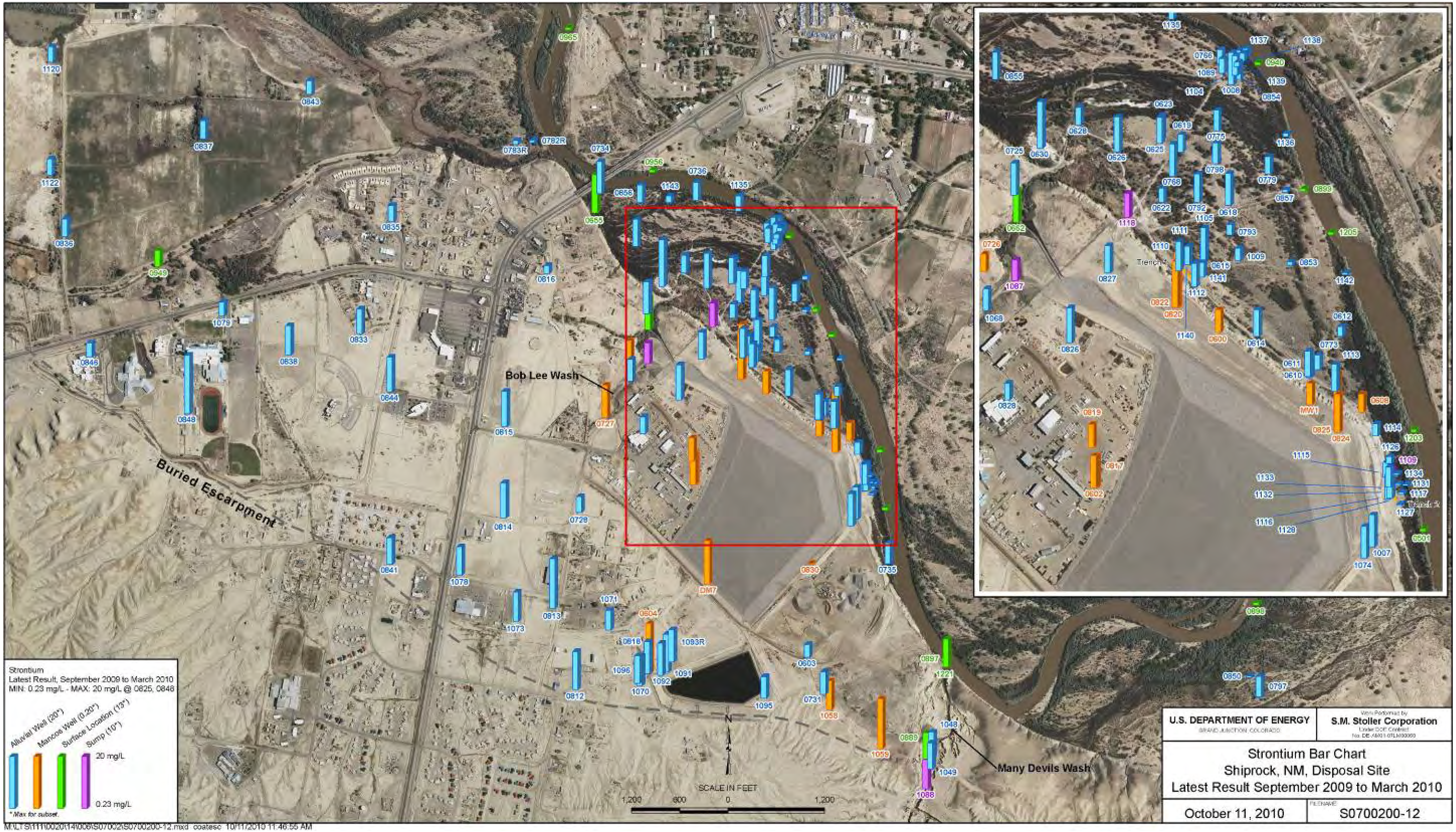

Figure 1−7b. Relative Distribution of Strontium in Groundwater and Surface Water Samples, September 2009–March 2010

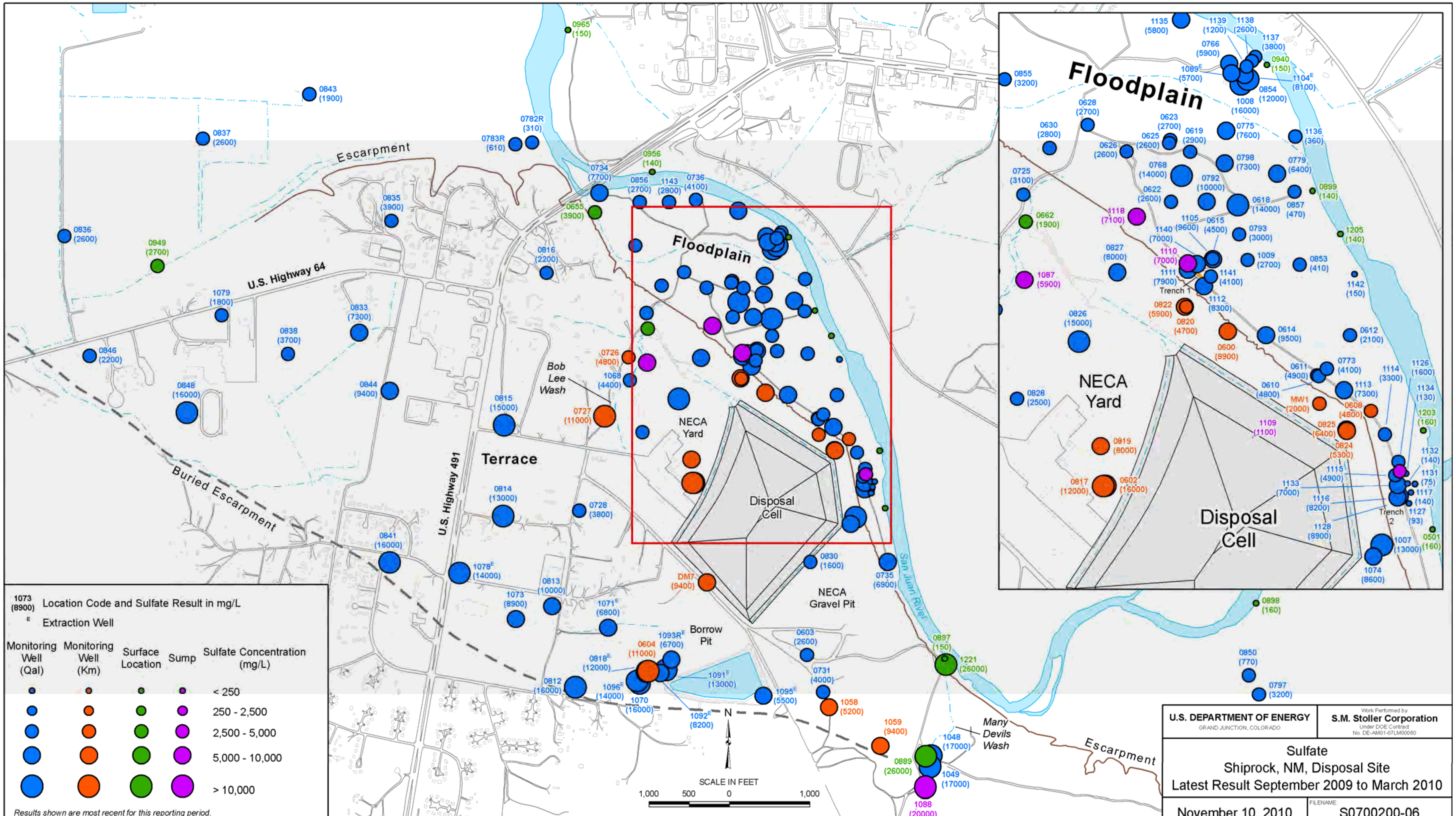

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Figure 1–8a. Sulfate Concentrations in Groundwater and Surface Water Samples, September 2009–March 2010

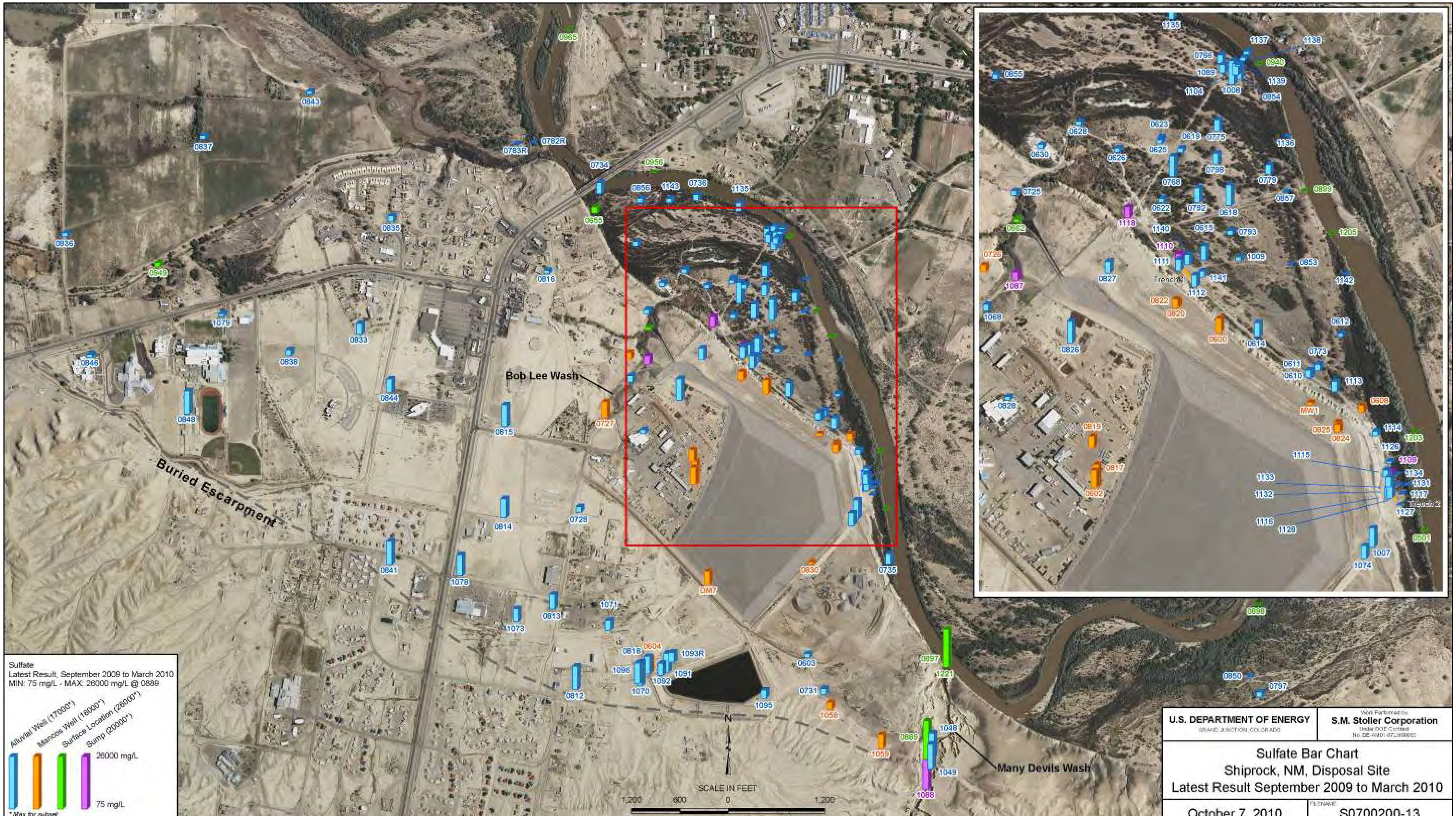

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Figure 1−8b. Relative Distribution of Sulfate in Groundwater and Surface Water Samples, September 2009–March 2010

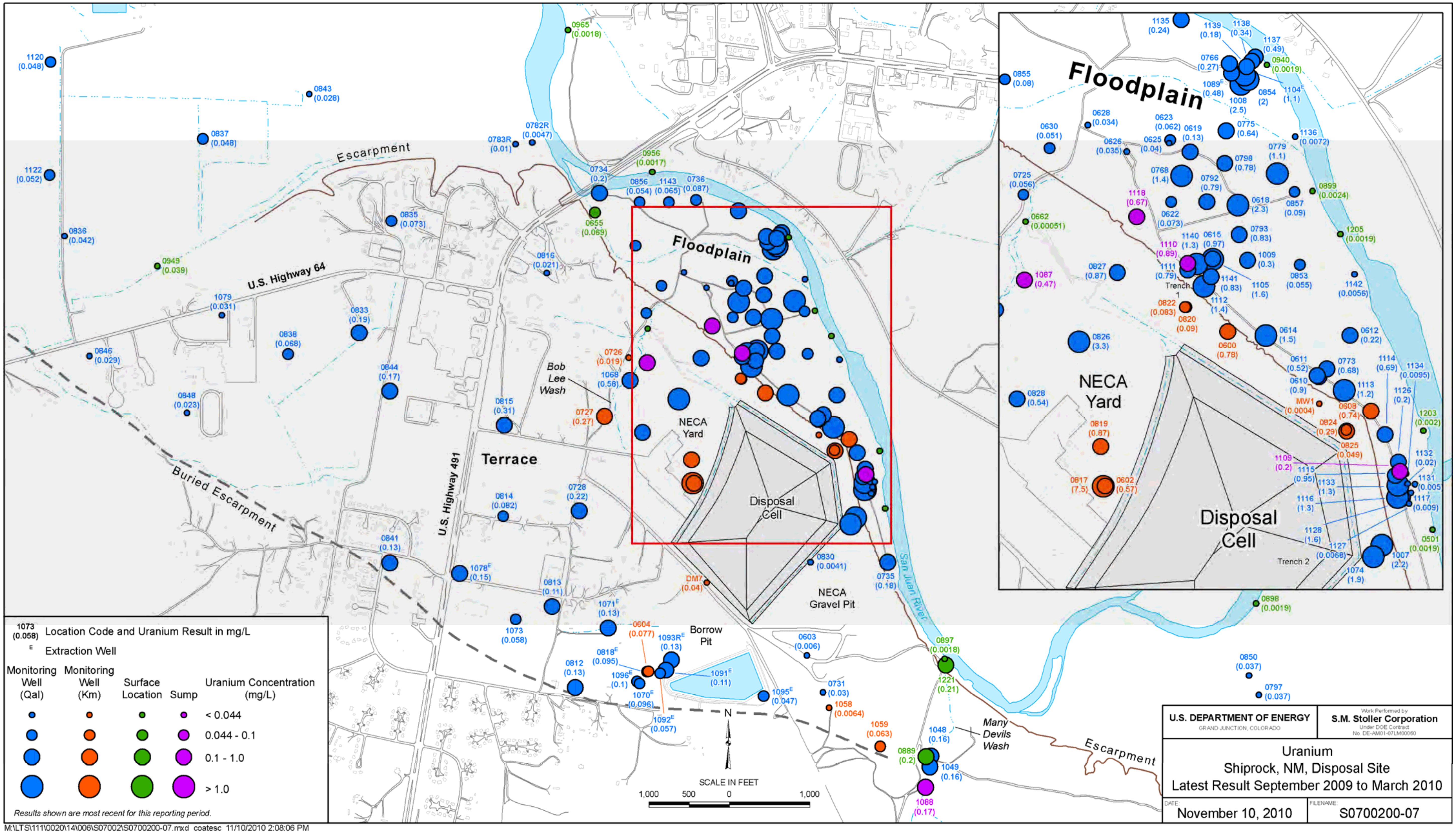

Figure 1–9a. Uranium Concentrations in Groundwater and Surface Water Samples, September 2009–March 2010

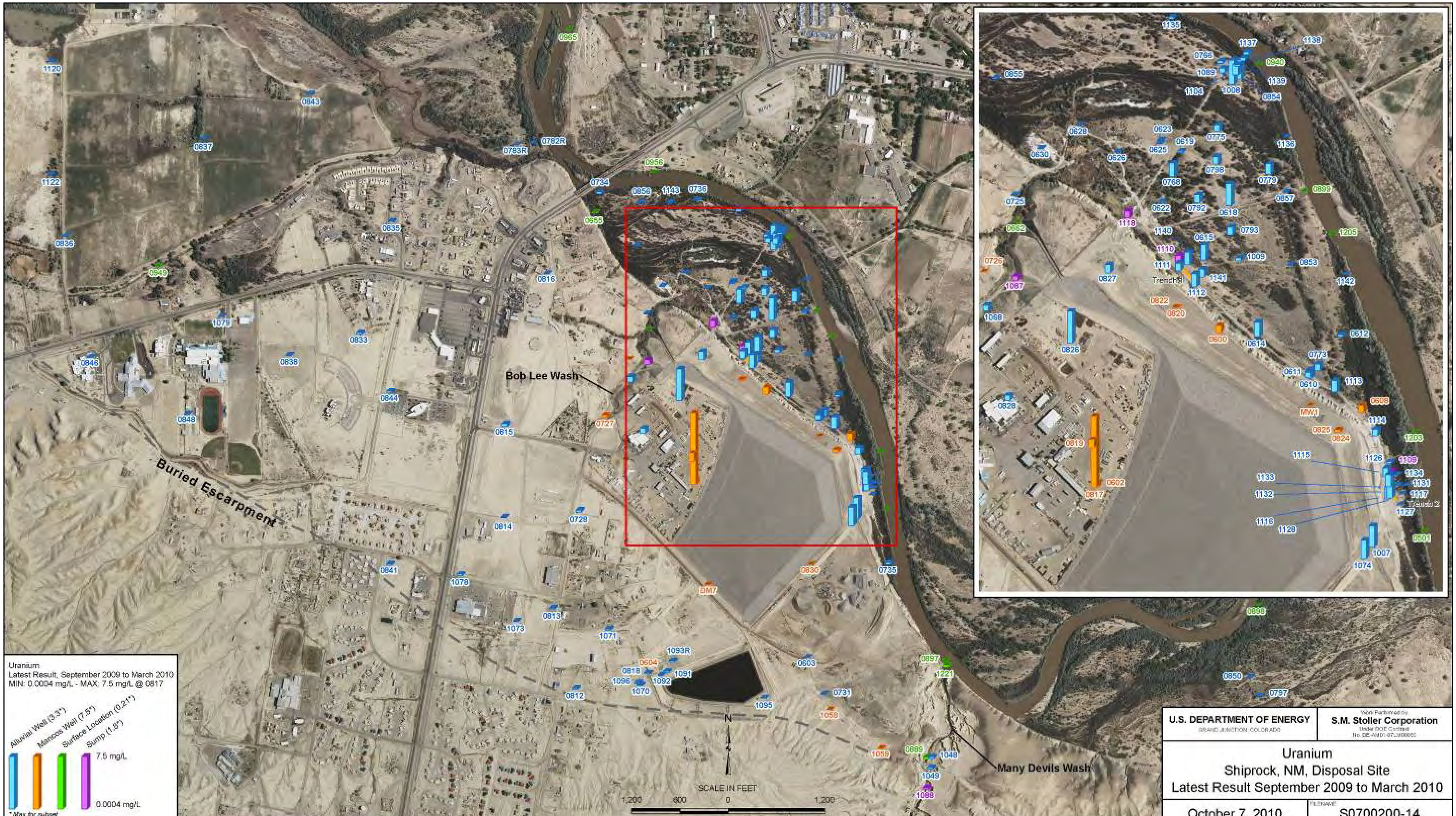

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Figure 1−9b. Relative Distribution of Uranium in Groundwater and Surface Water Samples, September 2009–March 2010

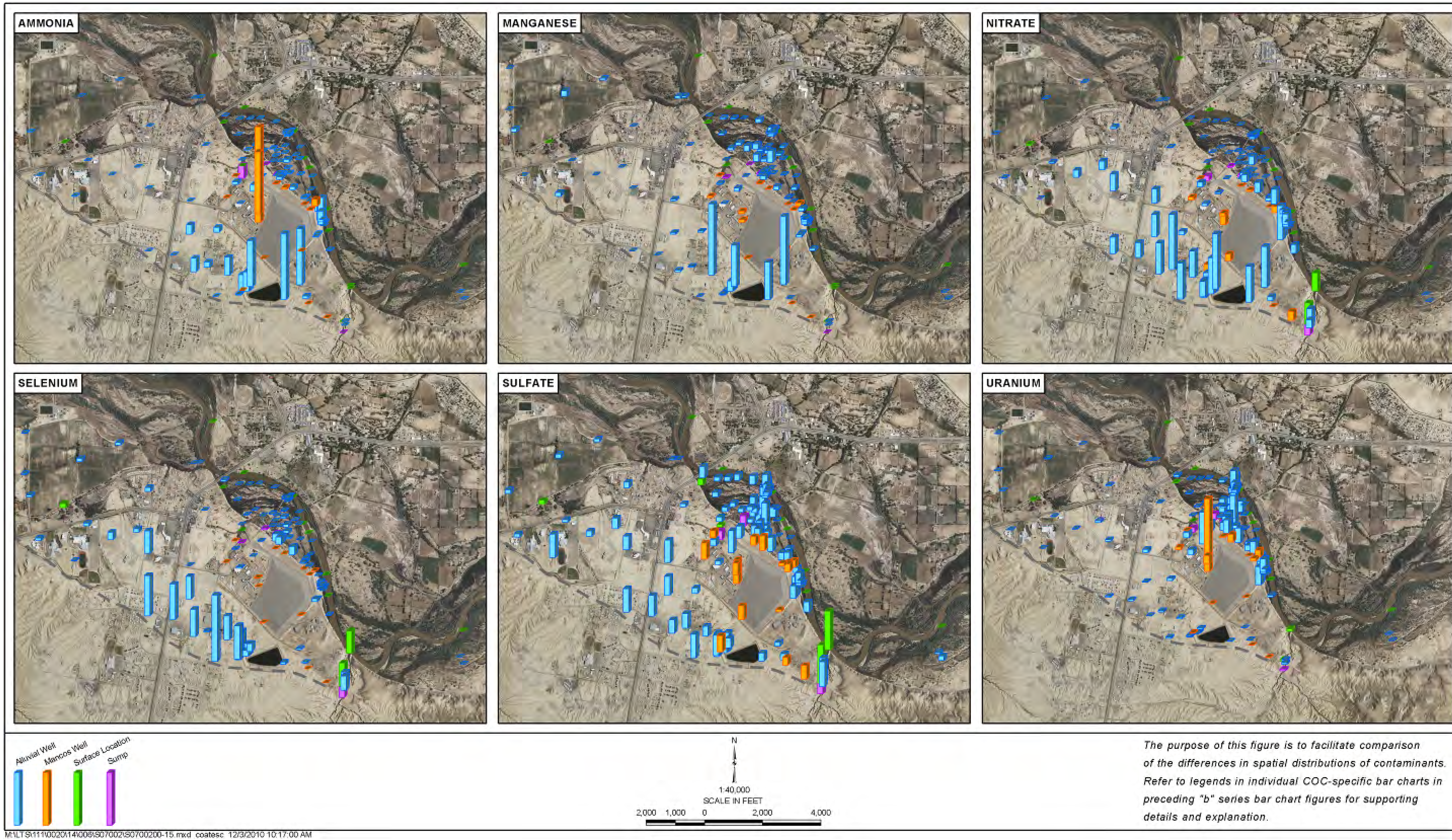

Figure 1–10. Side-By-Side Comparison of Relative Contaminant Distributions for the Primary COCs

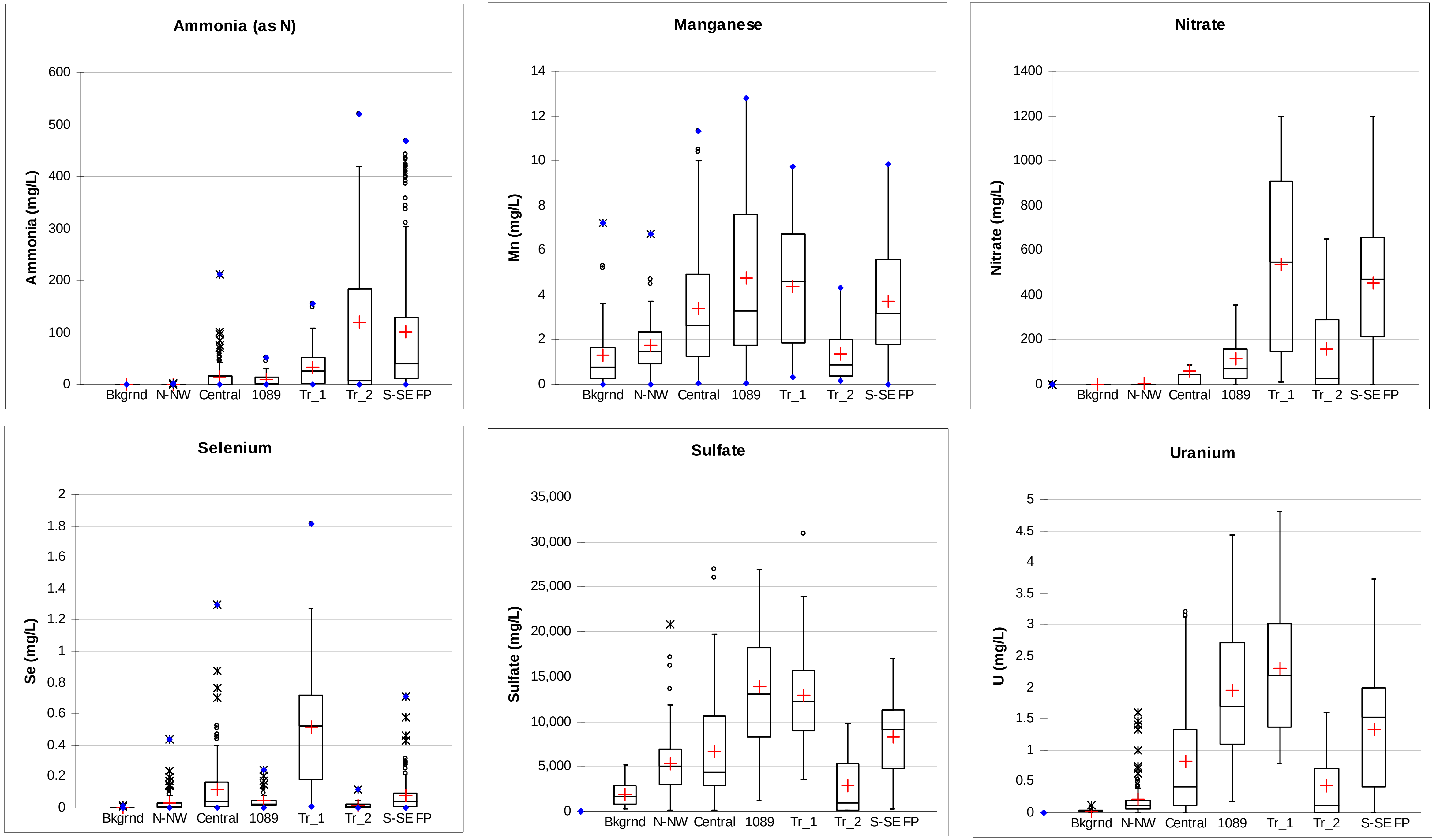

Figure 1–11. Historical Distribution of Shiprock Primary COCs in Floodplain Wells[†]

[†] The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of floodplain COCs (excluding strontium) for the floodplain well subgroups defined in Appendix A; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box. In each plot above, "Bkgrnd" refers to background wells 0797 and 0850; "N-NW" refers to North-Northwest floodplain wells (see orange-coded wells in Appendix A, Figure A–1); "Central" refers to central floodplain wells; "1089" corresponds to the Well 1089 area (see uppermost portion of Figure 1–2 inset); "Tr_1" and "Tr_2" refer to Trench 1 and 2 area wells, respectively; and "S-SE FP" corresponds to south-southeastern floodplain wells (again, refer to Appendix A, Figure A–1). The combined plot above is a summary version of the COC-specific statistical summaries provided in Appendix A. This appendix also documents the number of data points corresponding to each box in the plots above (an important consideration in data interpretation).

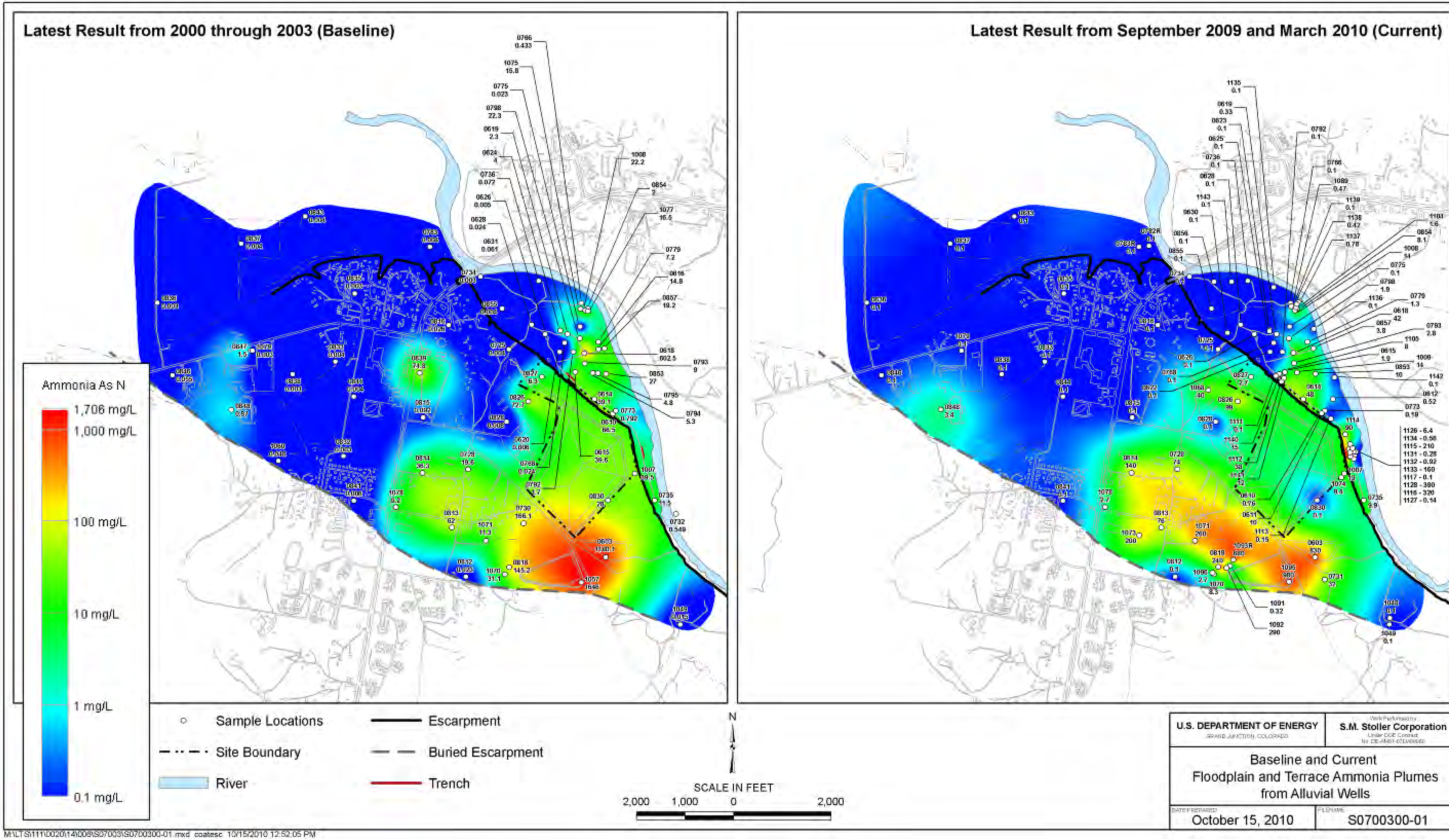

Figure 1–12. Baseline (2000–2003) and March 2010 Floodplain and Terrace Ammonia Plumes

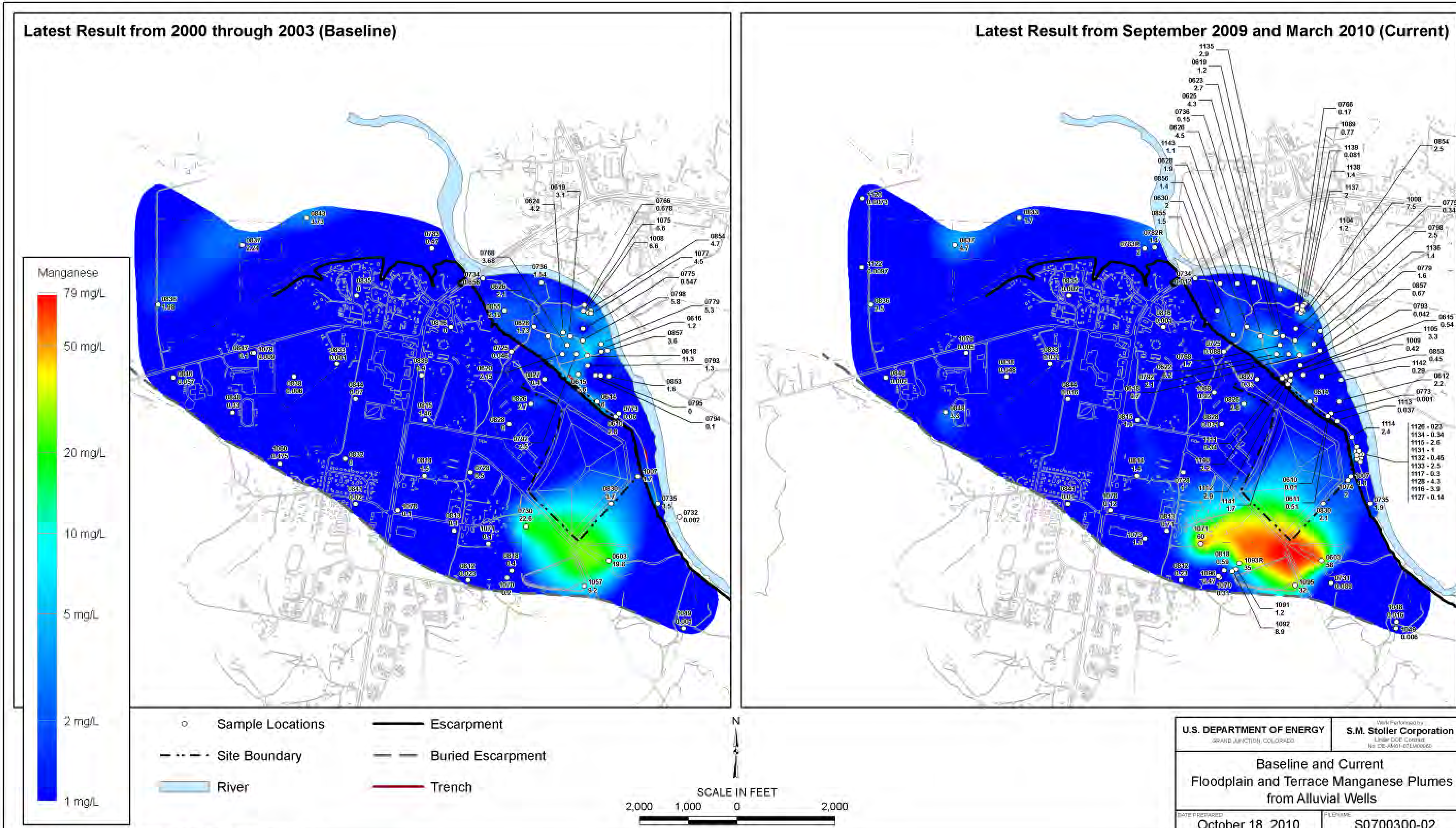

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Figure 1–13. Baseline (2000–2003) and March 2010 Floodplain and Terrace Manganese Plumes

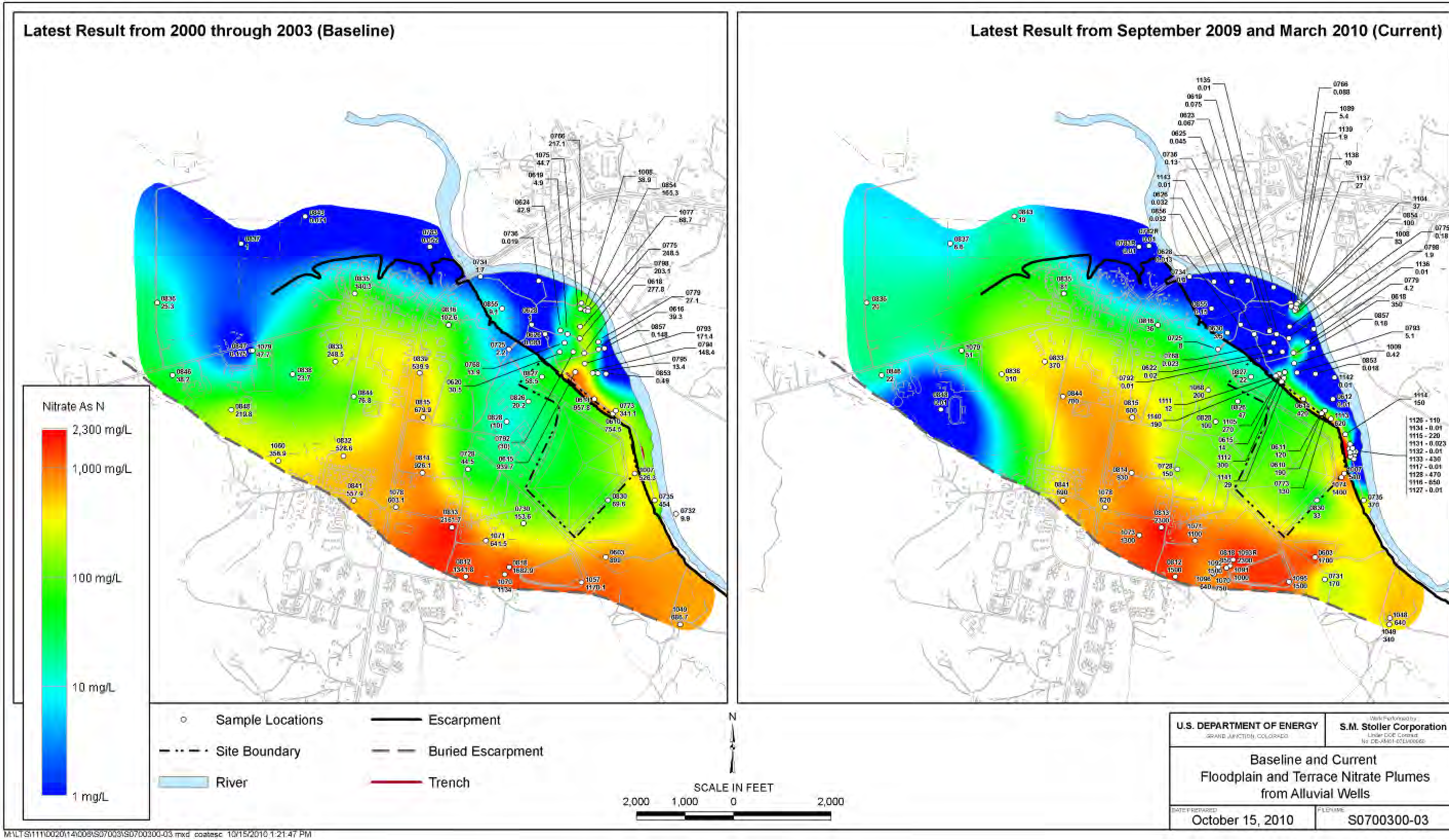

Figure 1–14. Baseline (2000–2003) and March 2010 Floodplain and Terrace Nitrate Plumes

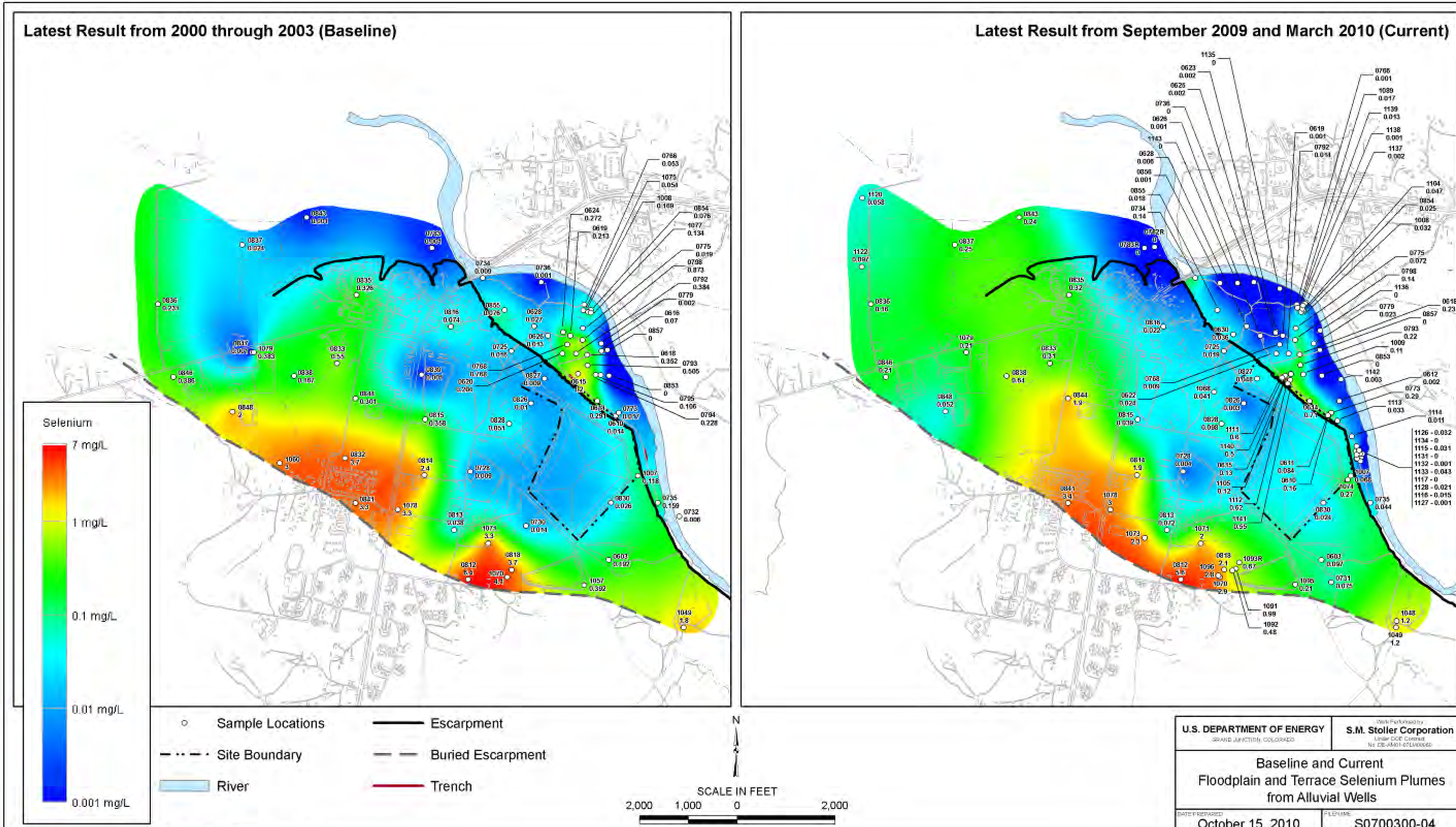

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Figure 1–15. Baseline (2000–2003) and March 2010 Floodplain and Terrace Selenium Plumes

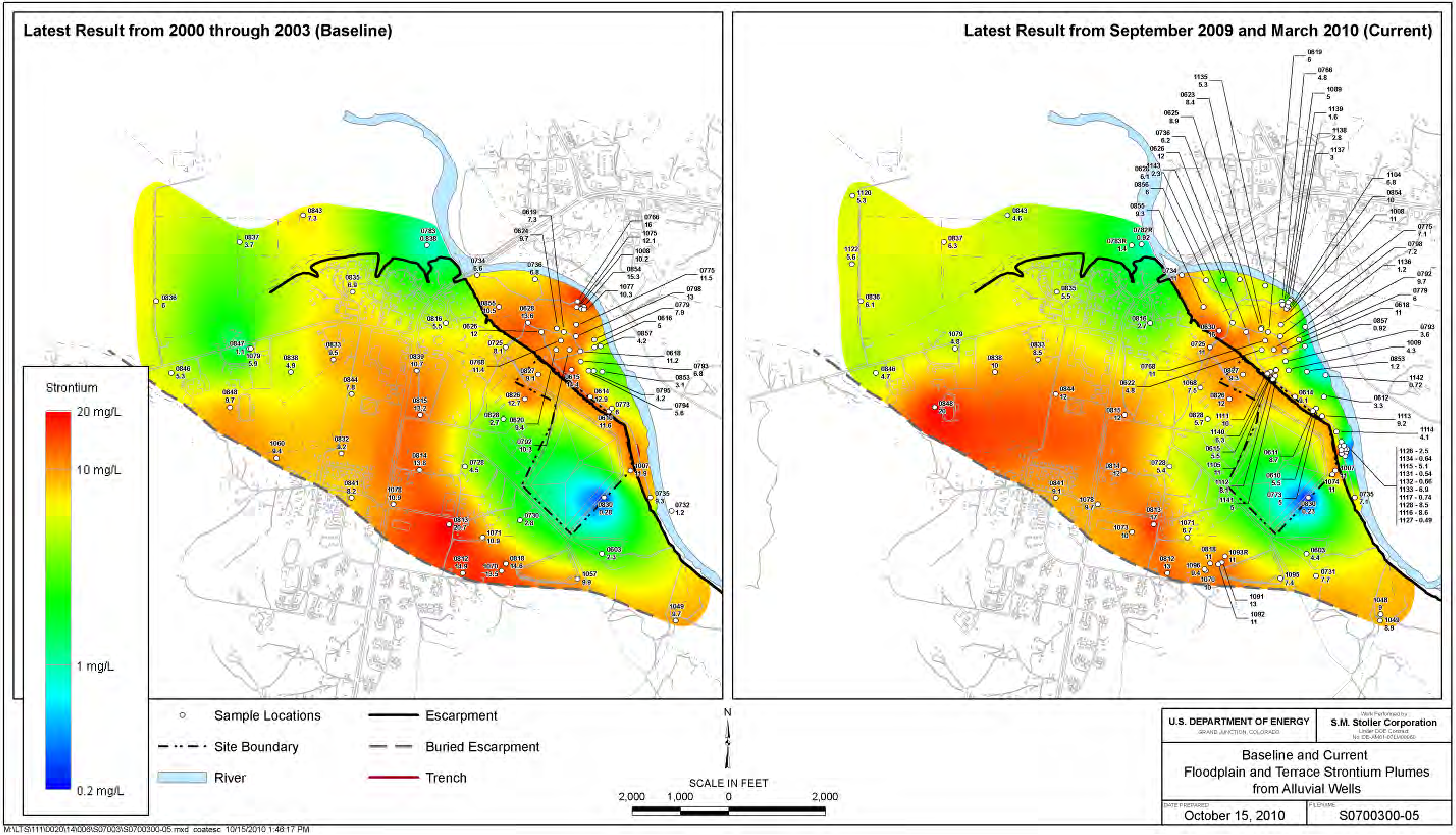

Figure 1–16. Baseline (2000–2003) and March 2010 Floodplain and Terrace Strontium Plumes

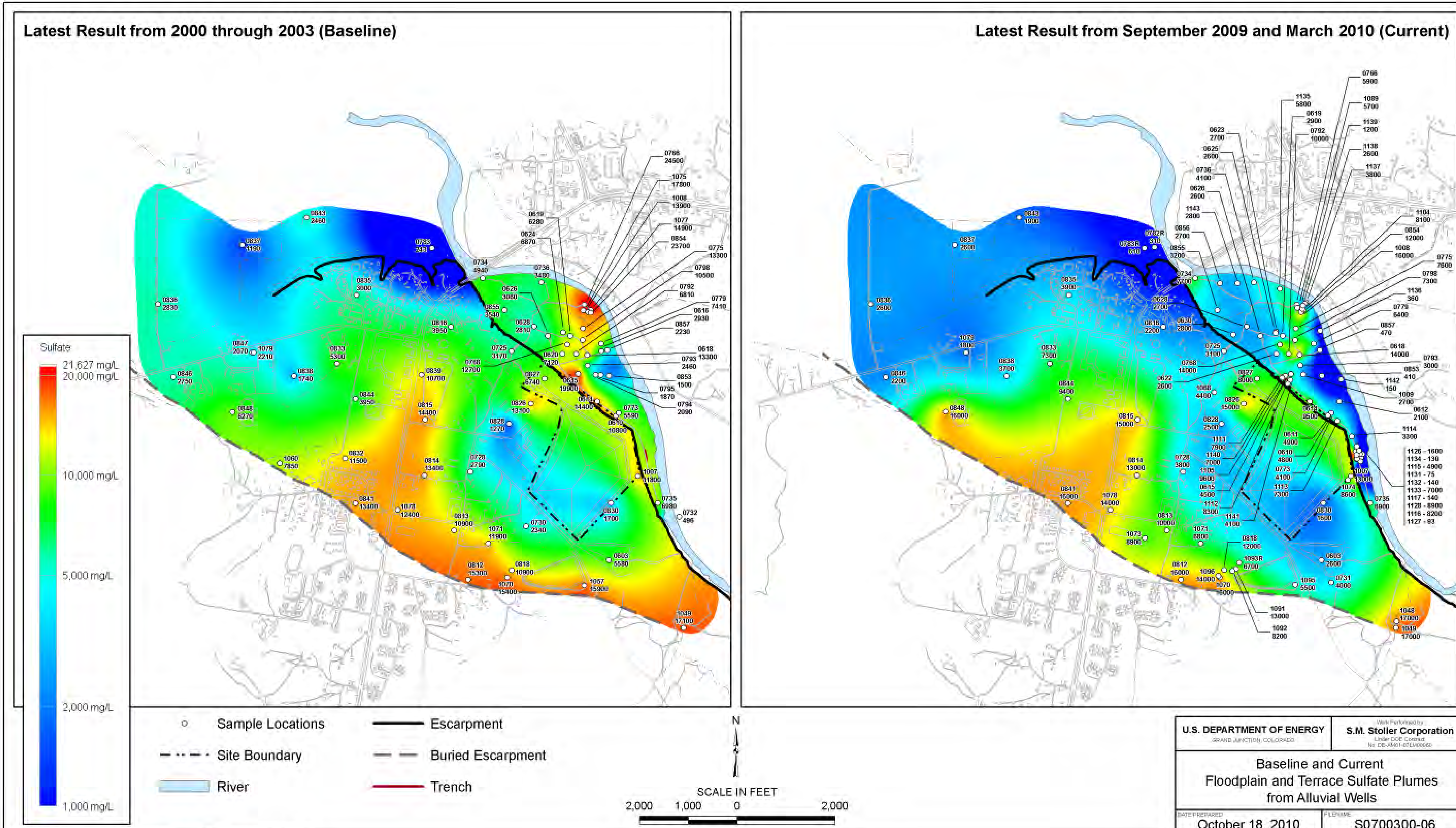

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Figure 1–17. Baseline (2000–2003) and March 2010 Floodplain and Terrace Sulfate Plumes

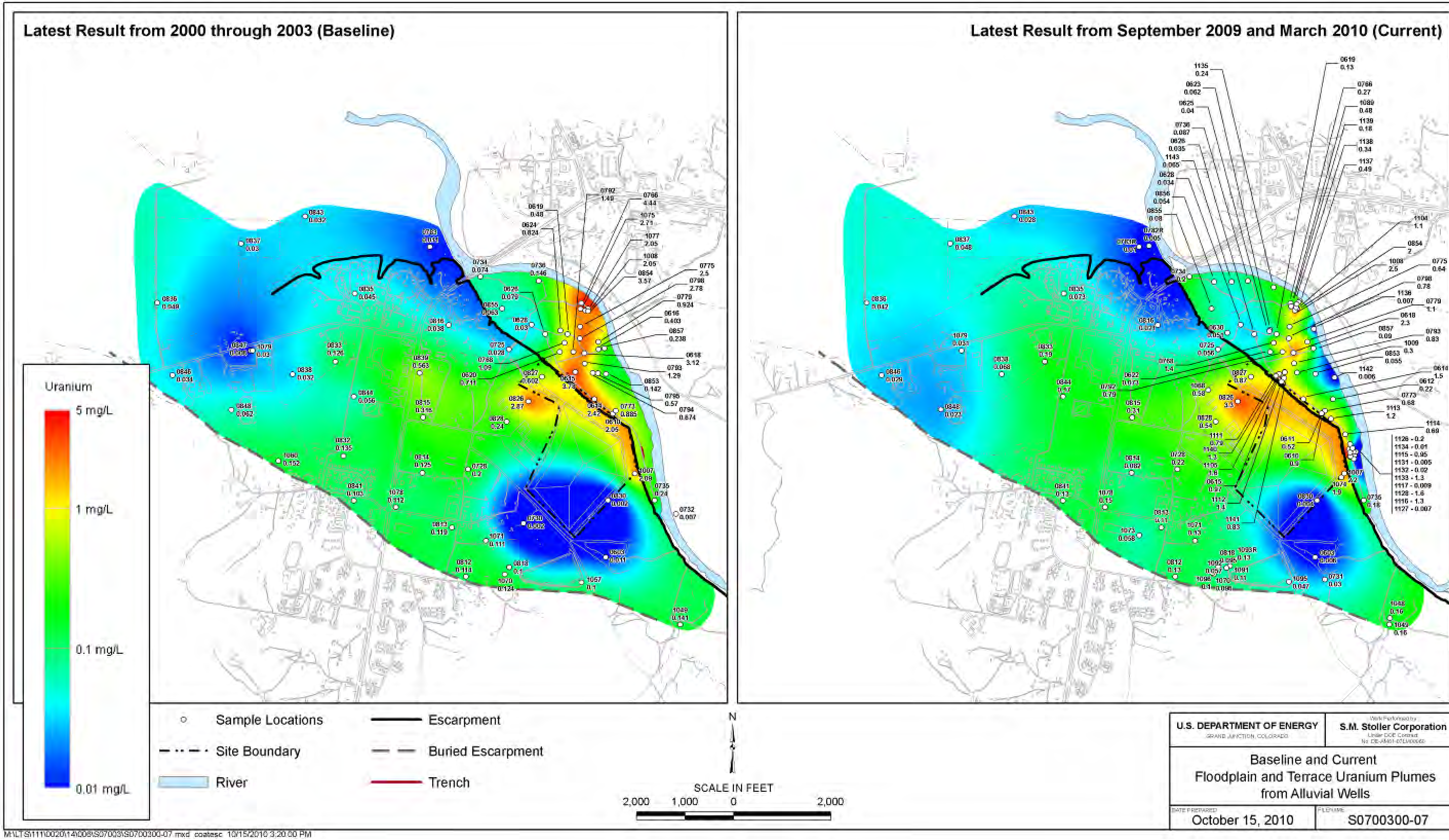

Figure 1–18. Baseline (2000–2003) and March 2010 Floodplain and Terrace Uranium Plumes

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2.0 Subsurface Conditions

This section summarizes hydraulic and water-quality characteristics of the floodplain and terrace groundwater systems for the April 2009 through March 2010 reporting period, approximately 7 years after the startup of the treatment system.

2.1 Floodplain Subsurface Conditions

The following discussion of current subsurface conditions in the floodplain is based on the collection and analysis of groundwater samples and groundwater level data through March 2010. Analyses of groundwater level trends, groundwater flow directions, and contaminant distributions in the floodplain are discussed below. Results are compared to baseline conditions established in the Baseline Performance Report (DOE 2003) to evaluate the effectiveness of the floodplain treatment system.

2.1.1 Floodplain Groundwater Level Trends and Flow Directions

Analysis of groundwater level (horizontal gradients) and flow data is important in evaluating the recharge and discharge effects of the floodplain aquifer caused by interaction with the San Juan River's flow dynamics and by the seasonal variability of river flow and precipitation. Results of previous three-point analyses showed very little change in groundwater flow directions and demonstrated that the flow system in the floodplain was operating as expected—that is, the flow of groundwater is predominantly toward the extraction wells (DOE 2008). The recent evaluation of the Trench 2 remediation system corroborates this conclusion (DOE 2009b).

Groundwater levels in the floodplain aquifer are manually recorded during routine groundwater sampling events. Figure 2–1, which plots groundwater levels for a representative subset of these wells, indicates that groundwater level fluctuations over the past 7 years have been on the order of 2 ft. As expected, higher groundwater levels generally coincide with elevated flows in the San Juan River. Apart from this expected variation, no trending is apparent (i.e., water levels in floodplain wells have been generally stable over time).

In addition to manual measurements, groundwater elevations in the floodplain aquifer are also measured every 4 hours by pressure transducers connected to dataloggers that are installed in five monitoring wells—0617, 0736, 0854, 0857, and 1008. These data are plotted in Figure 2–2, along with stream flow in the San Juan River, for comparison. Flow data were obtained from U.S. Geological Survey (USGS) Gaging Station 09368000 (San Juan River at Shiprock), located just east of well 0857 (Figure 1–1). The river flow in March 2003 was 649 cubic feet per second (cfs), and the flow in March 2010 was 944 cfs.[8]

The datalogger plots indicate a close correlation between groundwater levels and the San Juan River's flow patterns, indicating relatively rapid recharge and discharge of the aquifer related to change in river flow and surface water levels (Figure 2–2). It is well established that much of the water entering the floodplain aquifer does so via San Juan River losses along the southernmost tip of the aquifer. Thus, it is logical to assume that inflow from the river increases during high

[8] River flow measurements cited above correspond to the days manual water level measurements were taken at the Shiprock site (corresponding to the average of measurements from March 22 through March 26, 2010).

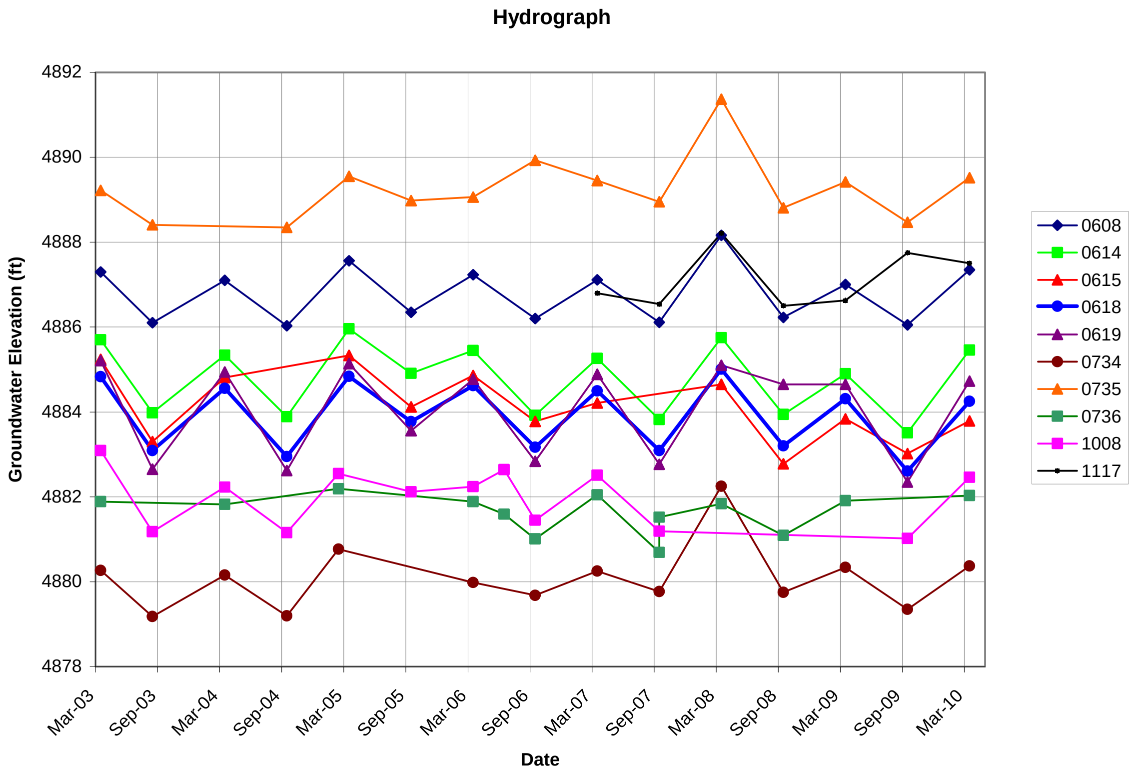

Figure 2–1. Floodplain Groundwater Elevations from Manual Measurements

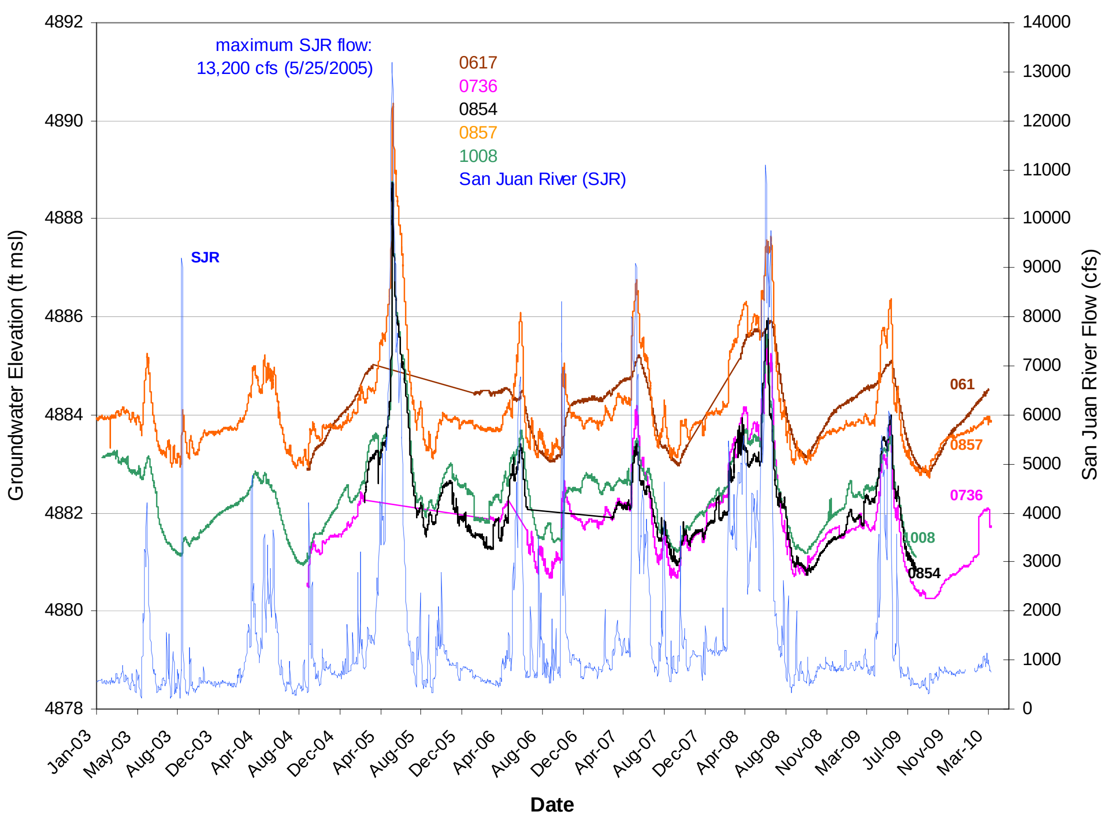

Figure 2–2. Floodplain Groundwater Elevations from Datalogger Measurements

runoff, and that this produces flow directions east of the disposal cell that are in a more northward to northwestward direction than normal. The potential for greater mixing of relatively clean water from the river with contaminated groundwater emanating from the former milling site would likely increase under such circumstances. A more detailed evaluation of floodplain groundwater flow and chemistry is provided in the recent evaluation of the Trench 2 groundwater remediation system (DOE 2009b).

2.1.2 Floodplain Contaminant Distributions and Temporal Trends

Groundwater samples were collected from selected floodplain monitoring wells in September 2009 and March 2010. The locations of these wells are shown in Figure 1–2, which also identifies the zone in which the wells were completed, alluvium (Qal) or Mancos Shale (Km). Variations in constituent concentrations over time from March 2003 (baseline) through March 2010 are plotted in Figures 2–3 through 2–9 for a representative subset of these wells. These wells, marked in Figure 1–2 with a "1" superscript, are:

- 0608—Km, near the disposal cell at the base of the escarpment;
- 0614—Qal/Km, base of escarpment between 0608 and Trench 1;
- 0615—Qal, Trench 1 area;
- 0618—Qal, northeast of Trench 1;
- 0619—Qal, northwest of well 0618;
- 0734—Qal, western floodplain near highway (farthest downgradient of well subset);
- 0735—Qal, upgradient of disposal cell, adjacent to river (farthest upgradient of subset);
- 0736—Qal, western floodplain;
- 1008—Qal, monitoring discontinued in 2006 and replaced by well 1104; and
- 1104—Qal, well 1089 area.

In the time–trend plots, trend lines are shown only for those wells exhibiting apparent trends. As shown in Figure 1–2 (see well locations with a "2" superscript) and summarized in Appendix A (Table A–1), nine new Geoprobe wells were installed in the floodplain during this reporting period. Seven (including three in a line toward the river from the well 1089 complex) were installed near the San Juan River to evaluate groundwater flow and monitor contaminant levels in groundwater that could enter the river. Also, two new alluvial wells (1140 and 1141) were installed about 50 ft from the east side of Trench 1 (nearest the river).

Previous annual reports (e.g., see DOE 2008) did not evaluate time trends for Trench 2 wells because there weren't sufficient data (in terms of number of samples) to draw any definitive conclusions. The following time-trend plots only address the subset of wells listed above (which does not include any Trench 2 area wells; subsequent annual reports will, however). To supplement the data presented in this section, Appendix A provides detailed information regarding historical analytical results for all floodplain wells. Therefore, in reviewing the following plots and interpretations, the reader is referred to this appendix for additional information, as well as the figures in Section 1 which plot the corresponding spatial distributions (see Figure 1–11 in particular).

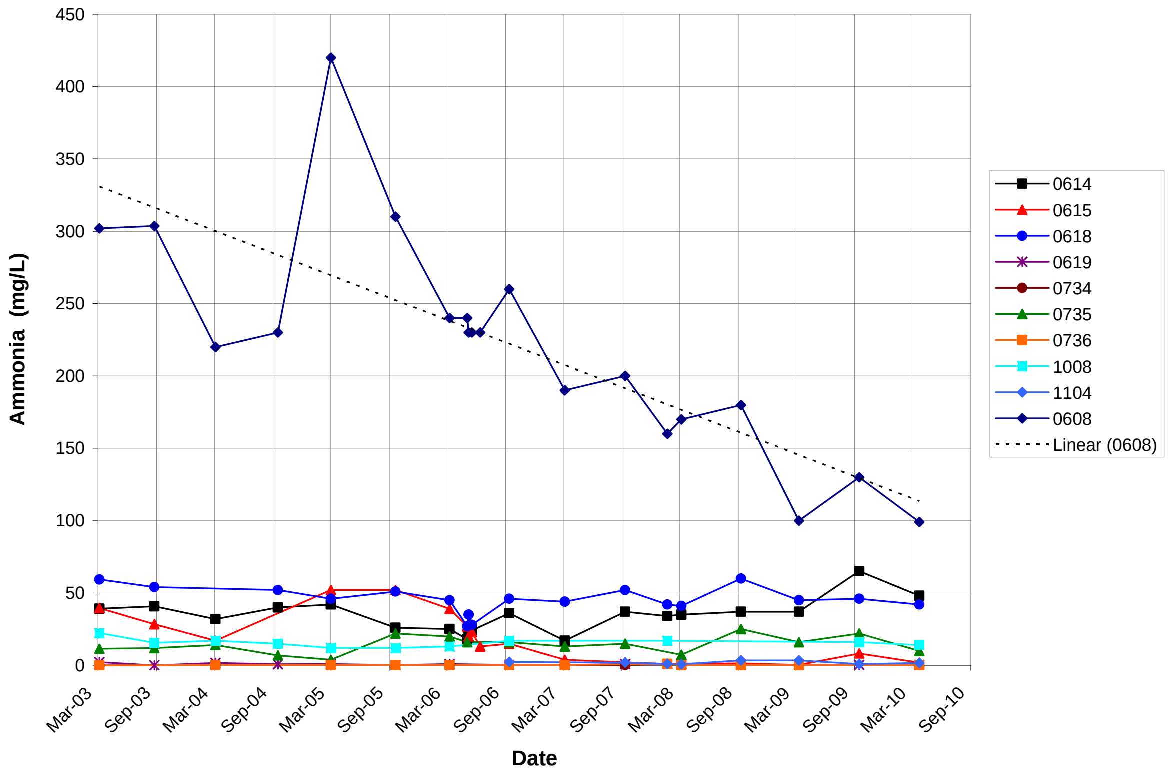

Figure 2–3a. Floodplain Ammonia (Total as Nitrogen) Groundwater Concentrations Versus Time

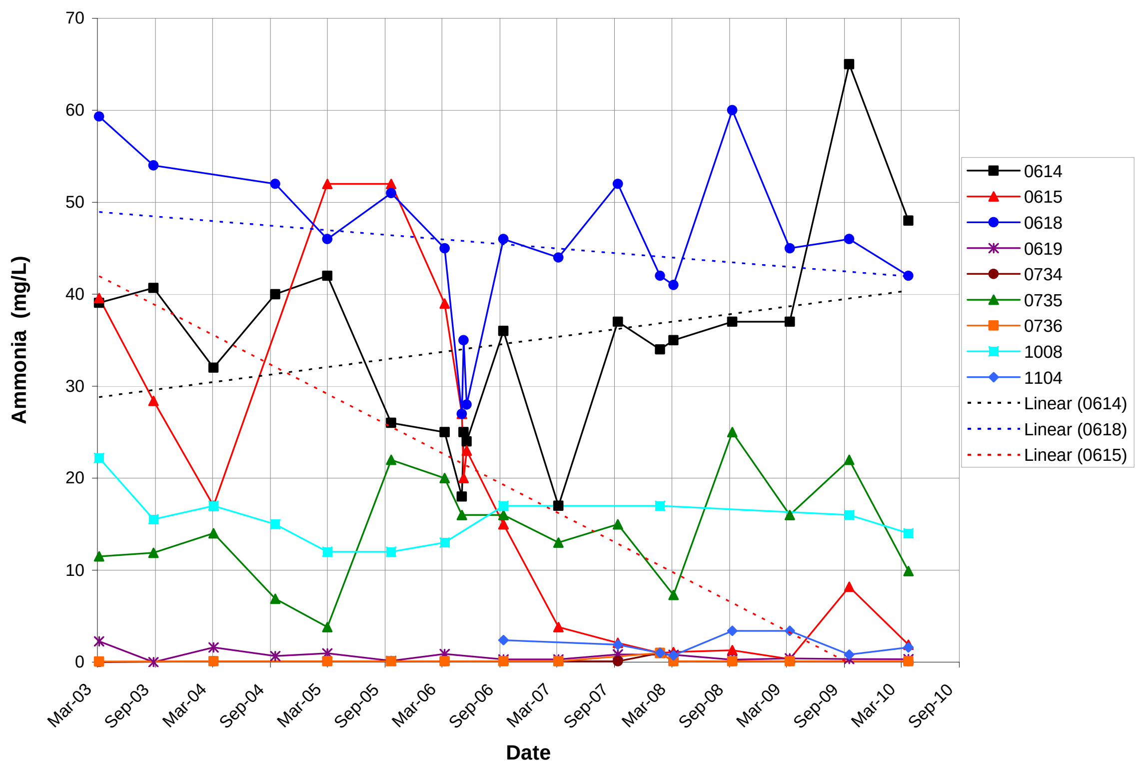

Figure 2-3b. Floodplain Ammonia Groundwater Concentrations Versus Time Excluding Well 0608

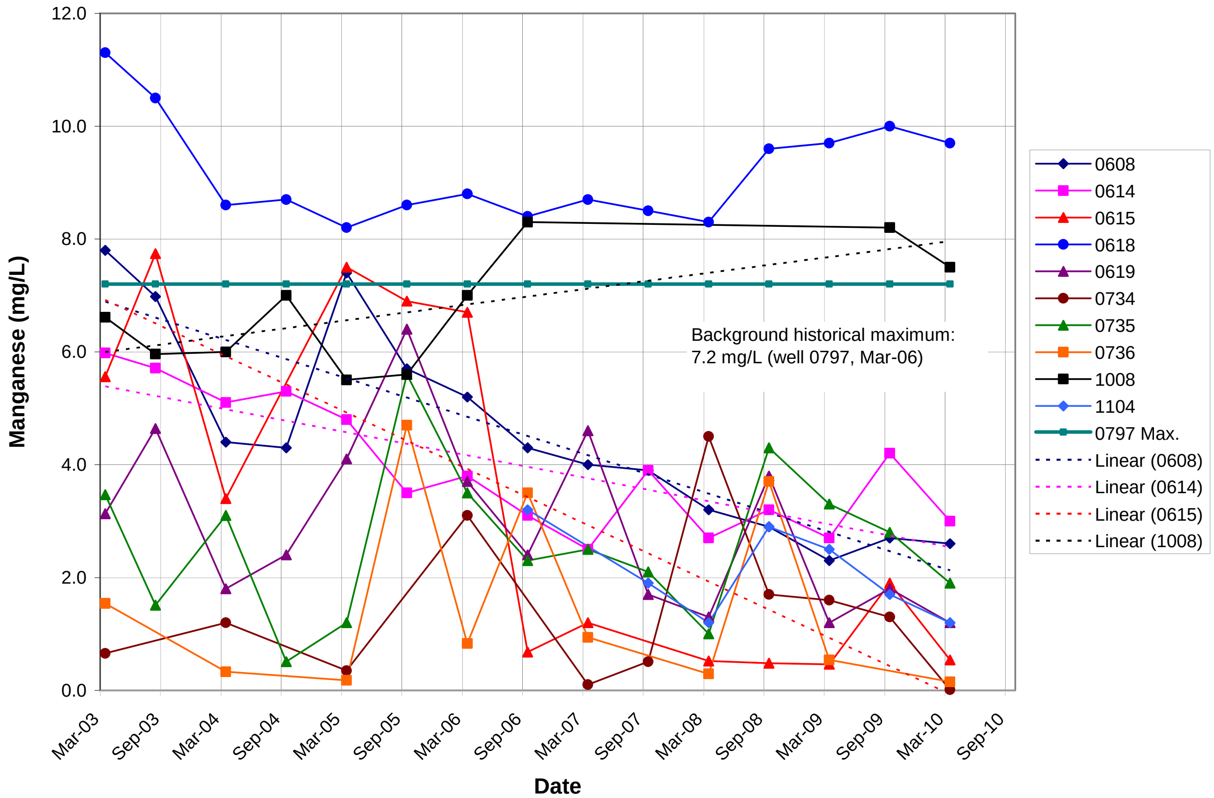

Figure 2–4. Floodplain Manganese Groundwater Concentrations Versus Time

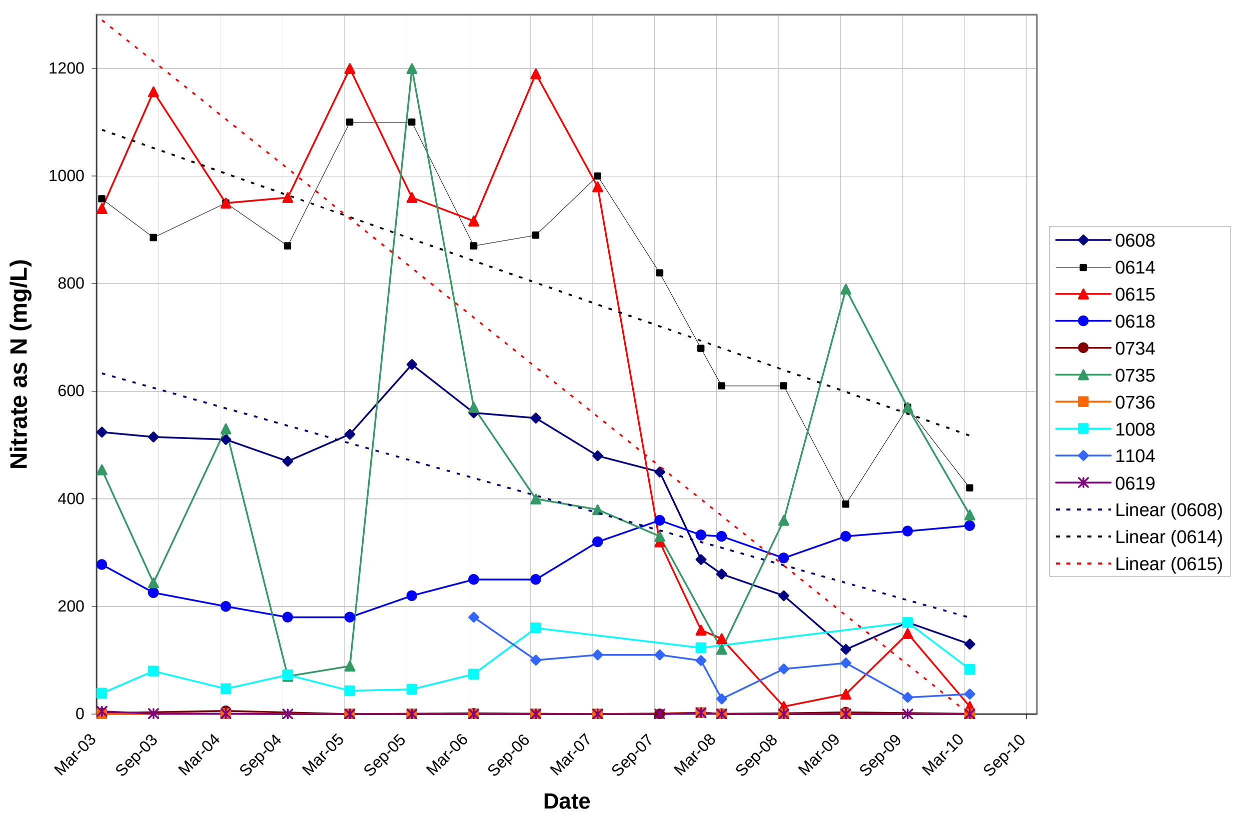

Figure 2–5. Floodplain Nitrate + Nitrite (as Nitrogen) Groundwater Concentrations Versus Time

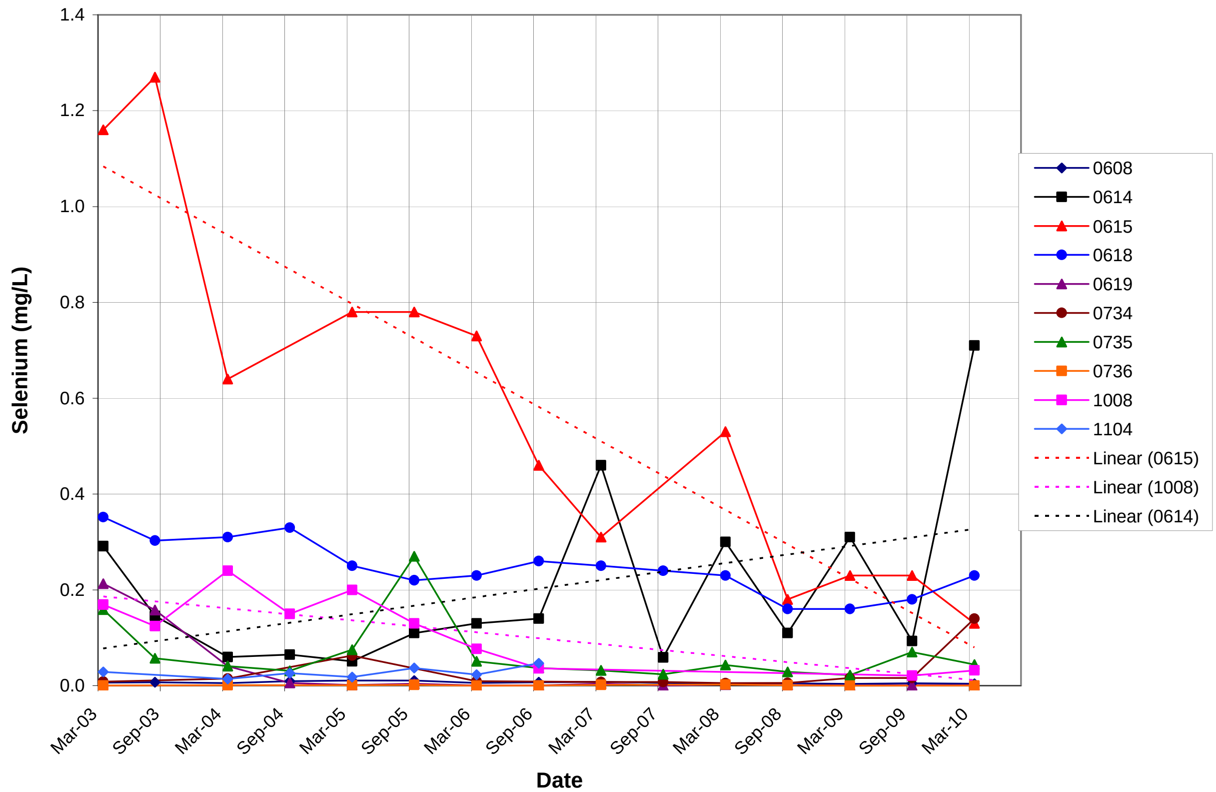

Figure 2–6. Floodplain Selenium Groundwater Concentrations Versus Time

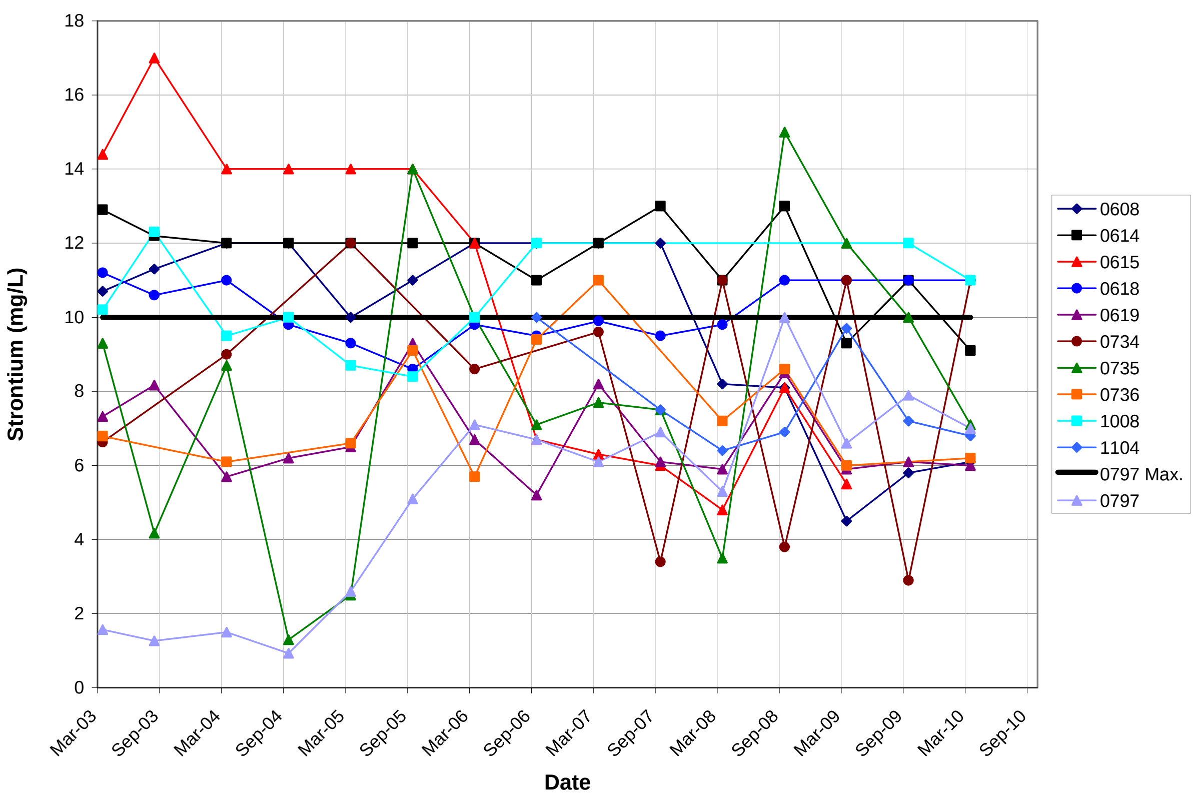

Figure 2–7. Floodplain Strontium Groundwater Concentrations Versus Time

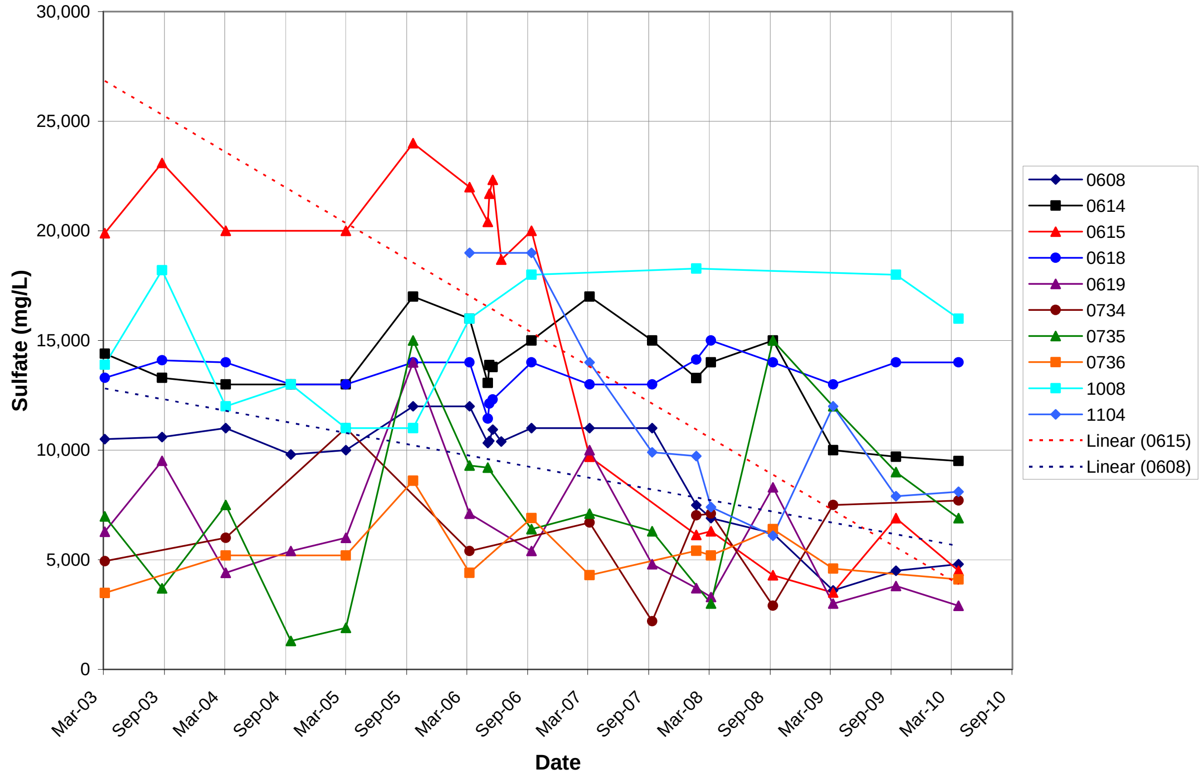

Figure 2–8. Floodplain Sulfate Groundwater Concentrations Versus Time

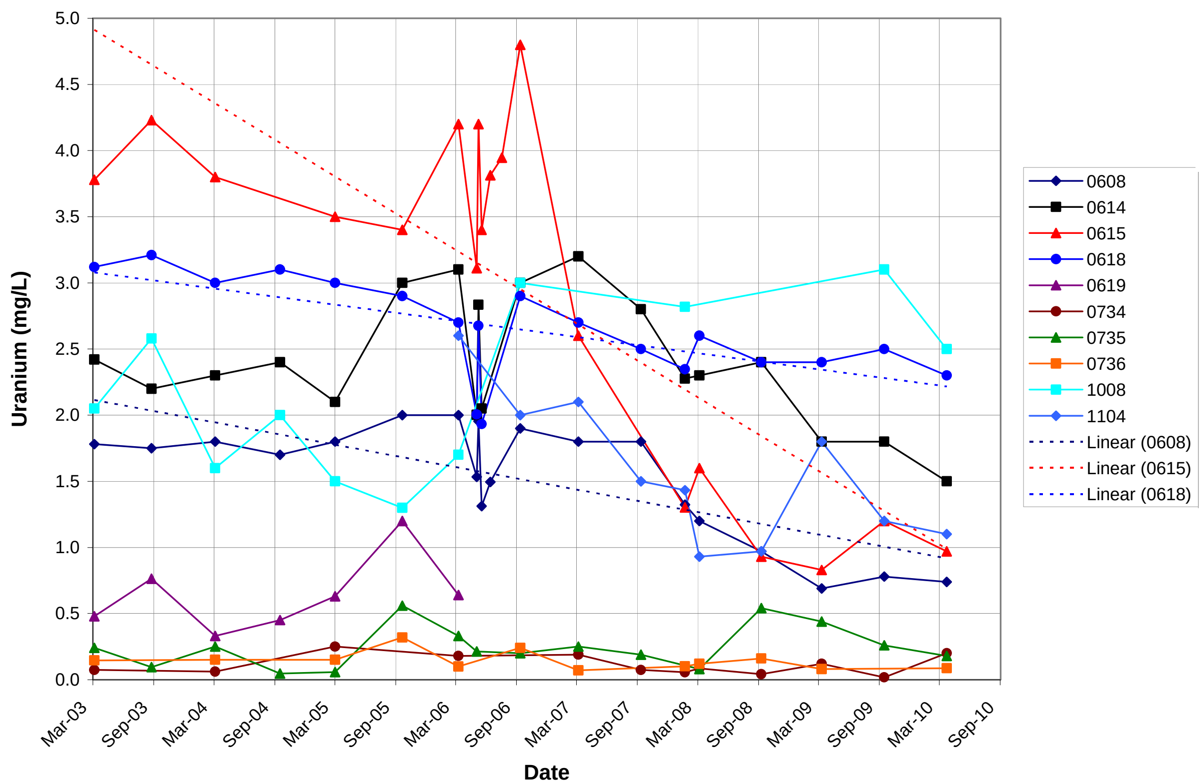

Figure 2–9. Floodplain Uranium Groundwater Concentrations Versus Time

For all COCs, as shown in the preceding figures, periodic variation attributable to meteorological and other influences is apparent in most wells. This small-scale variation is expected, as concentrations of constituents in groundwater in the floodplain alluvium are affected by changes in precipitation and river stage, discharge of groundwater from the artesian well that flows into Bob Lee Wash and then onto the floodplain, and pumping rates of the extraction wells and collection trenches. The following paragraphs discuss general trends observed for individual COCs.

Ammonia

In contrast to trends apparent for most other COCs, ammonia concentrations are highest in the western portion of the Trench 2 area closest to the disposal cell (see Figure 1–3, Figure 1–11, and Appendix A).[9] Concentrations on the east (San Juan River) side are much lower, however. This difference in magnitude could be evidence of the effectiveness of the remediation system in this area. As shown in Figure 2–3a, with the exception of well 0608 (screened in the Mancos Shale, at the base of the escarpment) and Trench 1 area alluvial well 0615, ammonia concentrations in groundwater (in the subset of wells plotted) have not varied significantly over the past 7 years. Ammonia concentrations in well 0608 seem to have stabilized at about 100–150 mg/L for the past year, compared with the 300 mg/L baseline measurement in March 2003 and the historical maximum of 420 mg/L in March 2005. Ammonia concentrations in well 0615, located in the Trench 1 area, have also decreased (Figure 2–3b). Floodplain-wide, ammonia concentrations ranged from 0.1 to 390 mg/L during this reporting period; the maximum was measured at Trench 2 well 1128. Lower, but still elevated ammonia levels occur in other areas of the floodplain (e.g., Trench 1 area and well 1089 area). However, no contamination is apparent in the northwest floodplain.

Manganese

As discussed in Section 1, manganese levels are most elevated on the terrace; on the floodplain, no notable trends are apparent (see Figures 1–4, 1–10, 1–11). Although decreases are apparent (Figure 2–4), these are also not noteworthy, as most decreases are within the range of normal variability measured for floodplain background wells 0797 and 0850. With the exception of Trench 1 area wells 0618 and 1008, manganese levels in the subset of wells plotted in Figure 2–4 are below the maximum floodplain background concentration (7.2 mg/L). This is also the case floodplain-wide, where manganese concentrations for this reporting period range from less than 0.001 to 10 mg/L in well 0618. The average manganese concentration was 2.0 mg/L, which is well below the 7.2 mg/L background maximum.

Nitrate

As observed for ammonia, nitrate concentrations in well 0608 (completed in the Mancos Shale near the escarpment) and Trench 1 area well 0615 have decreased notably since the baseline period. Nitrate (as N) concentrations in well 0608 continue to decrease since installation of the floodplain trenches in 2006—from the maximum of 650 mg/L in September 2005 to a historical low of 130 mg/L in March 2010. Nitrate concentrations in well 0615 also reduced markedly, nearly two orders of magnitude relative to 2003–2005 measurements (Figure 2–5). A similar decrease is apparent for well 0614, located between well 0608 and Trench 1. Nitrate

[9] In this section, when referencing the paired (graduated symbol and bar chart) plots in Section 1, only the main figure number is noted (i.e., Figure 1–3 refers to both Figure 1–3a and Figure 1–3b).

concentrations in well 0735, upgradient of the disposal cell, which had increased during the last reporting period, decreased from 790 mg/L in March 2009 to 370 mg/L in March 2010. Nitrate levels have fluctuated widely in this well historically.

For this reporting period, floodplain-wide, nitrate concentrations ranged from 0.01 mg/L in the northwest floodplain to 650 mg/L at well 1116 (west of Trench 2 near the base of the escarpment [not plotted in Figure 2–5]). As shown in Figure 1–5 and Figure 1–14, the highest concentrations of nitrate occur in wells near the escarpment. As is the case for other COCs (e.g., uranium and sulfate), nitrate concentrations are generally lower in the northwest portion of the floodplain where groundwater is influenced by influx from the artesian well feeding Bob Lee Wash. Nitrate concentrations are also low in central floodplain wells (see Figure 1–11 and Appendix A). The plume maps shown in Figure 1–14 illustrate the reduction in nitrate concentrations in the central floodplain and Trench 2 area since the baseline period.

Selenium

In general, selenium concentrations in floodplain groundwater have not varied significantly over the past 7 years (Figure 2–6; also see Figure 1–11 and Appendix A). However, selenium concentrations in Trench 1 area well 0615 have decreased from a peak of 1.3 mg/L in August 2003 to a historical low of 0.13 mg/L in March 2010. Decreases are also apparent in well 1008. Selenium levels recently increased markedly in well 0614 (located near the base of the escarpment between Trenches 1 and 2), from 0.093 mg/L in September 2009 to the historical maximum of 0.7 mg/L in March 2010 (Figure 2–6). Floodplain-wide, selenium concentrations ranged from 0.001 to 0.71 mg/L (well 0614), and the average concentration was 0.09 mg/L (exceeding both the 40 CFR 192 and EPA MCLs; Table 1−1).

Strontium

As discussed in Section 1.2, strontium is not typically associated with uranium milling sites but was selected as a COC based on a conservative risk assessment, which was driven by strontium concentrations in sediments, rather than in groundwater (DOE 1994). The fact that strontium may be naturally occurring at the Shiprock site (rather than associated with former milling processes) is evident in Figure 1–7b, which shows that strontium concentrations are fairly uniform across the site. Although the plots in Appendix A indicate that strontium concentrations in floodplain wells are slightly elevated relative to background, the magnitudes are not noteworthy (see final plot in Appendix A, Figure A–6). [A correlation with calcium is apparent; the latter trend could account for these observations.] No notable temporal trends are evident in Figure 2–7, and all floodplain measurements to date have been below EPA's risk-based screening level for groundwater (22 mg/L) discussed in Section 1.2. For the 2009–2010 reporting period (excluding background), strontium concentrations ranged from 0.5 to 19 mg/L (well 0792); the average concentration was 6.4 mg/L (also see Figure 1–7).

Sulfate

As observed for all other COCs, sulfate concentrations in Trench 1 area well 0615 have decreased notably since installation of the trenches in spring 2006—from the maximum of 24,000 mg/L in September 2006 to a low of 4500 mg/L in March 2010 (Figure 2–8). Between March 2003 and September 2007, sulfate concentrations in well 0608, completed in the Mancos Shale, were stable at about 10,000 mg/L. However, sulfate concentrations in this well have since declined; the most recent (March 2010) measurement was 4800 mg/L. Apart from the expected variation attributable to river stage and other influences discussed previously, sulfate concentration trends in remaining wells plotted in Figure 2–8 continue to be relatively stable. The best demonstration of changes in sulfate since the onset of remediation is provided in Figure 1–17 (see plume map comparison). In this figure, marked reductions in sulfate concentrations are apparent, in particular at Trenches 1 and 2, in the well 1089 area. Despite these reductions, sulfate concentrations on the floodplain are still elevated relative to background (see Figure 1–8, 1–11, and Appendix A). During this reporting period, sulfate concentrations in floodplain monitoring wells (excluding background) ranged from 75 to 18,000 mg/L (maximum in well 1008).

Historically, sulfate levels in floodplain background wells have been highly elevated relative to EPA's secondary standard of 250 mg/L. Except for a recent anomalously low measurement in September 2009, sulfate levels in well 0797 have generally been increasing; a maximum of 5200 mg/L was measured in September 2008 (Figure 2−10). In addition to considering background, sulfate concentrations must also be evaluated relative to levels detected in terrace artesian well 0648. The water entering the northwest portion of the floodplain from this well has sulfate concentrations ranging between about 2000 and 3000 mg/L (the most recent measurement, in March 2009, was 2200 mg/L). As shown in Figure 1–8, sulfate concentrations in groundwater in the northwest portion of the floodplain are generally consistent with this artesian groundwater component.

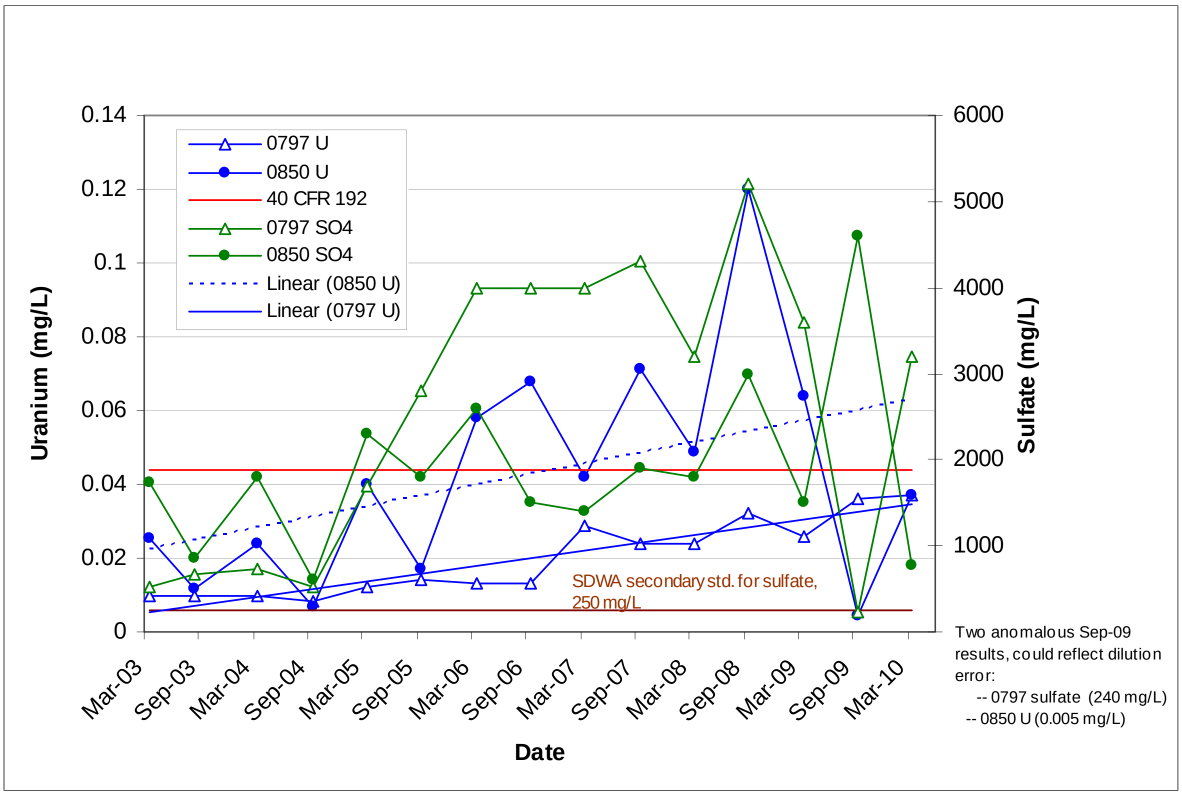

Figure 2–10. Time–Trend Plots of Uranium and Sulfate in Floodplain Background Wells 0797 and 0850

Uranium

As discussed in Figure 1–4 and shown in the corresponding figures (Figures 1–9 through 1–11; Figure 1–18), uranium concentrations are highest around the disposal cell and on the floodplain, at the base of the escarpment and in the Trench 1 and well 1089 areas. In terms of temporal trends, trends for uranium generally parallel those reported for sulfate. As shown in Figure 2–9, for the subset of wells plotted, the most marked decreases are evident in Trench 1 area well 0615. Since the trenches were installed in 2006, uranium concentrations decreased from 4–5 mg/L to about 1 mg/L in the last several years (Figure 2–9). A slight decreasing trend is apparent in wells 0608 and 0618. Uranium concentrations in remaining wells plotted in Figure 2–9 are variable and exhibit no apparent trend. Floodplain-wide, uranium concentrations ranged from 0.005 to 2.5 mg/L in March 2010 (maximum in well 1008). Uranium concentrations are generally highest near the escarpment and between Trench 1 and well 1089 (Figures 1–9 and 1–18). Also, as observed for sulfate and as demonstrated in Figure 2–10, uranium concentrations have been elevated in background wells (relative to the 0.044 mg/L standard), in particular in well 0850.

2.1.3 Floodplain Contaminant Removal

During the remediation system's first 7 years of operation at the Shiprock site, the extraction wells and trenches have removed nearly 750,000 pounds of contaminants from the alluvial groundwater system (see Table 3–2). The addition of the two drainage trenches in spring 2006 has enhanced the amount of groundwater and mass of constituents removed from the alluvial system. It is also likely that pumping of groundwater from the floodplain is preventing contaminant discharge to the San Juan River, as concentrations of nitrate and uranium in river samples have remained below previously established upgradient background benchmark values, including during low-flow periods, since 2004 (Figure 2–11).

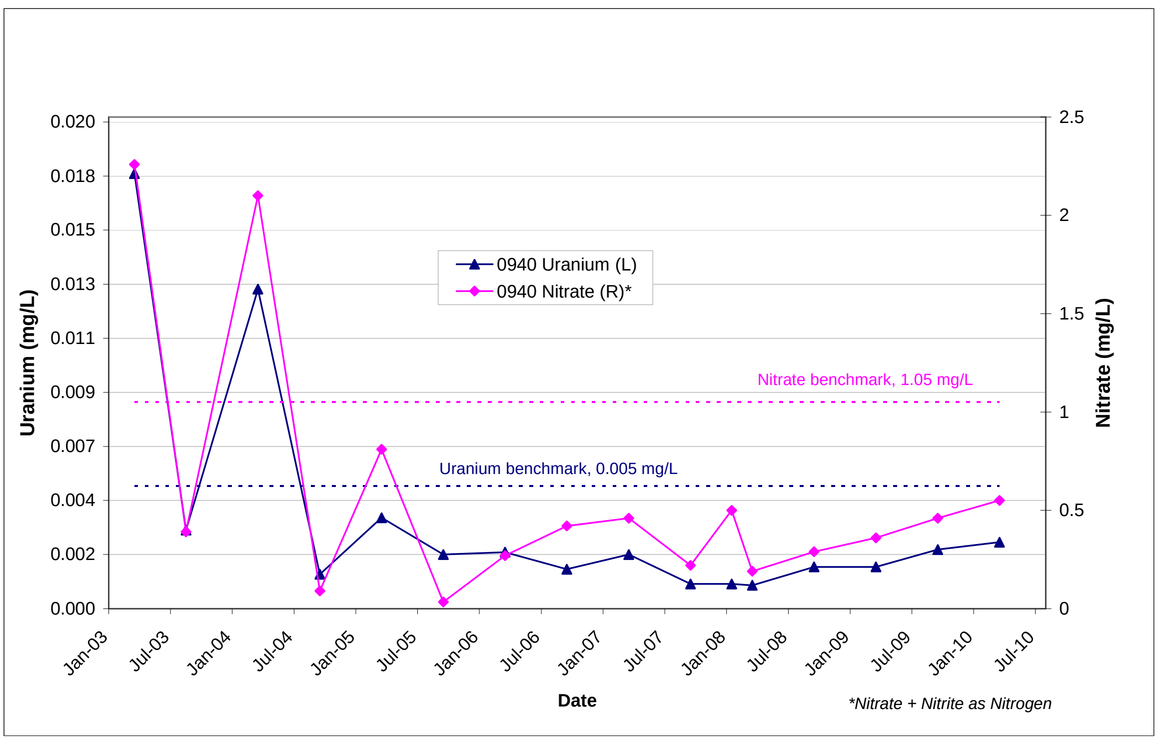

Figure 2–11. Uranium and Nitrate Concentrations in the San Juan River (Location 0940)

As shown in Figure 2–11, uranium and nitrate trends are correlated, and a very slight increase is apparent in recent years (2008 to 2010). To supplement the time-trend plot above, the box plots shown in Figure 2–12 show the historical distribution of uranium and the two other primary COCs, nitrate and sulfate, at all San Juan River sample locations. In these plots, locations are ordered (from left to right) by direction of river flow (upstream to downstream); 0898, the easternmost river sample location in Figure 1–2 is the upstream (background) location. The plots in Figure 1–12 show that, apart from the historical elevated concentrations at 0940 noted previously, there are no significant differences between the upstream and downstream locations. For all COCs plotted, historical distributions are very similar, indicating no apparent significant influence from the site.

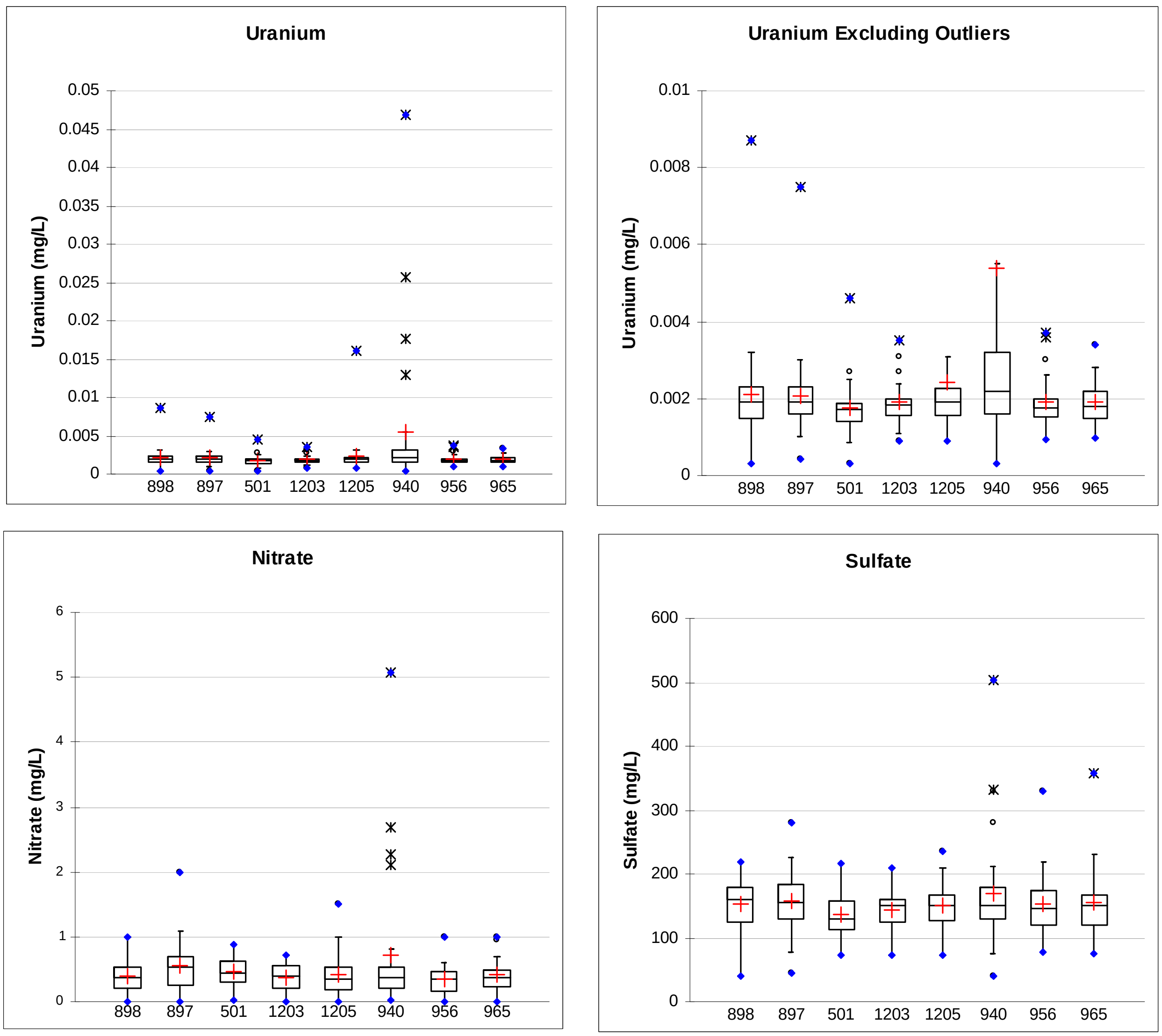

Figure 2–12. Historical Distributions of Uranium, Nitrate, and Sulfate at San Juan River Sample Locations[†]

[†] The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of uranium nitrate, and sulfate for each San Juan River sampling location; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box.

2.2 Terrace System Subsurface Conditions

The discussion of current subsurface conditions on the terrace is based on collection and analysis of groundwater level data through March 2010. Analyses of groundwater level trends and flow directions, drain flow rates, and seep flow rates associated with the terrace are discussed below. Results are compared to baseline conditions established in March 2003 in the Baseline Performance Report (DOE 2003) to evaluate the effectiveness of the terrace treatment system.

Currently, there are no concentration-driven performance standards for the terrace system because the compliance strategy is active remediation (hydrologic control) to eliminate exposure pathways at escarpment seeps and at Bob Lee and Many Devils Washes. As a best management practice, selected contaminant concentrations are measured at each extraction well, drain, and seep. Estimates of mass removal from the terrace system, compiled during this performance period, are presented in Section 3.2.3 of this report.

2.2.1 Terrace Groundwater Level Trends

Groundwater level data from the terrace collected during the March 2010 sampling event were compared to baseline groundwater elevation data from March 2003 reported in the Baseline Performance Report (DOE 2003). Figure 2–13 presents a qualitative map view of some of the changes in groundwater elevation during this period. This figure demonstrates that groundwater elevations have declined across the entire terrace groundwater system.

For wells screened in the alluvium, of the 32 groundwater level measurements taken in September 2009 or March 2010, the majority show declines relative to the baseline period of March 2003. Declines ranged from 0.02 ft to a maximum decrease of 6.1 ft in well 0848, located in the west terrace; the average decrease was 1.9 ft. As was the case last year (DOE 2009a), well 0730, located southwest of the disposal cell, was dry at the time of the March 2010 sampling event (a groundwater level decline of 4.7 ft was reported in 2008 [DOE 2008]).

As presented in greater detail in the following section, as of March 2010, the cumulative volume of water removed from the terrace extraction system since pumping began was approximately 21.3 million gallons. Pumping records indicate that approximately 2.7 million gallons were removed between April 2009 and April 2010. In 2010, the water levels in each of these wells had declined both relative to baseline conditions and, at some wells, relative to water level measurements made in 2009. Thus, it can generally be concluded that the extraction well field is resulting in the desired effect on groundwater levels in the terrace.

Water levels have also been monitored using pressure transducers connected to dataloggers in selected wells on the terrace. Plots of groundwater elevations versus time are shown in Figure 2−14 and Figure 2–15 for wells screened in shallower (water level elevations greater than 4930 ft) and deeper zones, respectively. Linear trend lines shown in Figure 2–14 indicate a decrease in water levels during the time of observation in most of the wells, although not of the magnitude reflected in Figure 2−13 (based on manual measurements). However, with the exception of well 0836, plots of groundwater elevation data for wells screened in deeper zones show little decrease.

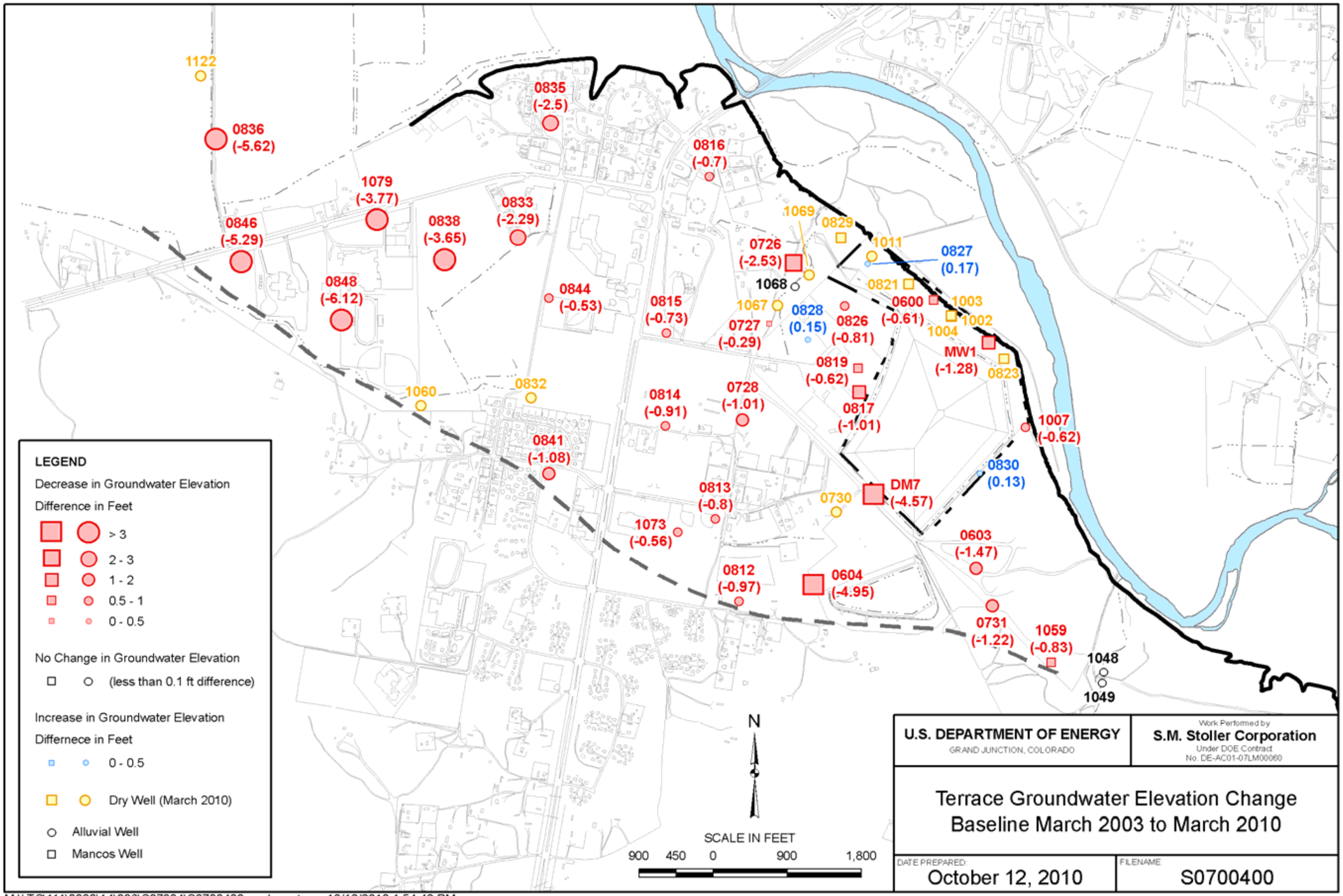

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Figure 2–13. Terrace Groundwater Elevation Changes from Baseline (March 2003) to Current (March 2010) Conditions

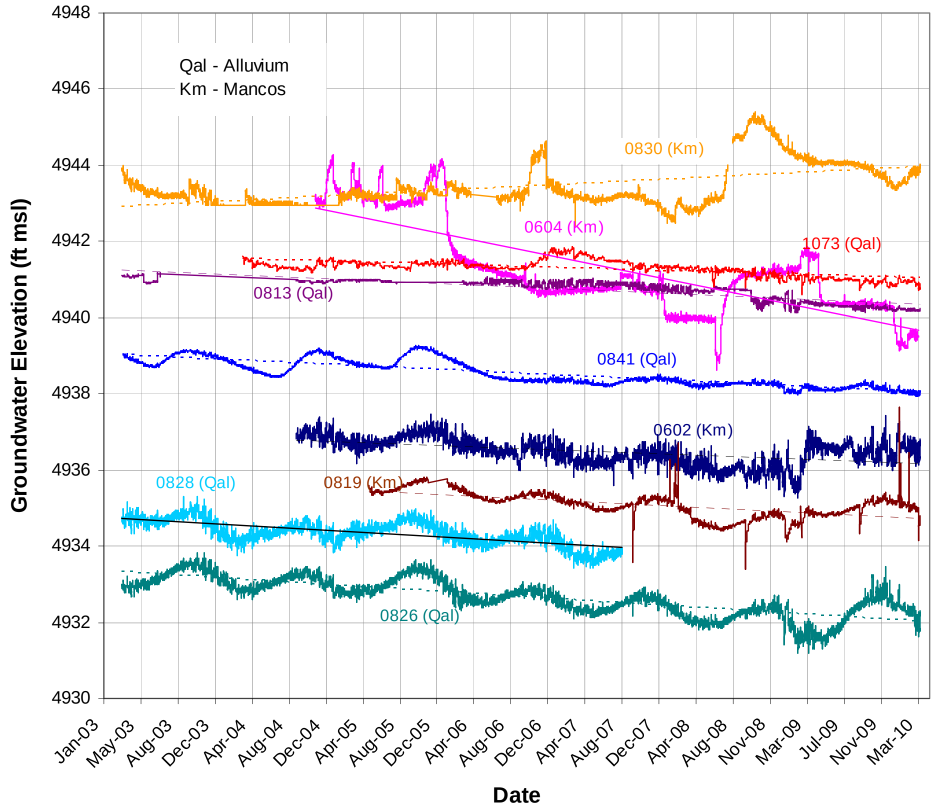

Figure 2–14. Terrace Datalogger Measurements, Wells with Water Elevations above 4930 ft

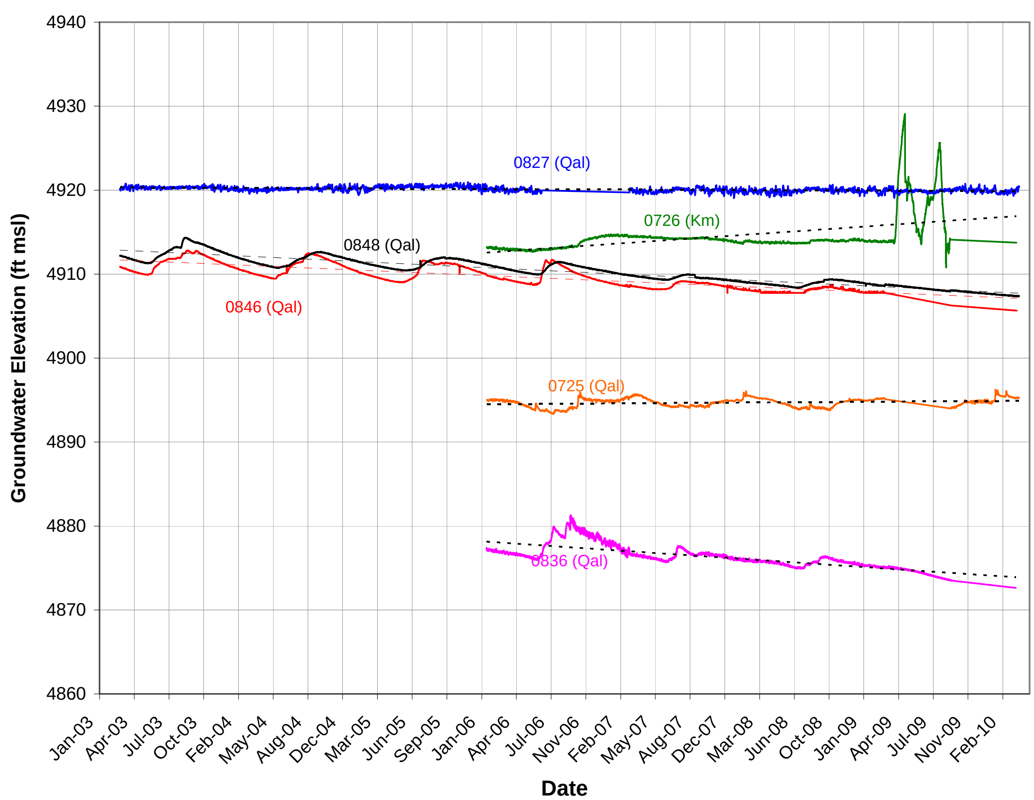

Figure 2–15. Terrace Datalogger Measurements, Deeper Wells

2.2.2 Drain Flow Rates

As discussed in the Baseline Performance Report (DOE 2003), the flow rates of the pumps removing water from the drains installed in Bob Lee Wash and Many Devils Wash were expected to decrease as groundwater levels in the terrace declined. Between April 2009 and March 2010, the average pumping rate from Bob Lee Wash was 2.6 gpm, comparable to the rate of 2.1 gpm reported last year (refer to Figure 3–16 in the following section) .

The average pumping rate from Many Devils Wash during the performance period was about 1 gpm (see Figure 3–17), about three times greater than the 0.3 gpm rate reported last year. This increased efficiency may be attributable to the installation of a diversion structure in August 2009. This structure was installed because of declining effectiveness of the collection drain and to better capture contaminated surface water in the wash. Shortly after installation, the flow rate of water from the sump increased from about 0.4 gpm to 0.8 gpm.

In response to stakeholder concerns that large storms could generate runoff from Many Devils Wash and result in contaminant loading to the San Juan River, DOE installed an automated sampling system in the lower end of the wash in May 2009. The automated sampler, monitored via telemetry, is designed to begin collecting samples with any increase in flow resulting in a surface water elevation increase of 2 inches, and to collect additional samples for each subsequent 2-inch increase in surface water elevation.[10]

[10] The only major storm since the sampler was installed occurred in October 2010 (after this reporting period); no samples were collected because the storm damaged the sampler. The sampler was repaired and re-installed.

3.0 Remediation System Performance

This section describes the key components of the floodplain and terrace groundwater remediation systems and summarizes their performance for the 2009–2010 reporting period.

3.1 Floodplain Remediation System

The floodplain remediation system consists of the three major components shown in Figure 1–1: two extraction wells (wells 1089 and 1104); two drainage trenches (horizontal wells), Trench 1 and Trench 2; and a sump (collection drain) used to collect discharges from seeps 0425 and 0426 on the escarpment. The objective of the floodplain groundwater extraction system is to reduce the mass of COCs in alluvial groundwater near the San Juan River and to lessen exposure and potential risks to aquatic life. All groundwater collected from the floodplain extraction wells and trenches is piped south to the terrace and discharged into the evaporation pond.

3.1.1 Extraction Well Performance

The floodplain extraction well system consists of wells 1089 and 1104 (Figure 1–1). These wells were constructed using slotted culverts placed in trenches excavated to bedrock. Corresponding pumping rates and cumulative volumes of groundwater extracted are plotted in Figures 3–1 and 3–2. From April 2009 through March 2010, approximately 3 million gallons of water were removed from well 1089 at an average pumping rate of 5.9 gpm.[11] These values are comparable to those reported last year (DOE 2009a). Pumping rates at well 1104 were much lower than at well 1089, averaging about 0.6 gpm and yielding a total cumulative extracted volume of nearly 297,000 gallons. During the 7-year period since the start of operations in March 2003 through the end of March 2010, totals of approximately 19.7 and 3.4 million gallons of water have been removed from wells 1089 and 1104, respectively.

3.1.2 Floodplain Drain System Performance

In spring 2006, two drainage trenches—Trench 1 (1110) and Trench 2 (1109)—were installed in the floodplain just below the escarpment to enhance the extraction of groundwater from the alluvial system (Figure 1–1). Pumping began in April 2006. From April 2009 through March 2010, approximately 3.8 million gallons of water were removed from Trench 1 at an average pumping rate of 9.0 gpm (Figure 3–3). Although the average pumping rate is comparable to that reported for the 2008–2009 performance evaluation period (9.2 gpm; DOE 2009a), the cumulative volume was lower than last year's production of 4.9 million gallons.

In 2009–2010, nearly 2.3 million gallons of water were removed from Trench 2 at an average pumping rate of 15.2 gpm (Figure 3–4). Although this rate is similar to that reported last year (16.1 gpm average, DOE 2009a), the annual extracted volume is markedly lower than the approximate 8.5 million gallons pumped in 2008–2009. This reduction in annual extracted volume is attributable to the fact that pumping at Trench 2 was shut down periodically to increase evaporation pond capacity and maintain safe pond water levels (see Section 3.2.3 for further discussion).

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[11] In the text of this report, total volumes are rounded (e.g., to the nearest thousand or larger); corresponding non-rounded values are shown in the figures and are listed in Table 3–2. Also (important to consider in any comparisons), average pumping rates reported here are for pumping conditions only (zero values are excluded).

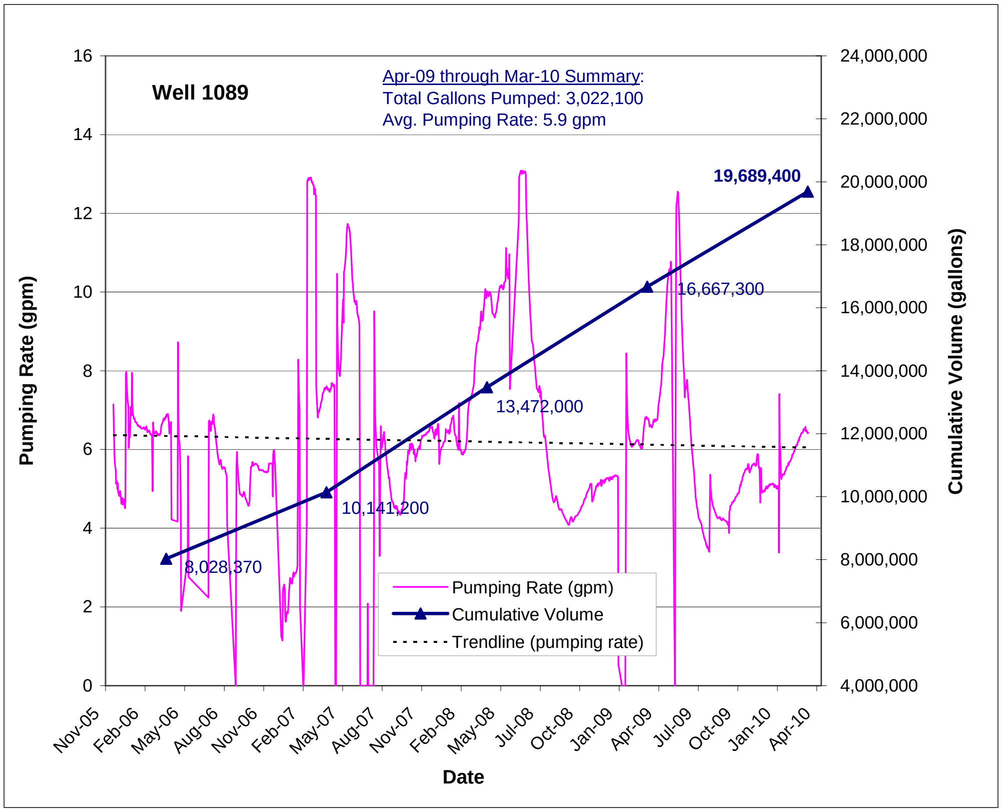

Figure 3–1. Floodplain Well 1089 Pumping Rate and Cumulative Groundwater Volume Extracted

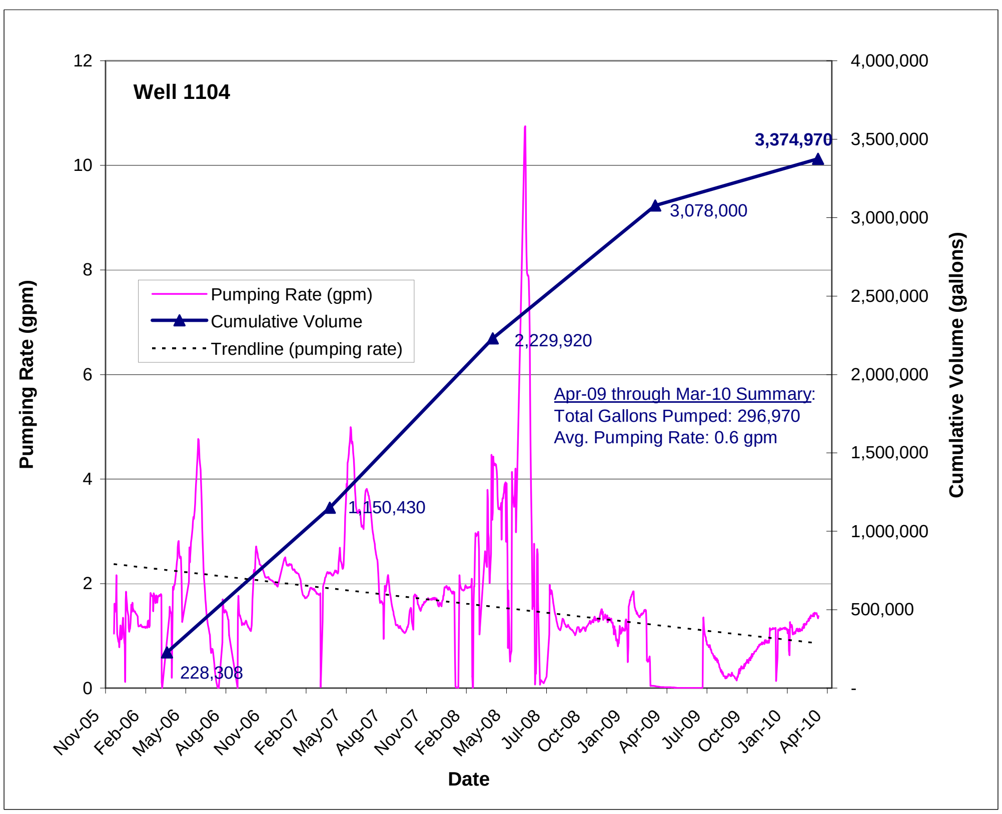

Figure 3–2. Floodplain Well 1104 Pumping Rate and Cumulative Groundwater Volume Extracted

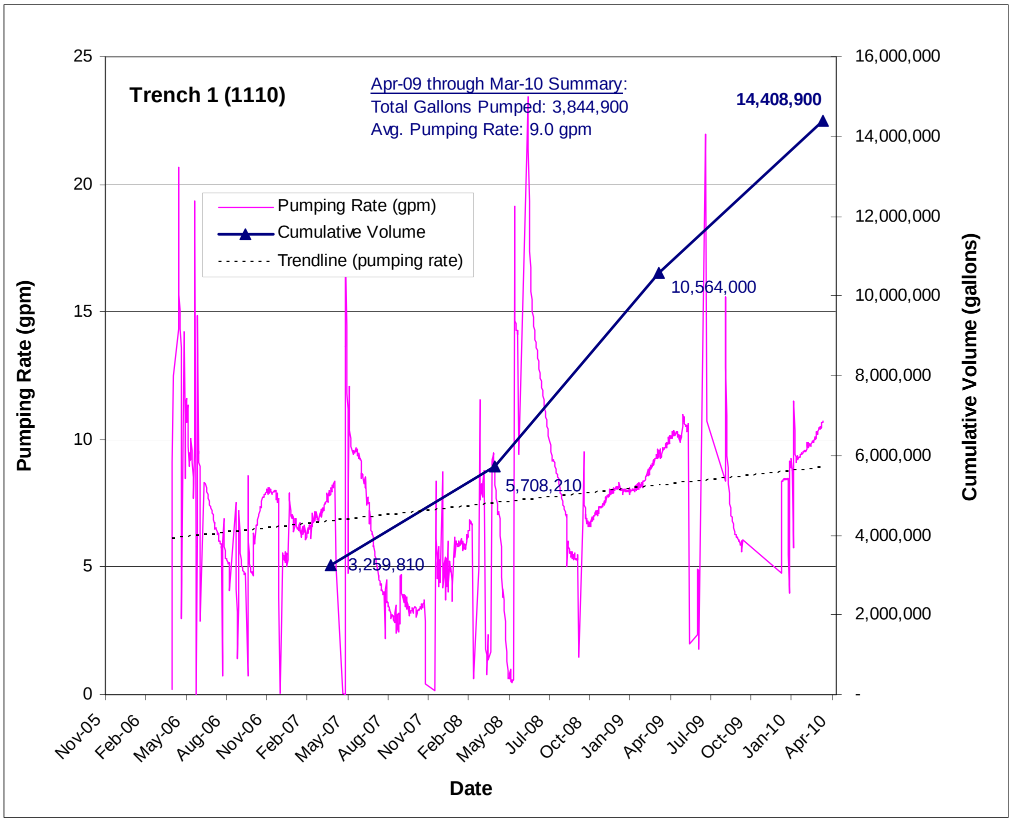

Figure 3–3. Floodplain Trench 1 Pumping Rate and Cumulative Groundwater Volume Extracted

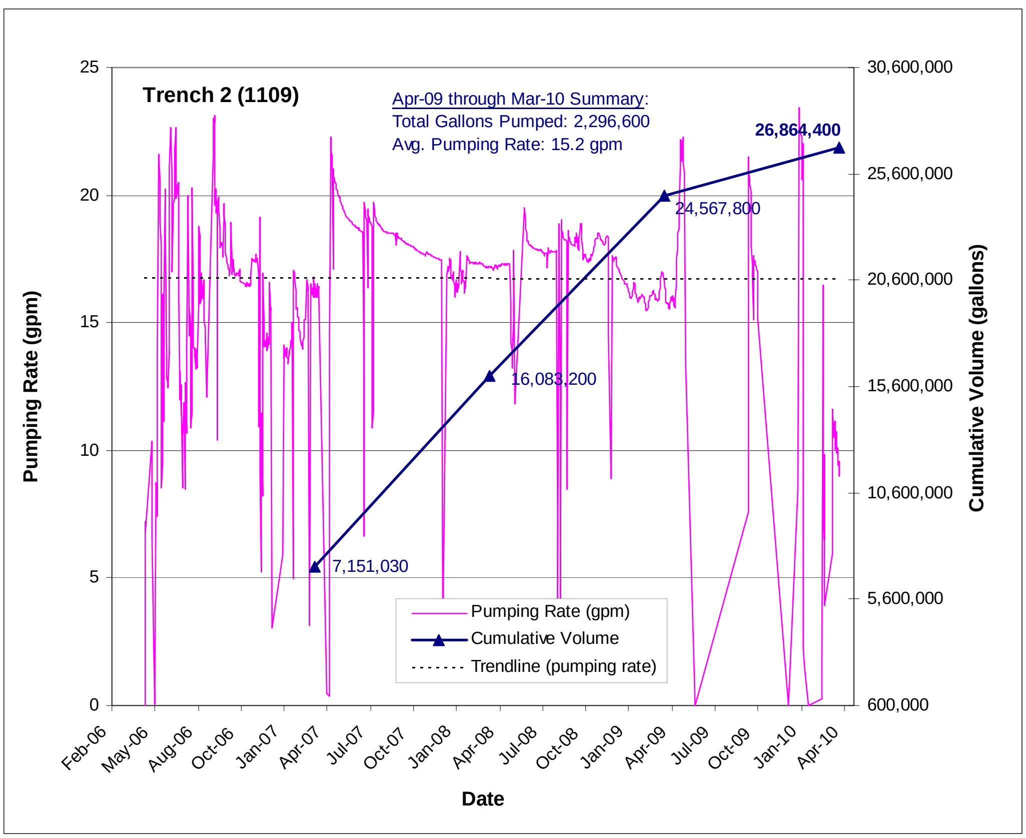

Figure 3–4. Floodplain Trench 2 Pumping Rate and Cumulative Groundwater Volume Extracted

3.1.3 Floodplain Seep Sump Performance

In August 2006, seeps 0425 and 0426 were incorporated into the remediation system. Groundwater discharge from these two seeps is piped into a collection drain (1118 in Figure 1–1) and then pumped to the evaporation pond. From April 2009 through March 2010, the average discharge rate from the seep collection drain was 0.35 gpm (essentially equal to the 0.34 gpm rate reported for 2008–2009). Approximately 182,000 gallons were pumped from the seeps during this period, yielding a total cumulative volume of about 1.2 million gallons. Figure 3–5 plots the historical rates of groundwater discharge from the escarpment seeps, showing the gradual decline in flows over the last several years. Also, with few exceptions, flows have generally been below the previously established goal of 0.9 gpm since spring 2008 (see DOE 2005, DOE 2010a).

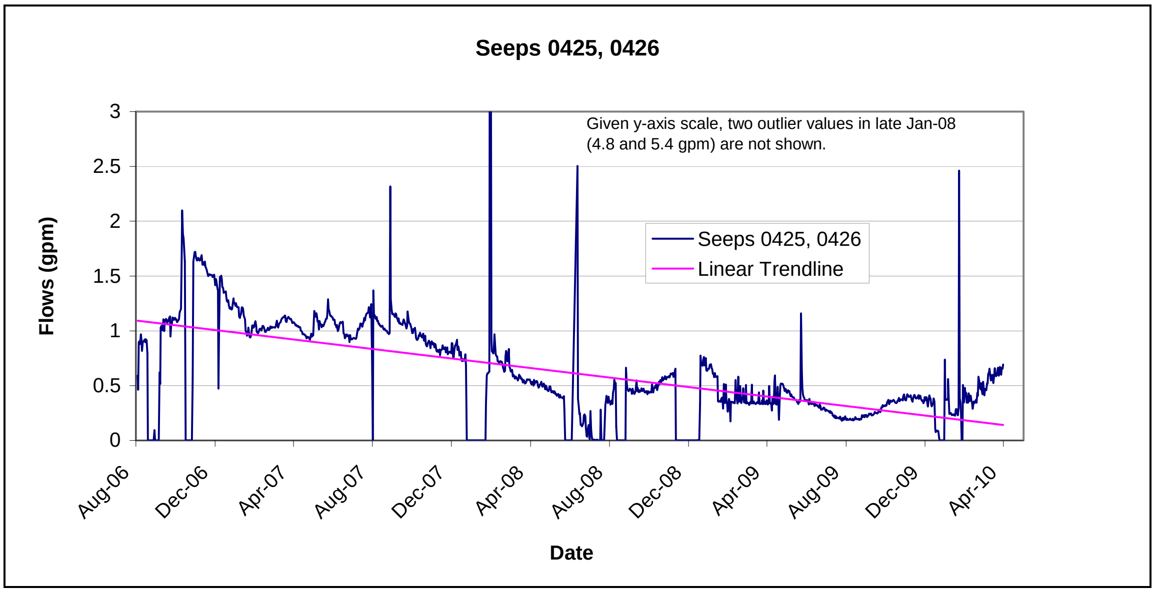

Figure 3–5. Historical Seep Flows (Seeps 0425 and 0426)

3.2 Terrace Remediation System

The objective of the terrace remediation system is to remove groundwater from the southern portion of the terrace area so that potential exposure pathways at seeps and at Bob Lee Wash and Many Devils Wash are eventually eliminated, and the flow of groundwater from the terrace to the floodplain is reduced. The terrace remediation system consists of four major components shown in Figure 1–1: the extraction wells, the evaporation pond, the terrace drains (Bob Lee Wash and Many Devils Wash), and the terrace outfall drainage channel diversion. DOE also continues to evaluate the feasibility of phytoremediation on the terrace, using deep-rooted plants to enhance evapotranspiration in the radon barrier borrow pit area south of the disposal cell, and also between the disposal cell and the escarpment. The goal of phytoremediation in these areas is hydraulic control, to limit the spread of contaminants in groundwater.

3.2.1 Extraction Well Performance

During the current period, the terrace remediation well field consisted of wells 0818, 1070, 1071, 1078, 1091, 1092, 1093, 1095, and 1096 (Figure 1–1). Table 3–1 compares the average pumping rate and total groundwater volume removed from each extraction well for the current (2009-2010) and previous (2008–2009) reporting periods.

Table 3–1. Terrace Extraction Wells: Average Pumping Rates and Total Groundwater Volume Removed

Well	Previous Period (April 1, 2008, through March 31, 2009)		Current Period (April 1, 2009, through March 31, 2010)	
	Average Pumping Rate (gpm)	Total Groundwater Volume Removed (gallons)	Average Pumping Rate (gpm)	Total Groundwater Volume Removed (gallons)
0818	0.13	67,413	0.44	227,890
1070	0.012	6307	0.015	6450
1071	0.0006	287	0.001	297
1078	0.28	148,730	0.25	136,510
1091	0.0004	189	0.019	4952
1092	0.00002	12	0.00001	7
1093R	0.75	396,577	0.6	124,030
1095	0.5	260,910	0.5	225,170
1096	0.5	266,560	0.38	135,670
Total	**2.2**	**1,146,985**	**2.2**	**860,976**

As shown in Table 3–1, the current-period average pumping rates ranged from 0.00001 gpm to 0.6 gpm, and the total groundwater volume removed from each well during this period ranged from only 7 gallons (well 1092) to approximately 228,000 gallons (well 0818). The cumulative total volume removed during the current period was approximately 25 percent less than during the previous reporting period. This decrease in annual extracted volume is expected to continue as more water is removed from the aquifer.

As discussed in greater detail in the recent review of the Shiprock remediation strategy (DOE 2010a), one of the initial objectives for the terrace remediation system was attainment of a cumulative 8 gpm extraction rate, a goal based on groundwater modeling conducted for the SOWP (see DOE 2000, DOE 2002, and DOE 2005). To help meet this objective, DOE expanded the terrace extraction well network between 2005 and 2007. Two new wells (1095 and 1096) were installed near the evaporation pond in March 2005. In September 2007, DOE installed a new large-diameter well (1093R) to increase the probability of collecting a larger volume of water. Despite these enhancements to the terrace extraction system, the 8 gpm objective has not been achieved. As shown in Figure 3–6, the combined pumping rate from terrace extraction wells has ranged between 2 and 4 gpm, below the 8 gpm objective.

Pumping rates and corresponding cumulative groundwater volumes removed from individual terrace extraction wells are presented in Figures 3–7 through 3–15. Although active remediation began in March 2003, these figures only plot data after 2004–2005, when site remediation system wells and drains were instrumented with LM's automated telemetry data collection system, referred to as System Operation and Analysis at Remote Sites (SOARS).

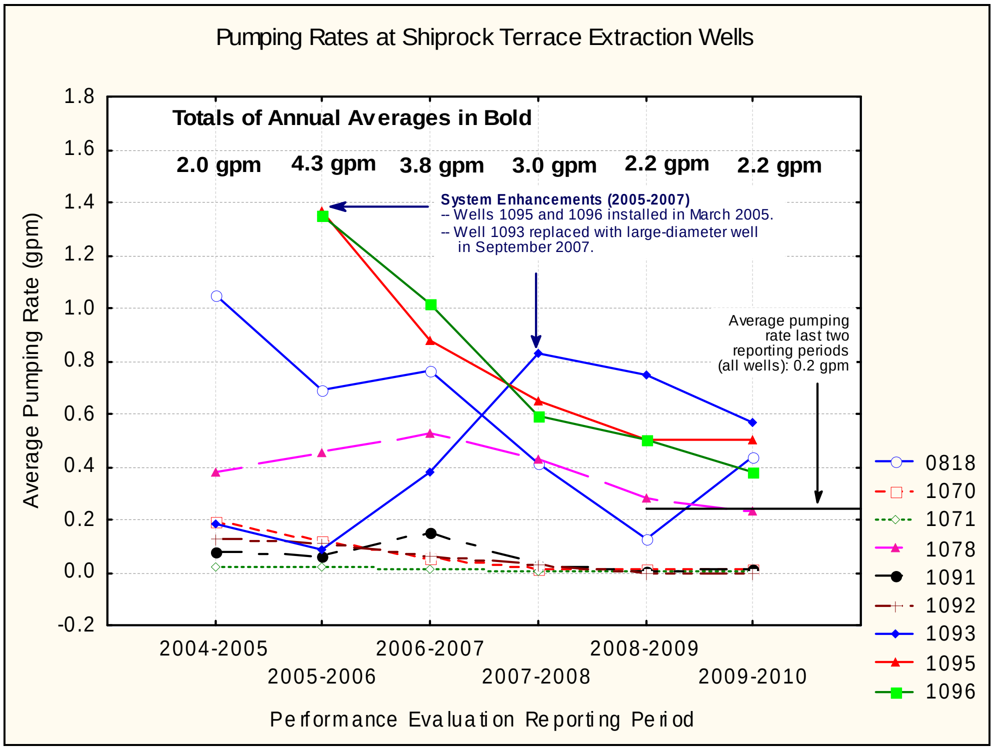

Figure 3–6. Historical Pumping Rate Summary for Terrace Extraction Wells

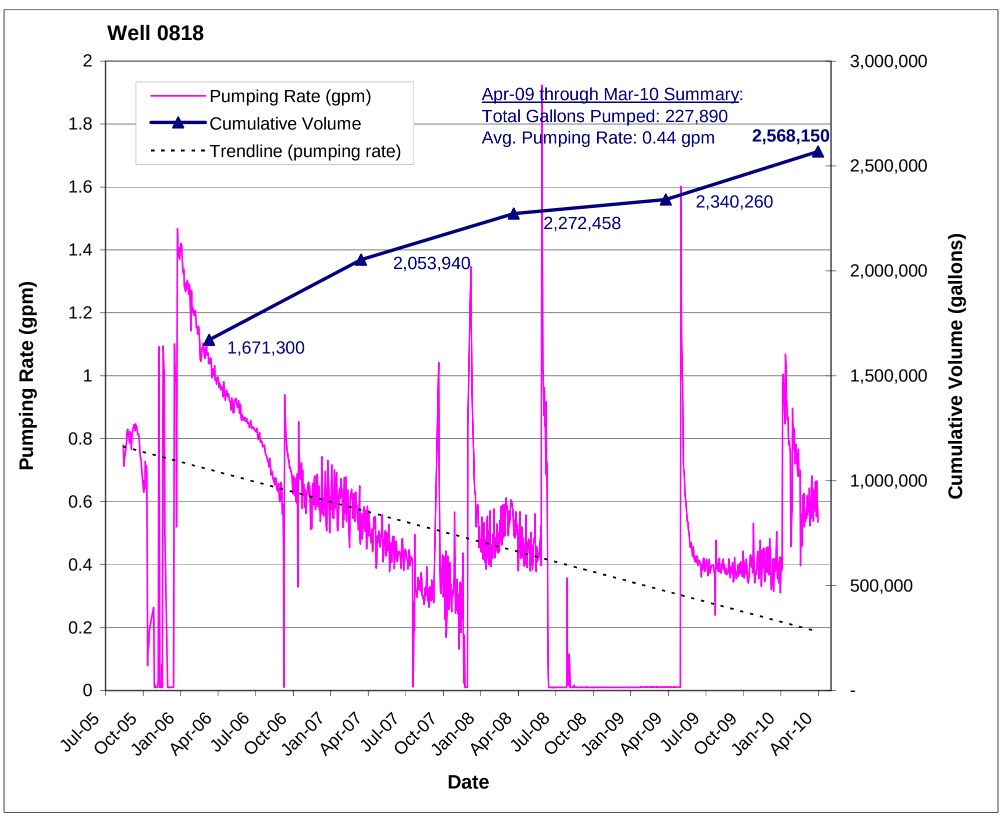

Figure 3–7. Terrace Well 0818 Pumping Rate and Cumulative Groundwater Volume Extracted

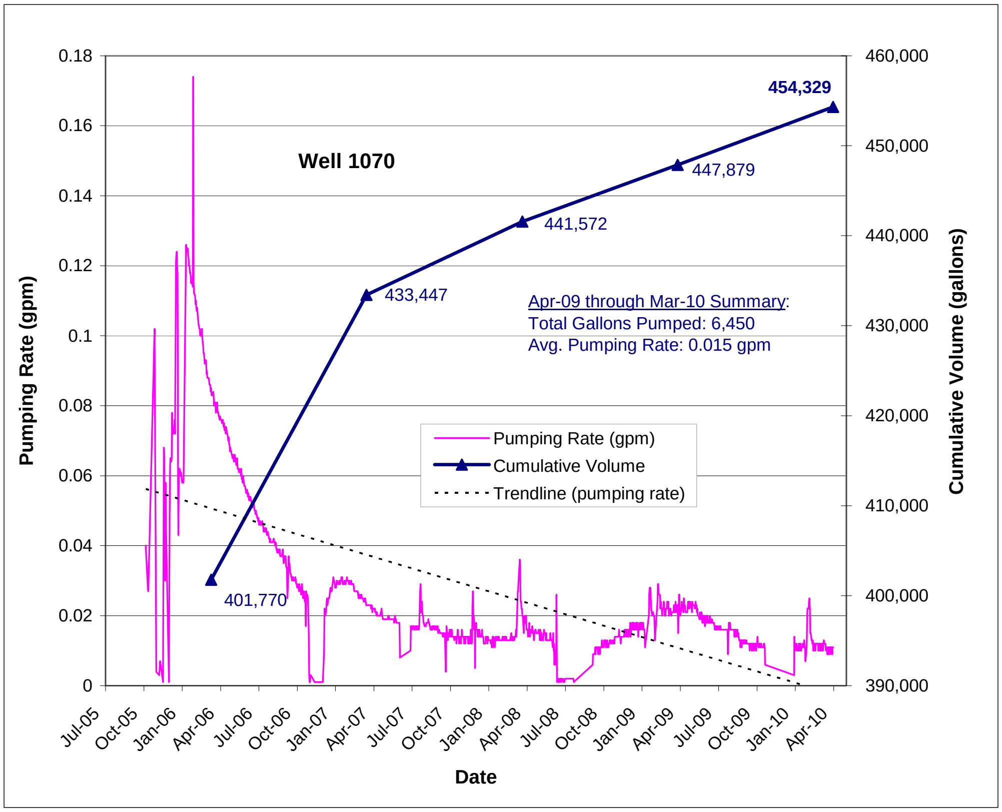

Figure 3–8. Terrace Well 1070 Pumping Rate and Cumulative Groundwater Volume Extracted

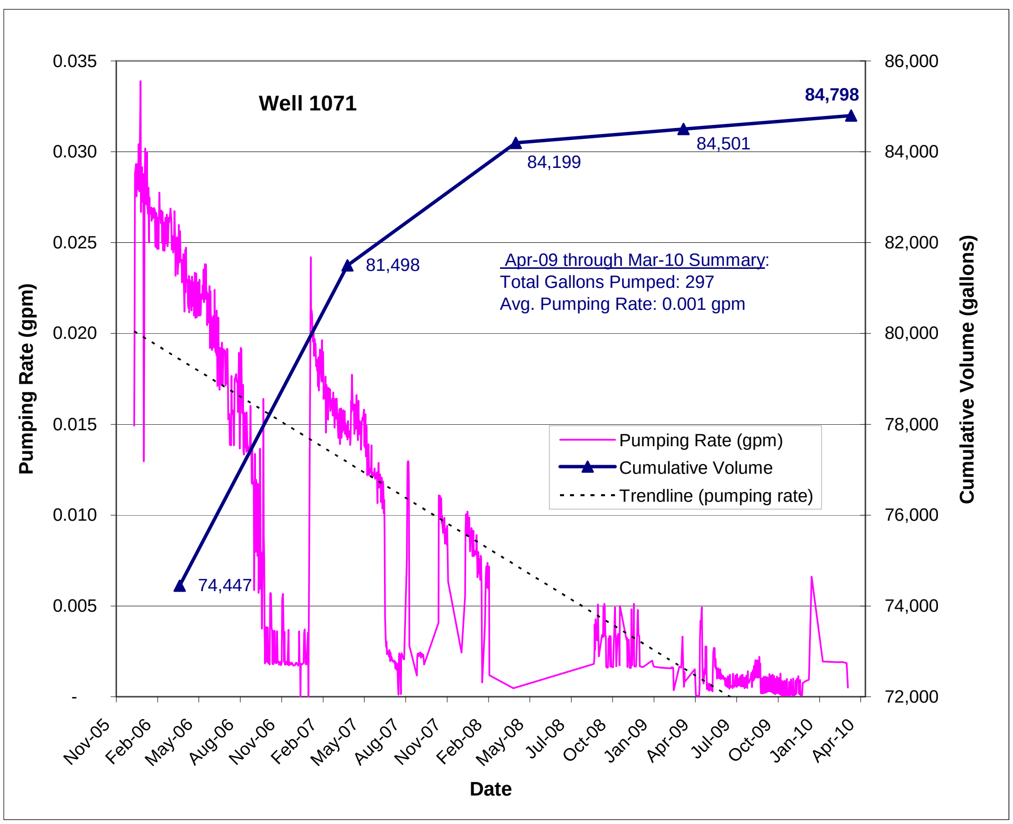

Figure 3–9. Terrace Well 1071 Pumping Rate and Cumulative Groundwater Volume Extracted

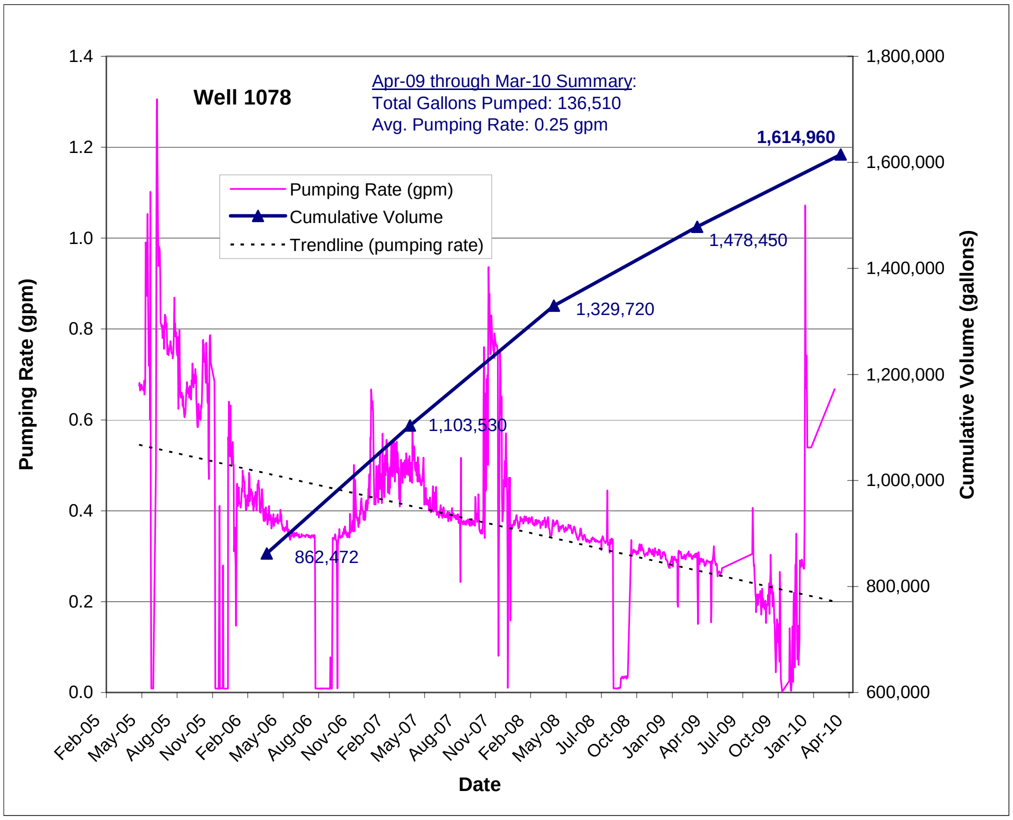

Figure 3–10. Terrace Well 1078 Pumping Rate and Cumulative Groundwater Volume Extracted

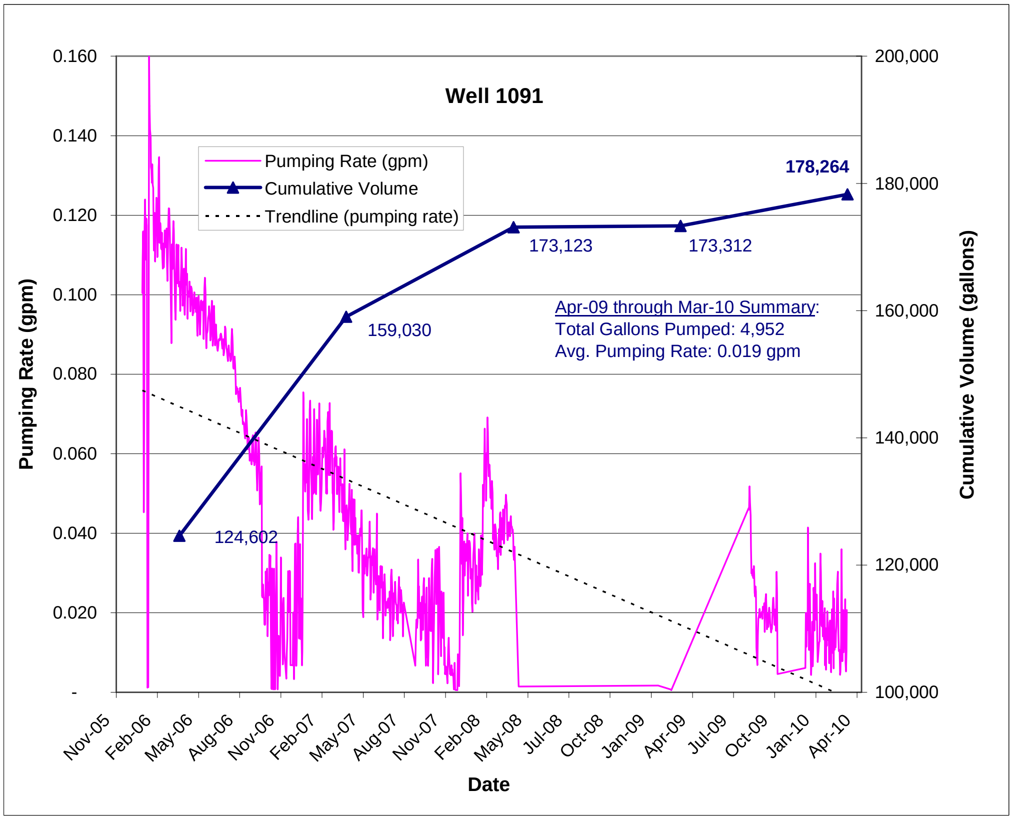

Figure 3–11. Terrace Well 1091 Pumping Rate and Cumulative Groundwater Volume Extracted

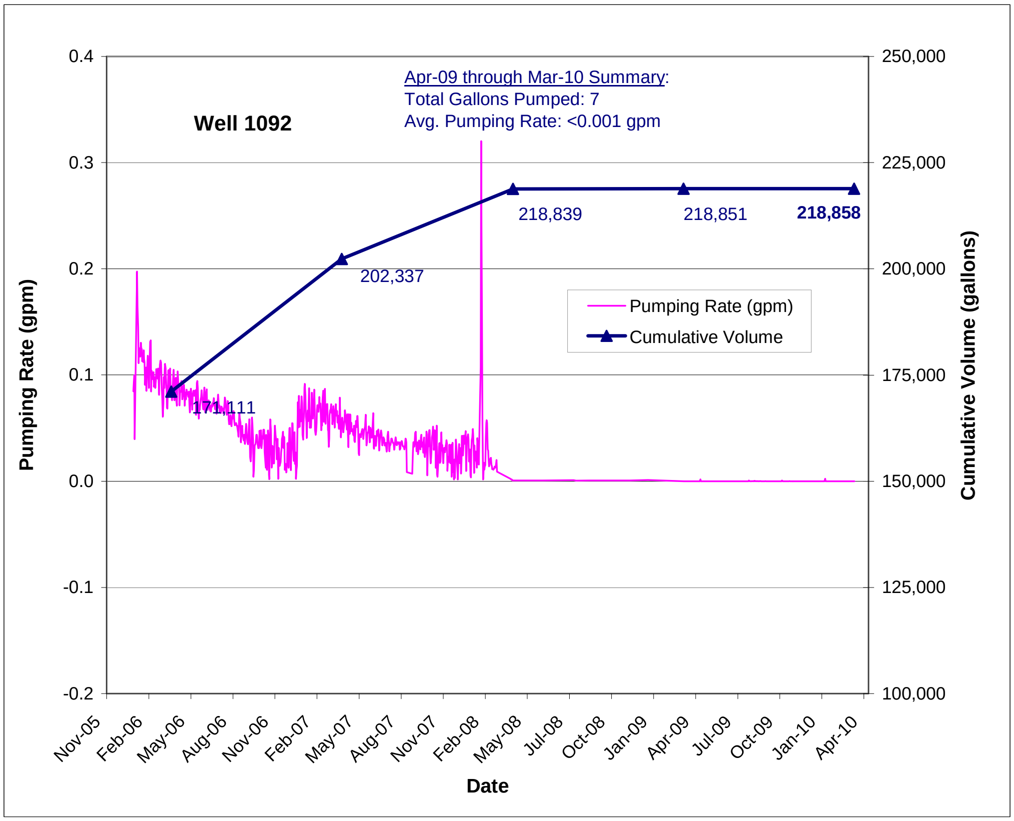

Figure 3–12. Terrace Well 1092 Pumping Rate and Cumulative Groundwater Volume Extracted

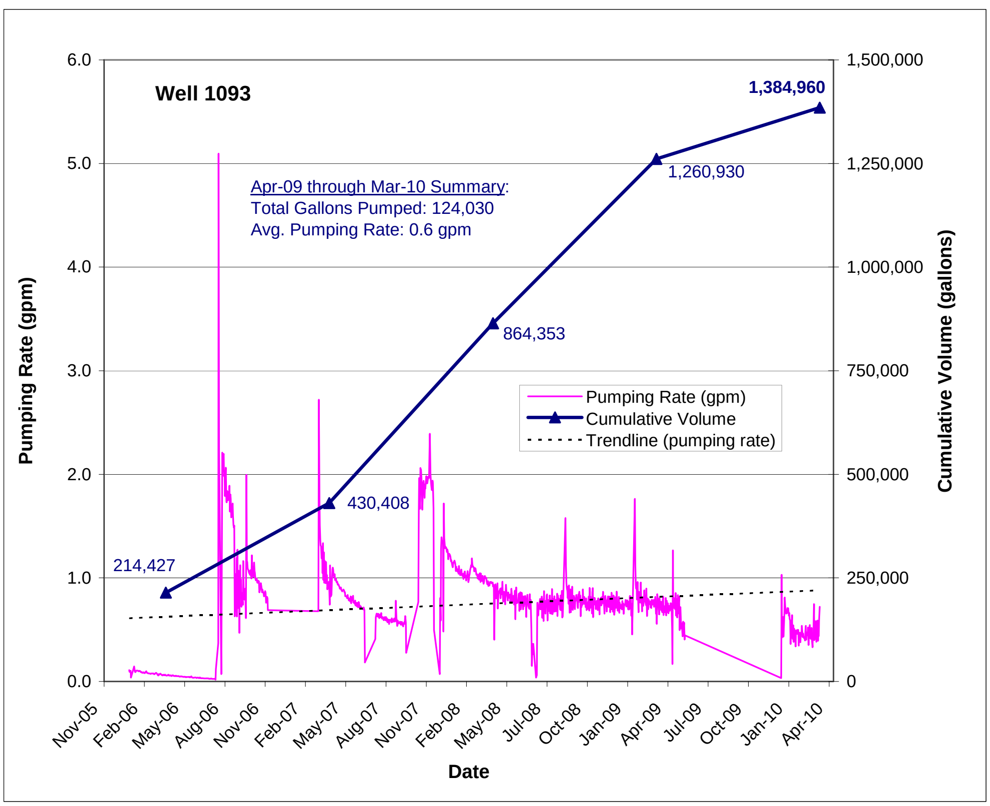

Figure 3–13. Terrace Well 1093 Pumping Rate and Cumulative Groundwater Volume Extracted

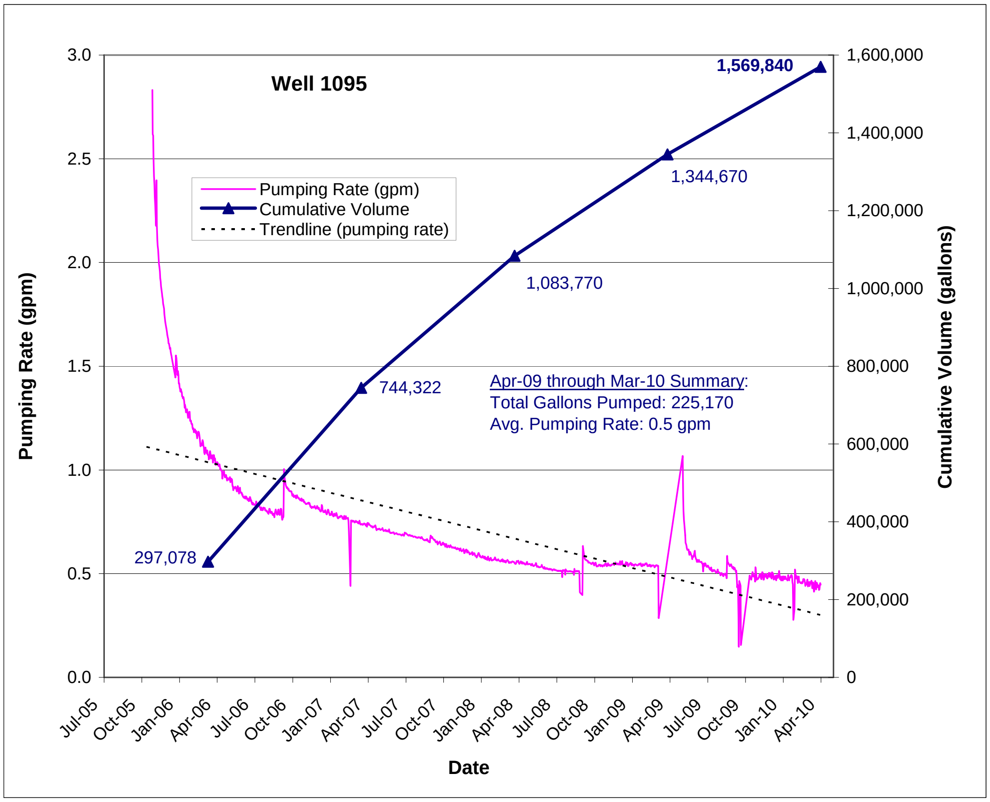

Figure 3–14. Terrace Well 1095 Pumping Rate and Cumulative Groundwater Volume Extracted

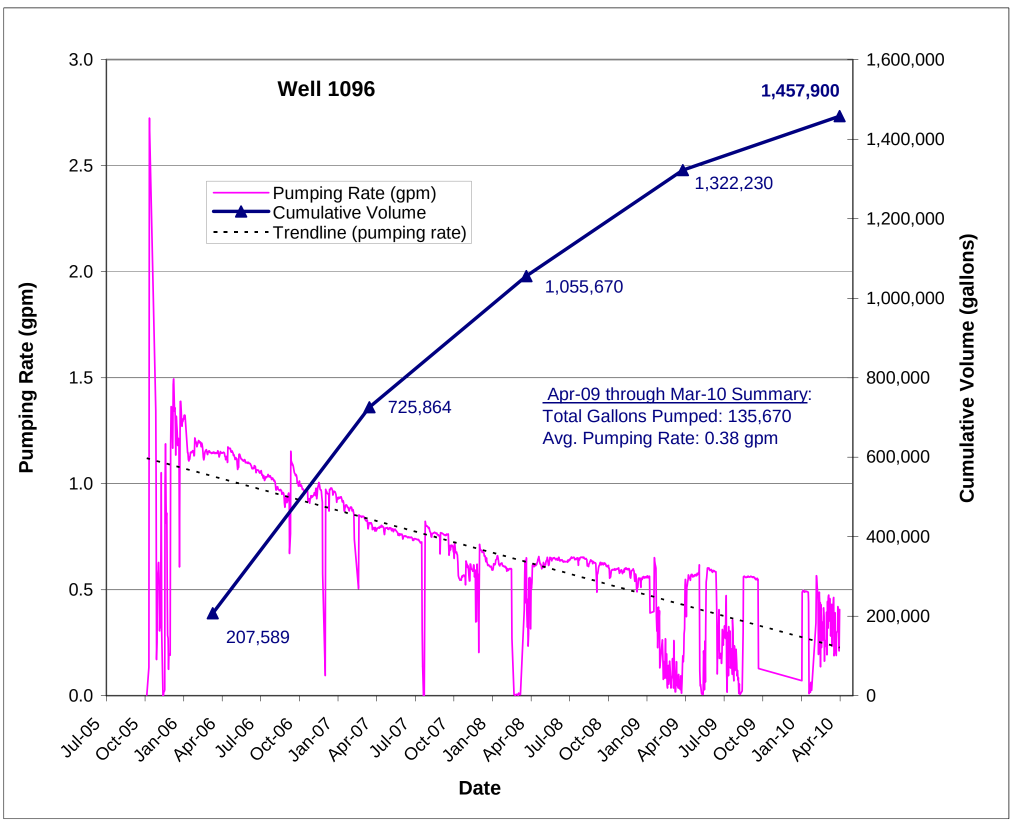

Figure 3–15. Terrace Well 1096 Pumping Rate and Cumulative Groundwater Volume Extracted

3.2.2 Terrace Drain System Performance

The terrace extraction system collects seepage from Bob Lee Wash and Many Devils Wash using subsurface interceptor drains. These drains, which consist of perforated pipe surrounded by drain rock and lined with impermeable geomembrane and geotextile filter fabric, are offset from the centerline of each wash to minimize the infiltration of surface water. All water collected by these drains is pumped through a pipeline to the evaporation pond.

Extraction rates and cumulative flow volumes for the pump installed in the Bob Lee Wash (location 1087) drain are plotted in Figure 3–16. During the current performance period, the average pumping rate from Bob Lee Wash was 2.6 gpm, and the groundwater interceptor drain removed approximately 1.4 million gallons of water.

The pumping rates and volume of water removed from the groundwater interceptor drain in Many Devils Wash (location 1088) are plotted in Figure 3–17. During the current performance period, the average pumping rate from Many Devils Wash was 0.96 gpm, and the groundwater interceptor drain removed approximately 468,000 gallons of water. As discussed in the previous section, because of increasing flows and apparent decreased effectiveness of the drain, DOE installed a diversion structure in August 2009.

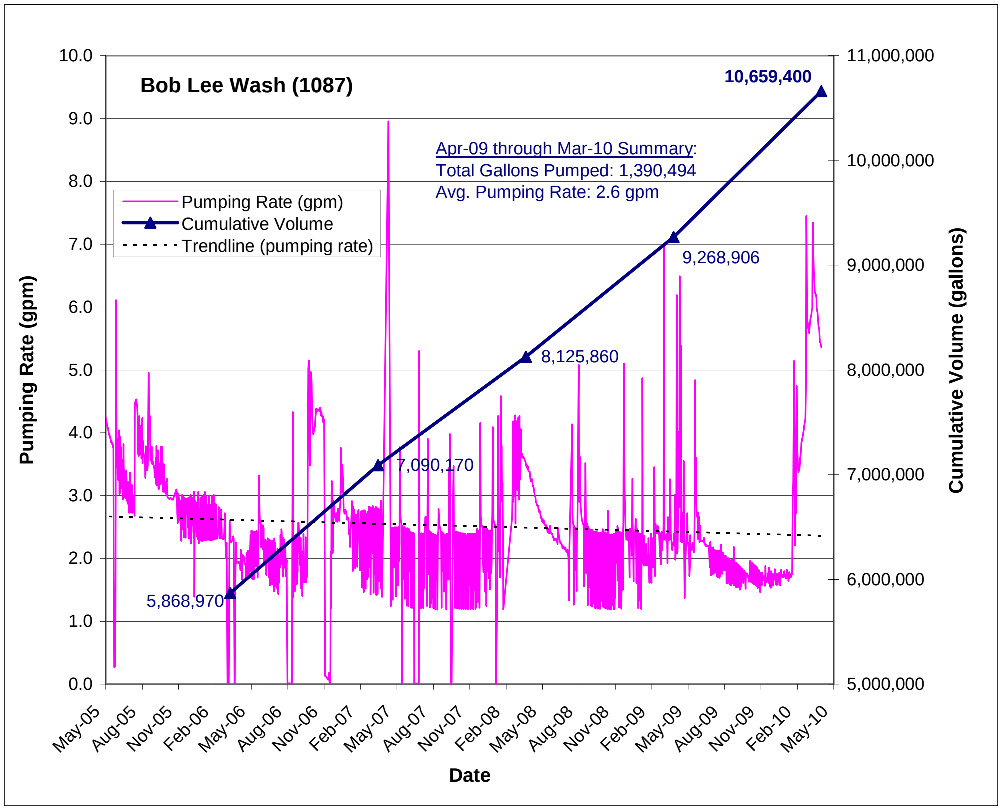

Figure 3–16. Bob Lee Wash Pumping Rate and Cumulative Groundwater Volume Extracted

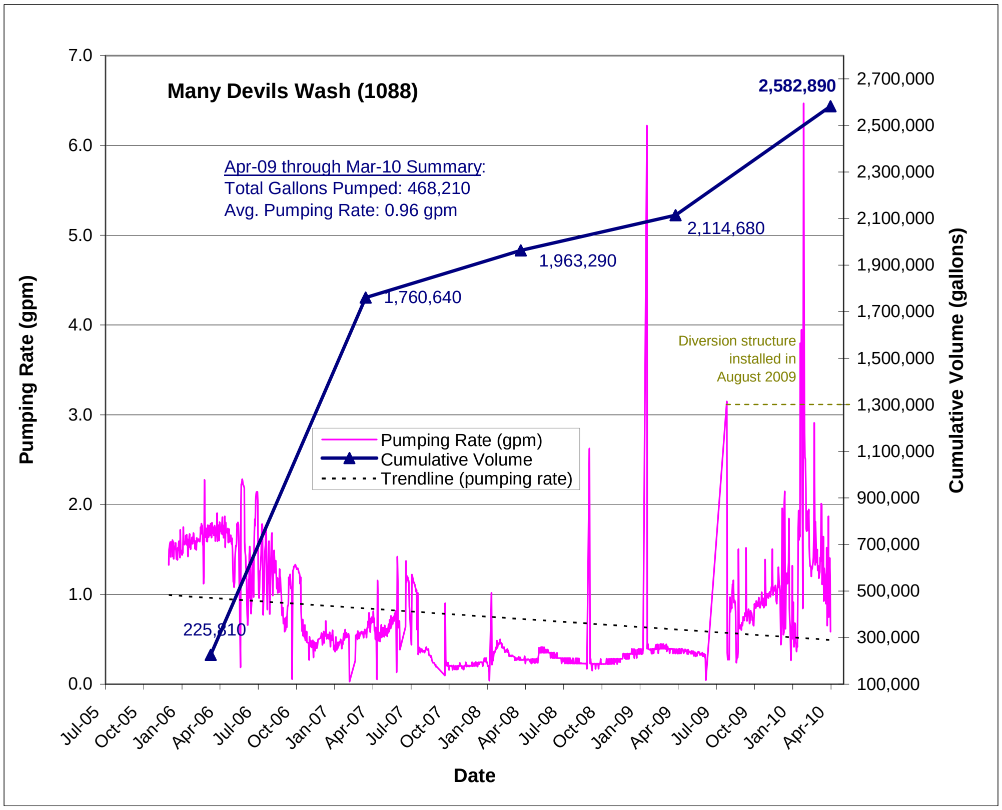

Figure 3–17. Many Devils Wash Pumping Rate and Cumulative Groundwater Volume Extracted

3.2.3 Evaporation Pond

The selected method for handling groundwater from the interceptor drains and extraction wells is solar evaporation. The contaminated groundwater is pumped to a lined evaporation pond in the south part of the radon cover borrow pit area (Figure 1–1). The average water level in this 11-acre pond was 5.2 ft in March 2010 (measured as the distance above transducers), leaving approximately 2.8 ft of unfilled pond capacity.

From April 2009 through March 2010, approximately 12.4 million gallons of extracted groundwater were pumped to the evaporation pond. The majority (78 percent) of the influent liquids entering the pond were from the floodplain aquifer, whereas 22 percent of the inflow originated from the terrace groundwater system. This annual input to the pond is markedly lower than the 20 million gallons reported for 2008–2009. As discussed in Section 3.1.2, pumping at Trench 2 was shut down periodically to increase pond capacity and to maintain safe water levels in the pond.

At the end of the 2009–2010 reporting period, a cumulative volume of nearly 87 million gallons of water has been pumped to the evaporation pond from all sources since the start of operations in March 2003 (cumulative contributions of 25 and 75 percent from the terrace and floodplain, respectively). Figure 3–18 plots the total volume of water pumped to the pond and the relative contributions from the floodplain and terrace systems.

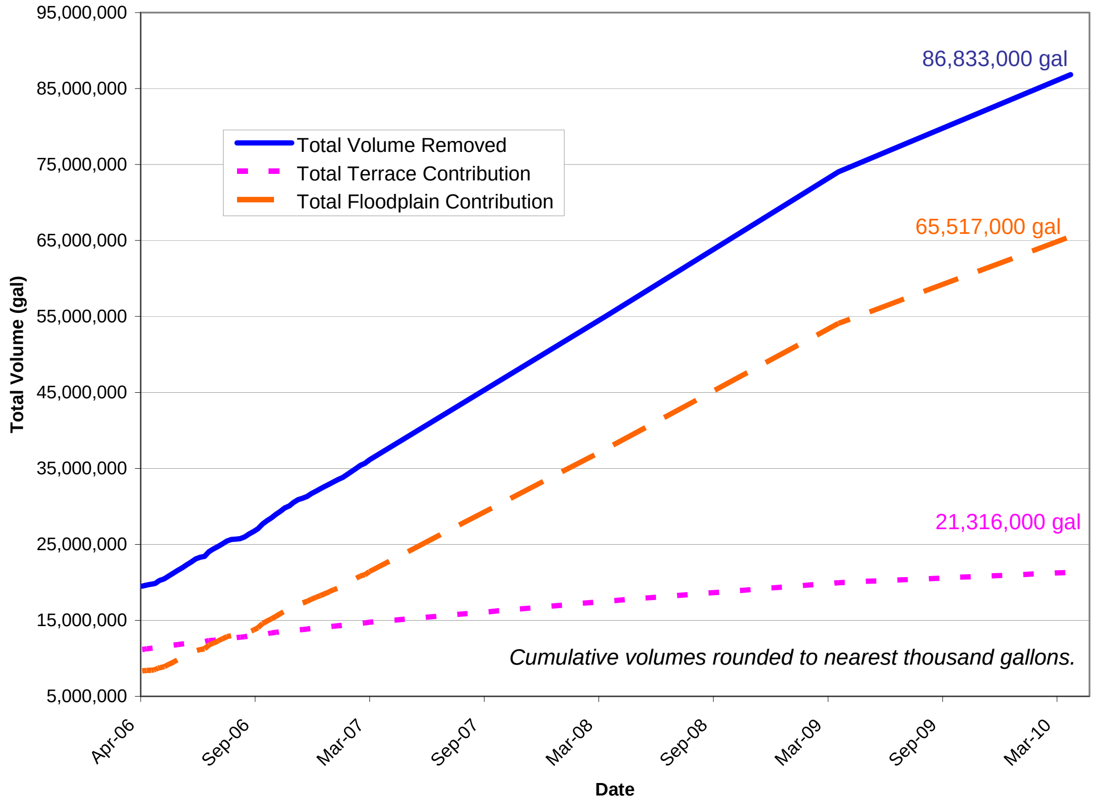

Figure 3–18. Total Groundwater Volume Pumped to the Evaporation Pond

The estimated masses of nitrate, sulfate, and uranium entering the evaporation pond from the floodplain extraction wells and trenches and terrace groundwater extraction system are summarized in Table 3–2. As shown in this table, approximately 21,000 pounds of nitrate, 727,000 pounds of sulfate, and 70 pounds of uranium were pumped to the evaporation pond during the 2009–2010 performance evaluation period. These estimates were computed from the average concentrations measured in each extraction well and the corresponding annual cumulative volume pumped. Sulfate is the dominant COC (in terms of mass) that enters the evaporation pond because of its high concentrations in both the floodplain and terrace groundwater systems.

Table 3–2. Estimated Total Mass of Selected Constituents Pumped from Terrace and Floodplain

Location	**Annual cumulative volume (gal)[a]**	**Percent contribution**	**Nitrate - Average Concentration (mg/L)**	**Nitrate Mass Contribution per Location (kg)[b]**	**Nitrate Mass Contribution per Location (lb)[c]**	**Sulfate - Average Concentration (mg/L)**	**Sulfate Mass Contribution per Location (kg)[b]**	**Sulfate Mass Contribution per Location (lb)[c]**	**Uranium - Average Concentration (mg/L)**	**Uranium Mass Contribution per Location (kg)[b]**	**Uranium Mass Contribution per Location (lb)[c]**
Terrace											
0818	227,890	1.8	855	737	1626	12,000	10,351	22,819	0.096	0.083	0.183
1070	6450	0.05	740	18.1	39.8	16,000	391	861	0.098	0.002	0.005
1071	297	0.002	1100	1.2	2.7	6450	7.3	16.0	0.135	0.0002	0.0003
1078	136,510	1.1	630	326	718	14,500	7492	16,517	0.150	0.078	0.171
1091	4952	0.04	1050	19.68	43.39	14,000	262.4	578.50	0.125	0.0023	0.00517
1092	7.0	0.0001	1950	0.05	0.11	7300	0.19	0.43	0.049	0.000001	<0.001
1093	124,030	1.0	2500	1174	2587	6250	2934	6468	0.135	0.063	0.140
1095	225,170	1.8	1650	1406	3100	5500	4687	10,334	0.049	0.042	0.092
1096	135,670	1.1	635	326	719	14,000	7189	15,849	0.110	0.056	0.125
1087 (BLW)	1,390,494	11.2	315	1658	3655	7900	41,578	91,663	0.615	3.237	7.136
1088 (MDW)	468,210	3.8	700	1241	2735	23,000	40,760	89,860	0.200	0.354	0.781
Floodplain											
1089	3,022,100	24.5	13.2	151	333	6750	77,211	170,219	0.79	9.04	19.9
1104	296,970	2.4	34.0	38	84	8000	8992	19,824	1.15	1.29	2.85
Trench 1 (1110)	3,844,900	31.1	115	1674	3690	7500	109,147	240,626	1.095	15.94	35.1
Trench 2 (1109)	2,296,600	18.6	90.5	787	1734	1600	13,908	30,662	0.26	2.26	4.98
Seep sump (1118)	182,187	1.5	34.0	23	52	6900	4758	10,490	0.655	0.45	0.996
			Total Masses:	9579	21,119		329,668	726,787		32.9	72.5
Total Terrace	2,719,680	22.0									
Total Floodplain	9,642,757	78.0									
Total to Pond	12,362,437										

[a] Annual cumulative volumes derived from data used to generate plots in Figure 3–1 through Figure 3–15 (data from April 1, 2009, through March 31, 2010).
[b] Mass in kilogram (kg) derived = annual volume × 3.785 (liters to gallons) × average concentration × (1/1,000,000)
[c] Conversion to pounds (lb) = kg × 2.2046
MDW = Many Devils Wash; BLW = Bob Lee Wash

3.2.4 Passive and Enhanced Phytoremediation

Passive phytoremediation (no human intervention) and hydraulic control are ongoing at the Shiprock site. DOE began phytoremediation pilot studies in 2006 to evaluate the feasibility of using deep-rooted native plants to enhance evapotranspiration in the radon cover borrow pit south of the disposal cell, where nitrate levels are elevated in alluvial sediments (Figures 1–5b through 1–12), and also on the terrace between the disposal cell and the escarpment north of the disposal cell, where a uranium plume enters the floodplain (see Figures 1–9b through 1–16). The goal of phytoremediation in these areas is hydraulic control (as opposed to contaminant removal), to limit the spread of contaminants in groundwater. The four irrigated phytoremediation test plots, established in 2006 and measuring 15 meters by 15 meters, are shown on Figure 1–1 and in the Figure 3–19 schematic below. To date, all work has been done in concert with Diné College.

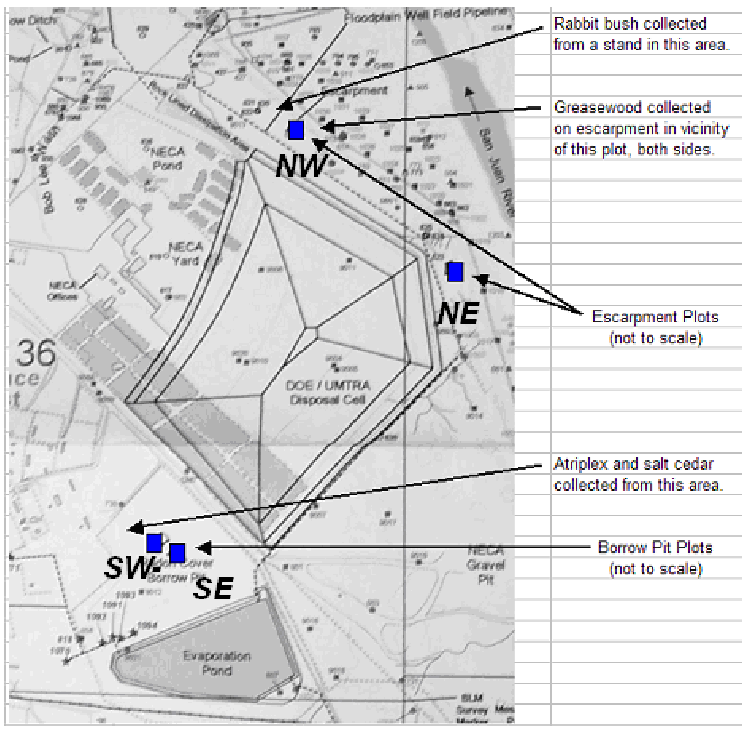

Figure 3–19. Map of Phytoremediation Test Plots in the Radon Barrier Borrow Pit and on the Terrace above the San Juan River Escarpment

Volunteer tamarisk, black greasewood, and four-wing saltbush currently growing in the borrow pit area are likely extracting groundwater, nitrate, and possibly other groundwater constituents. A few scattered black greasewood plants that have established on the terrace are also likely removing water that might otherwise daylight in contaminated seeps at the base of the escarpment. Higher rates of water extraction by woody plants in both locations may improve hydraulic control. More recently, DOE began evaluating the feasibility of enhanced phytoremediation, which entails deliberate planting of the areas (versus the volunteer growth). This technique, still in early experimental stages, may be an economical addition to the current groundwater compliance strategy.

Three objectives of the phytoremediation pilot studies have been established. These objectives and the associated findings and progress to date are summarized below.

Objective 1—Establish native phreatophytic shrubs by transplanting seedlings started in a greenhouse and then irrigating transplants until roots have accessed plume groundwater.

Findings and status:

- Diné College students irrigate and maintain the plantings and annually measure plant growth. Irrigated transplants have grown larger in the escarpment plots than in the radon cover borrow pit plots.
- On the escarpment, oxygen and deuterium isotope studies indicate that volunteer black greasewood plants, typically difficult to establish from transplants, are rooted down to groundwater. To date, analyses indicate that transplanted black greasewood and fourwing saltbush growing in the test plots have not intercepted contaminated groundwater.
- In contrast, plants are not doing well in the radon cover borrow pit area, where oxygen and deuterium isotope studies indicate that volunteer saltbush and rabbitbrush have not reached groundwater, and irrigated transplants are not expected to. Given these findings, the objective of these plots has changed. The objective now is to establish native vegetation, control the soil water balance, and limit recharge and, hence, the volume of the plume water.

Objective 2—Once plant roots have accessed groundwater, evaluate the human health and ecological risks associated with uptake of groundwater constituents and accumulation in aboveground plant tissue.

Findings and status:

- Diné College students harvested plant tissue from both the volunteer and transplanted phreatophytic shrubs in the escarpment plots in 2010. Although these results are still being evaluated, little contaminant uptake is evident to date, indicating no potential human health or ecological risks associated with a bio-uptake pathway.
- Plants in the radon cover borrow pit plots were not sampled because they are not rooted in groundwater.

Objective 3—Evaluate the potential beneficial effects of phytoremediation on plume water volume, plume migration, and flow in existing contaminated seeps at the base of the escarpment and in floodplain groundwater.

If results from the escarpment studies addressing objectives 1 and 2 are favorable, DOE will calculate potential annual transpiration rates based on plant leaf area and biomass, and coordinate with project hydrologists to evaluate potential benefits with respect to the hydrologic control of terrace groundwater and its potential impact on the seeps and floodplain groundwater plume.

In summary, as part of the overall phased remediation approach, DOE is applying at the Shiprock site, the phytoremediation pilot study will continue. DOE will evaluate a specific plan for phytoremediation pending analysis of overall findings and data when pilot studies end.

4.0 Performance Summary

This section summarizes the findings of the most recent (April 2009 through March 2010) assessment of the floodplain and terrace groundwater remediation systems at the Shiprock site, marking the end of the seventh year of active groundwater remediation.

- Groundwater in the floodplain system is currently being extracted from two wells (wells 1089 and 1104) adjacent to the San Juan River north of the disposal cell, two collection trenches (Trench 1 and Trench 2), and a seep collection sump. Approximately 9.6 million gallons of groundwater were extracted from the floodplain aquifer system during this performance period, yielding a cumulative total of about 65.5 million gallons extracted since March 2003.
- Groundwater in the terrace system is currently being extracted from two drainage trenches (in Bob Lee and Many Devils Washes) and nine wells. From April 2009 through March 2010, approximately 2.7 million gallons of groundwater were extracted from the terrace system, yielding a total cumulative volume (extracted since March 2003) of about 21.3 million gallons. The cumulative volume removed from both terrace and floodplain combined was approximately 87 million gallons.
- Terrace-wide, the majority of the alluvial groundwater level measurements taken during this performance period declined relative to the baseline (2003) period (Figure 2–13); average and maximum decreases were 1.7 ft and 6.1 ft, respectively. These findings indicate that the extraction well field is attaining the terrace performance dewatering objectives.
- Contaminated groundwater that could potentially discharge to the San Juan River is now being intercepted by the remediation system. This contaminated groundwater is pumped to the evaporation pond on the terrace just south of the disposal cell. The estimated masses of sulfate, nitrate, and uranium removed from the floodplain and terrace well fields during this performance period were 727,000 pounds, 21,000 pounds, and 70 pounds, respectively.
- As observed during the last (2008–2009) reporting period, marked decreases in contaminant concentrations are evident in selected floodplain wells—in particular, Trench 1 area wells 0614 and 0615. COC concentrations in easternmost Trench 2 area wells (closest to the San Juan River) are also markedly lower than those nearer the escarpment, demonstrating the effectiveness of the Trench 2 system.
- Following previous recommendations (DOE 2009a), as well as recommendations by stakeholders, nine new Geoprobe wells were installed in the floodplain during this reporting period. Seven (including three in a line toward the river from the well 1089 complex) were installed near the San Juan River to evaluate groundwater flow and monitor contaminant levels in groundwater that could enter the river. Also, two new alluvial wells (1140 and 1141) were installed about 50 ft from the east side of Trench 1 (nearest the river).
- In response to stakeholder concerns that large storms could generate runoff from Many Devils Wash, causing contaminants to flush into the San Juan River, DOE installed an automated sampling system in the lower end of the wash in May 2009. Also, because the effectiveness of the subsurface drain in Many Devils Wash had been decreasing in previous years, DOE installed a new diversion structure in August 2009.

5.0 Recommendations

The following recommendations are provided to help improve the performance and evaluation of the Shiprock remediation system:

- The floodplain extraction system appears to be functioning as expected. The addition of the two trenches at the base of the escarpment enhances the removal of contaminant mass from groundwater in the alluvium. However, given the success demonstrated in the previous evaluation of Trench 2 (DOE 2009b), DOE is proposing similar instrumentation and investigation for the Trench 1 area and the floodplain as a whole. These proposals are outlined below.

  — Alluvial wells near the river in the vicinity of well 1089 will be monitored (time frame and frequency to be determined) to demonstrate that groundwater pumping in this locale prevents discharge of contaminated water to the river and actually induces a moderate influx of surface water into the alluvial aquifer.

  — Alluvial wells located east and south of Trench 1 will also be monitored to assess the capacity of Trench 1 pumping to effect decreases in contaminant plume mass.

  — Using a combination of hydraulic, water chemistry, and temperature data collected at wells distributed throughout the entire floodplain and along the San Juan River, DOE will employ analytical techniques similar to those used previously in the Trench 2 evaluation (DOE 2009b) to: (1) better understand interactions between the alluvial aquifer and the river, and (2) evaluate the combined effectiveness of floodplain groundwater extraction components (well 1089, Trench 1 and Trench 2) in reducing contaminant mass. This work will culminate in the development of a floodplain-wide flow and fate and transport model.

  — The floodplain-wide groundwater model will be used to address key issues regarding management of the alluvial aquifer, including (1) the capacity of groundwater extraction components to prevent contaminant discharge to the river, (2) optimal pumping cycles for Trench 1 and Trench 2, (3) the relative benefits of a third trench between Trench 1 and the well 1089 area, and (4) the likely floodplain impacts of terminating flows from artesian well 0648.

- The terrace extraction system is operating adequately, and water levels are gradually declining. No additions to this system are recommended at this time (refer to DOE 2010a for further discussion). However, repairs to recent erosion damage around the Many Devils Wash diversion structure are recommended.

- As the remediation system continues to operate, it will become more important to monitor the fluid level in the evaporation pond. Between April 2009 and April 2010, an additional 3.5 ft of water was pumped into the 11-acre pond, leaving only about 2.2 ft of unfilled pond capacity. Pumping from Trench 2 was shut down periodically during 2009–2010 to increase pond capacity. Continued monitoring of the fluid level in the pond is recommended, along with periodic cessation of pumping as necessary to maintain sufficient freeboard.

- To mitigate potential ecological risks associated with the pond, in June 2010 DOE began adding dye to the evaporation pond to block sunlight as a way to kill algae and thus remove a potential food source to birds. This has been effective in reducing the algae, and DOE recommends that this practice continue.

- The performance of the terrace remedial action is currently tied to the reduction of flow from seeps 0425 and 0426 (which are now part of the remediation system) and from other seeps on the terrace, many of which are currently dry. Discharge from these seeps will continue to be monitored and included as part of the annual performance evaluation.
- Contaminant trends evaluated in this report indicate that at some locations on both the terrace and the floodplain, no trending is apparent. As shown in Figure 1–2, the sampling network at the Shiprock site is dense; for this reporting period, 118 monitoring wells were sampled (62 on the floodplain and 56 on the terrace). As discussed in the recently issued evaluation of the site remediation strategy (DOE 2010a), future work at the site will consist of more targeted characterization to address key areas (e.g., Many Devils Wash) and to better understand site conditions. Given this intent, DOE is considering using the Visual Sampling Plan (VSP) software to evaluate the current sampling regime and to assess potential temporal and spatial redundancies. Developed by Pacific Northwest National Laboratory, VSP is a widely used software tool that supports the development of site sampling plans based on statistical sampling theory and statistical analysis of sample results (http://vsp.pnl.gov/).

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Appendix A

Sampling Summary and Descriptive Statistics for Floodplain Monitoring Wells

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Table A–1. Summary of Floodplain Locations Sampled, September 2009–March 2010

Well ID	ZOC	Area	Sampling		Water Levels		Comments/Notes
			Sep-09	Mar-10	Sep-09	Mar-10	
0608	KM	S-SE FP	X	X	X	X	Base of escarpment
0610	AL	S-SE FP	X	X	X	X	Base of escarpment
0611	AL	S-SE FP	X	X	X	X	Base of escarpment
0612	AL	S-SE FP	X	X	X	X	
0614	AL	S-SE FP	X	X	X	X	Base of escarpment
0615	AL	Trench 1	X	X	X	X	River side of trench
0618	AL	Central FP	X	X	X	X	
0619	AL	Central FP	X	X	X	X	
0622	AL	Central FP	X	X	X	X	
0623	AL	Central FP	X	X	X	X	
0625	AL	Central FP	X	X	X	X	
0626	AL	Central FP	X	X	X	X	
0628	AL	Central FP	X	X	X	X	
0630	AL	Central FP	X	X	X	X	Near mouth of BLW
0734	AL	N-NW FP	X	X	X	X	
0735	AL	S-SE FP	X	X	X	X	Farthest south of the S-SE wells
0736	AL	N-NW FP	*	X	X	X	Data logger; well dry in Sep-09
0766	AL	1089 Area	*	X	X	X	Well dry in Sep-09
0768	AL	Central FP	*	X	X	X	Well dry in Sep-09
0773	AL	S-SE FP	*	X	X	X	Well dry in Sep-09
0775	AL	Central FP	*	X	X	X	Well dry in Sep-09
0779	AL	Central FP	*	X	X	X	Well dry in Sep-09
0782R	AL	N-NW FP	X	X	X	X	Island area NW of bridge
0783R	AL	N-NW FP	X	X	X	X	Island area NW of bridge
0792	AL	Central FP	X	X	X	X	
0793	AL	Central FP	X	X	X	X	
0797	AL	Background	X	X	X	X	
0798	AL	Central FP	X	X	X	X	
0850	AL	Background	X	X	X	X	
0853	AL	Central FP	X	X	X	X	
0854	AL	1089 Area	X	X	X	X	Data logger
0855	AL	N-NW FP	X	X	X	X	
0856	AL	N-NW FP	X	X	X	X	
0857	AL	Central FP	X	X	X	X	Data logger
1008	AL	1089 Area	X	X	X	X	Data logger
1009	AL	Central FP	X	X		X	
1089	AL	1089 Area	X	X			Extraction well; water levels not measured
1104	AL	1089 Area	X	X			Extraction well; water levels not measured
1105	AL	Trench 1	X	X	X		River side of trench
1109	AL	Trench 2	X	X			Treatment system sump
1110	AL	Trench 1	X	X	X		Treatment system sump
1111	AL	Trench 1	X	X	X	X	
1112	AL	Trench 1	X	X	X	X	
1113	AL	S-SE FP	X	X		X	Base of escarpment
1114	AL	S-SE FP	X	X	X	X	Base of escarpment

Table A–1 (continued). Summary of Floodplain Locations Sampled, September 2009–March 2010

Well ID	ZOC	Area	Sampling		Water Levels		Comments/Notes
			Sep-09	Mar-10	Sep-09	Mar-10	
1115	AL	Trench 2	X	X	X	X	
1116	AL	Trench 2	X		X	X	
1117	AL	Trench 2	X	X	X	X	
1126	AL	Trench 2	X		X	X	
1127	AL	Trench 2	X		X	X	
1128	AL	Trench 2		X			
1131	AL	Trench 2	X		X	X	
1132	AL	Trench 2	X	X	X	X	
1133	AL	Trench 2	X				
1134	AL	Trench 2	X	X	X	X	
1135	AL	N-NW FP		X		X	New well installed in Jan-10 ~500 ft NW of well 1089 area, between 1089 and 0736, near river.
1136	AL	Central FP		X		X	New well installed in Jan-10 ~600 ft SE of well 1089 area, between 1089 and 0857, near river.
1137	AL	1089 Area		X		X	New well installed in Jan-10; one of a line of 3 new wells (1137, 1138, 1139) installed closer to river near well 1089 area.
1138	AL	1089 Area		X		X	See description above for well 1137.
1139	AL	1089 Area		X		X	See description above for well 1137.
1140	AL	Trench 1	X	X	X	X	New well installed in May-09, river side
1141	AL	Trench 1	X	X	X	X	New well installed in May-09, river side
1142	AL	Central FP		X		X	New well installed in Jan-10 near river, ~400 ft east of well 0853 and ~700 ft south of gauging station.
1143	AL	N-NW FP		X		X	New well installed in Jan-10 about equidistant (~300-350 ft) between 0736 and 0856.
617	AL						Data logger only
862	KM	S-SE FP				X	Colocated with 0608; water levels only
863	KM	S-SE FP				X	Colocated with 0608; water levels only
1000	KM	S-SE FP				X	Colocated with 0614; water levels only
1001	KM	S-SE FP				X	Colocated with 0614; water levels only
1062	KM	S-SE FP				X	Colocated with 0608; water levels only

AL Alluvial well
KM Mancos Shale (well screened in)
ZOC Zone of completion
* Well sampled but dry.

Area Designations

Given the large number of wells installed on the floodplain, subsequent graphical plots are divided into the following 7 area groupings (locations shown in Figure A–1):

- Background
- Northwest Floodplain (N-NW FP)
- Central Floodplain (Central FP)
- Well 1089 Area
- Trench 1 Area
- Trench 2 Area
- South-Southeast Floodplain (S-SE FP)

The statistical summaries and plots that follow Figure A–1 are based on the entire historical data set. For older wells, the bulk of these data are from the 2000-to-present time period.

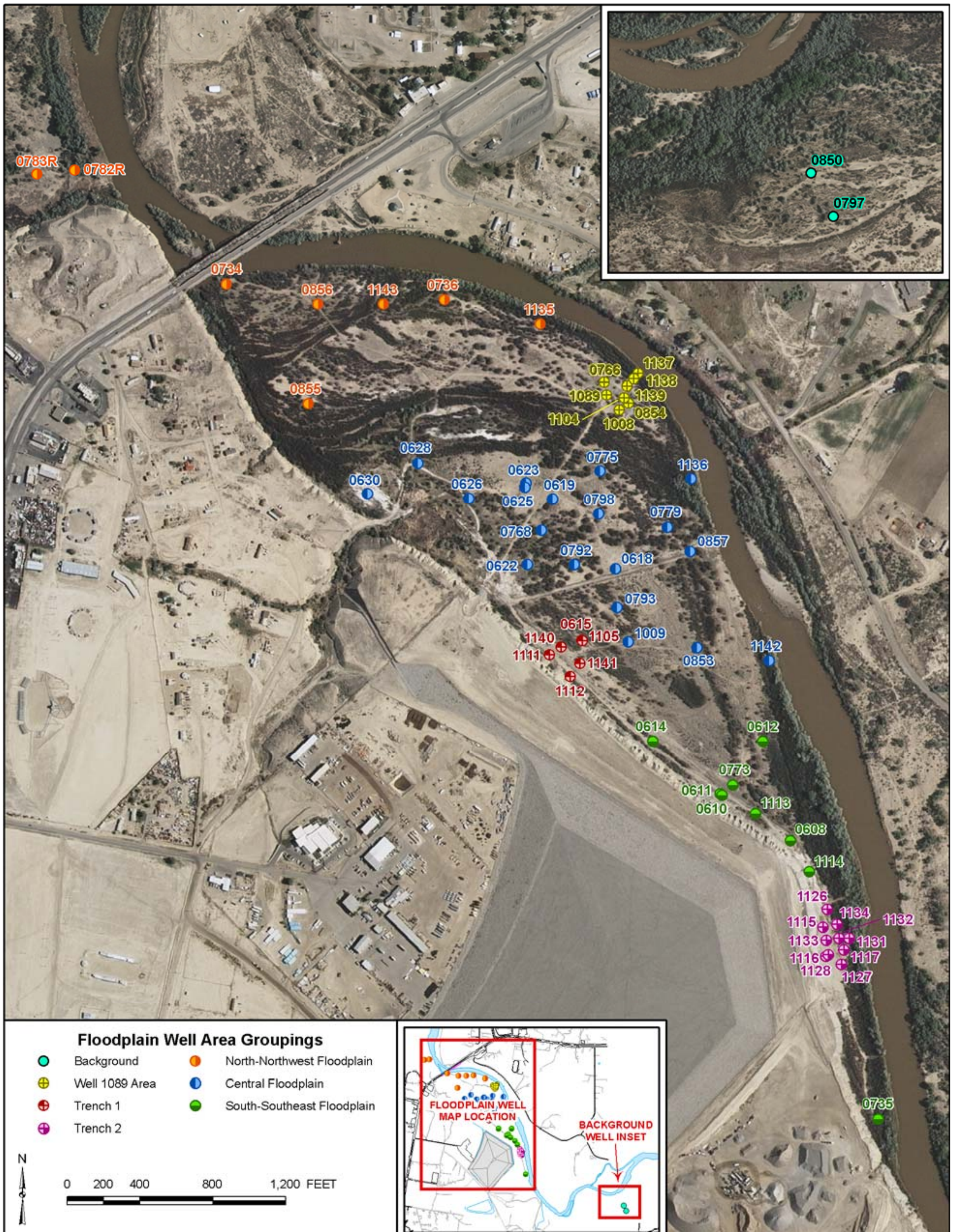

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Figure A–1. Shiprock Site Floodplain Well Area Groupings†

† Well groups used to categorize data for statistical graphics (box plots) provided in the following pages.

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Ammonia

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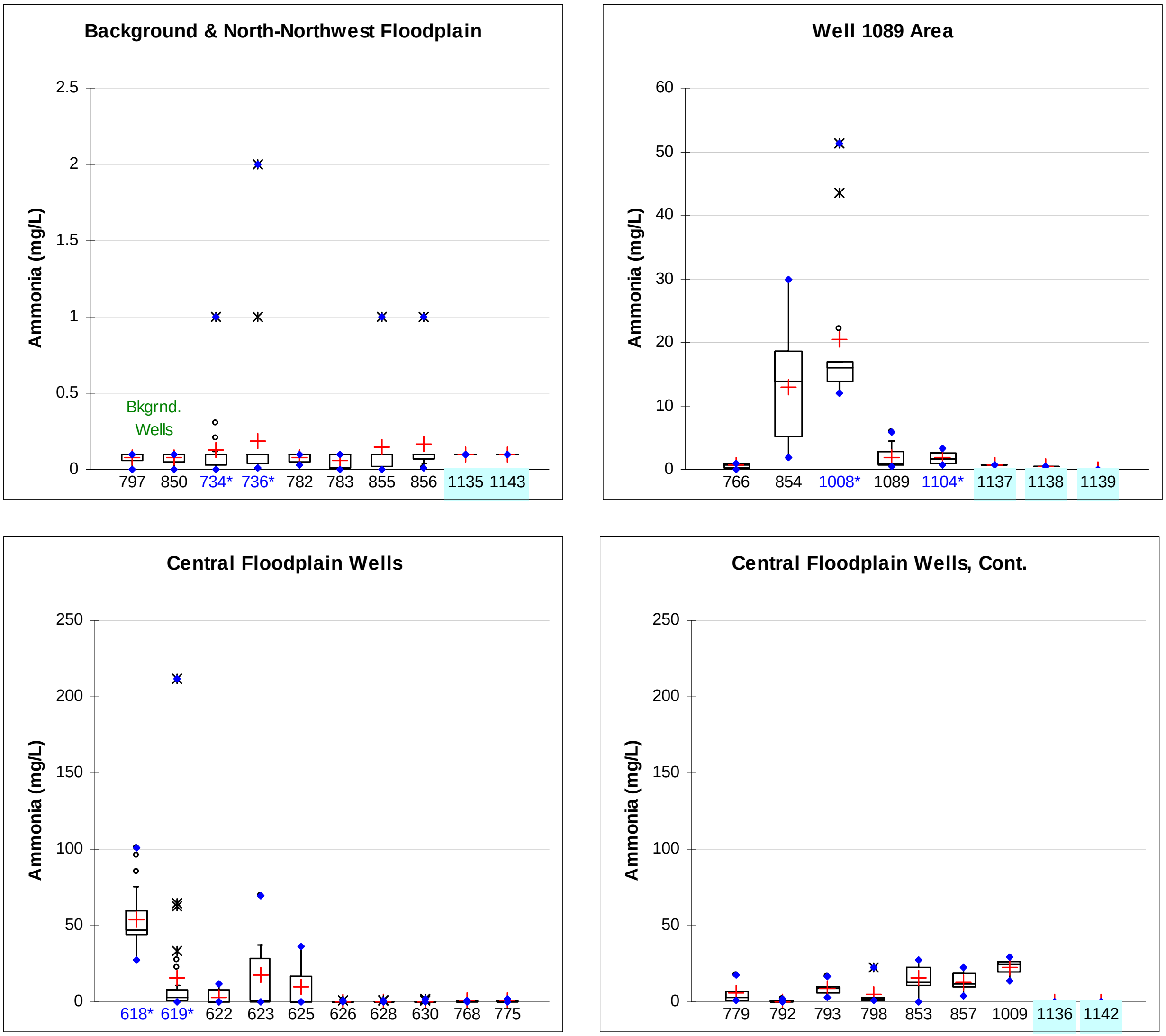

Figure A–2. Historical Distributions of Ammonia in Floodplain Monitoring Wells, page 1 of 2[†]

[†] The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of ammonia for each floodplain well or well grouping; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box. When interpreting these plots, it is important to account for the number of data points (N), listed below and in Table A–1. The greater the number of data points, the more reliable the interpretation of the plots. Well locations are shown in Figure A–1 by subgroup.

0734*	Time trends for COCs plotted in Section 2 of report.
1104	New well added in May 2009 or January 2010.

Background & North-Northwest Floodplain:

Well:	0797	0850	0734*	0736*	0782/0782R	0783/0783R	0855	0856	1135	1143
N:	19	24	23	24	6	7	11	10	1	1

Well 1089 Area:

Well:	0766	0854	1008*	1089	1104*	1137	1138	1139
N:	4	11	13	14	8	1	1	1

Central Floodplain Wells:

Well:	0618*	0619*	0622	0623	0625	0626	0628	0630	0768	0775	0779	0792	0793	0798	0853	0857	1009	1136	1142
N:	25	33	9	6	7	21	20	20	5	5	5	7	6	6	11	10	7	1	1

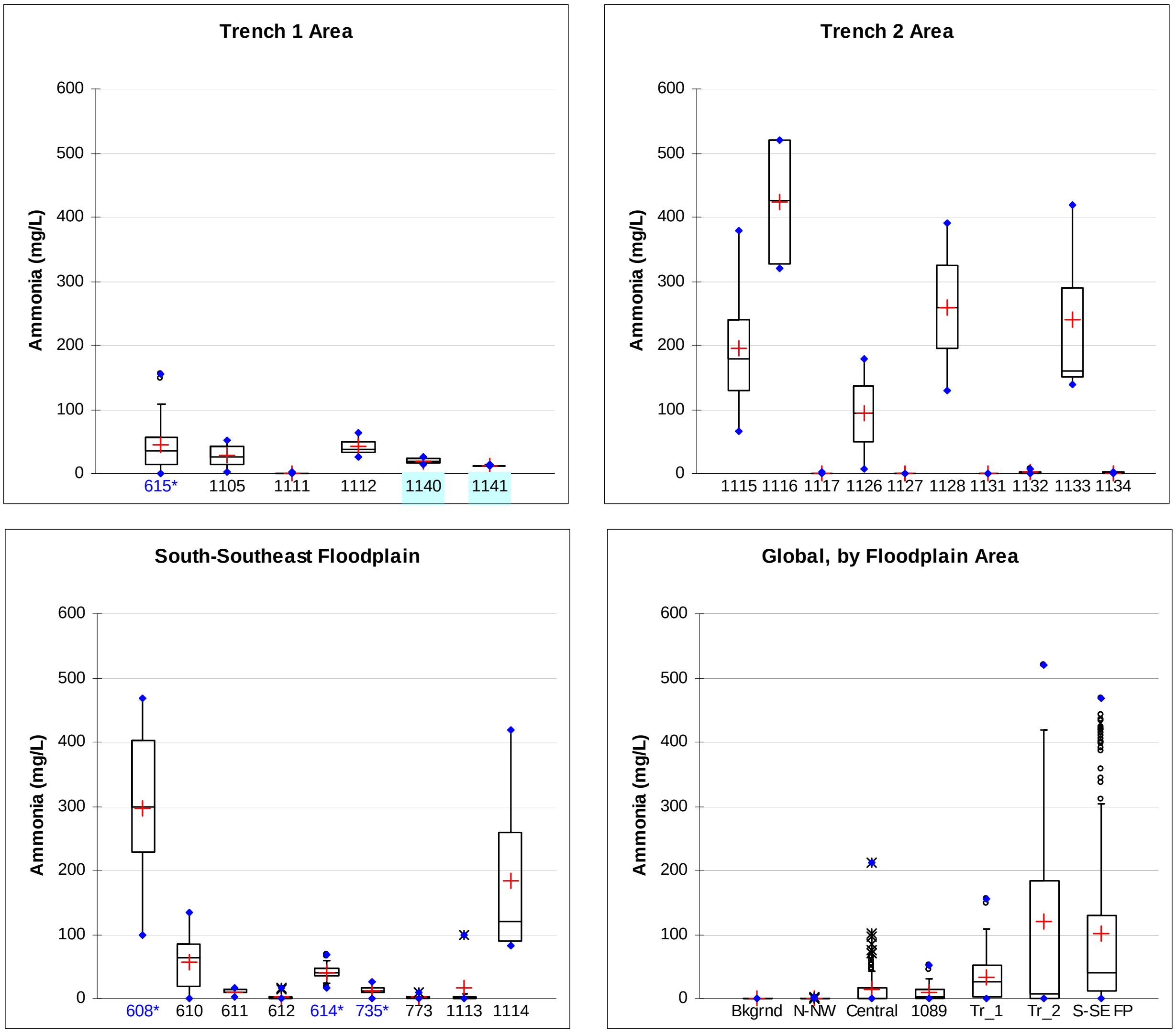

Figure A–2. Historical Distributions of Ammonia in Floodplain Monitoring Wells, page 2 of 2†

† See explanation on preceding page. The number of data points (N) corresponding to each well-specific plot shown above is provided below and in Table A–1.

Trench 1 Area Wells:

Well:	0615*	1105	1111	1112	1140	1141
N:	34	7	9	7	2	2

Trench 2 Area Wells:

Well:	1115	1116	1117	1126	1127	1128	1131	1132	1133	1134
N:	11	4	10	2	2	2	2	4	3	4

South-Southeast Floodplain Wells:

Well:	0608*	0610	0611	0612	0614*	0735*	0773	1113	1114
N:	40	20	5	15	38	28	5	7	11

Note:

In this appendix, in most cases (e.g., for COC-specific figures), individual plots are scaled to yield a common scale across subgroups. However, in the case of ammonia, this was not done because of the great differences in magnitude across the different floodplain area groupings. Therefore, in reviewing this figure, it is important to recognize the relative scales (e.g., as reflected in the final "Global" plot above).

Table A–2a. Summary Statistics for Ammonia in Floodplain Monitoring Wells, Sort on Well ID

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	658	41.9	0.001	520	520	0.10	2.9	36.3	92.0
608	40	297	99.0	467	368	228	299	402	108
610	20	55.8	0.76	134	133	18.8	62.5	85.4	40.0
611	5	10.5	1.6	17.0	15.4	9.0	10.0	15.0	6.0
612	15	2.7	0.02	16.3	16.3	0.09	0.52	2.4	5.0
614	38	40.1	17.0	68.0	51.0	35.3	40.1	46.3	12.1
615	34	44.6	0.35	155	155	13.5	36.5	57.0	41.3
618	25	53.9	27.0	101	74.0	44.0	47.4	59.3	18.9
619	33	15.2	0.01	212	212	0.67	3.0	8.1	38.9
622	9	3.3	0.08	11.6	11.5	0.10	0.10	8.0	4.7
623	6	18.1	0.10	70.0	69.9	0.10	0.55	28.0	29.4
625	7	10.1	0.10	36.0	35.9	0.10	0.26	17.1	16.7
626	21	0.16	0.01	1.0	0.99	0.05	0.08	0.19	0.22
628	20	0.18	0.02	1.2	1.2	0.05	0.08	0.10	0.32
630	20	0.24	0.001	1.9	1.9	0.06	0.09	0.13	0.45
734	23	0.12	0.001	1.0	1.0	0.03	0.10	0.10	0.20
735	28	12.8	0.30	25.0	24.7	9.6	12.6	16.0	5.8
736	24	0.19	0.01	2.0	2.0	0.04	0.10	0.10	0.43
766	4	0.59	0.10	1.0	0.90	0.35	0.64	0.88	0.41
768	5	0.51	0.02	1.3	1.3	0.10	0.10	1.0	0.60
773	5	3.0	0.19	10.0	9.8	0.79	1.9	2.0	4.0
775	5	0.69	0.02	2.2	2.2	0.10	0.10	1.0	0.94
779	5	6.1	0.96	18.0	17.1	1.3	3.0	7.2	7.1
782	6	0.08	0.03	0.10	0.07	0.05	0.10	0.10	0.03
783	7	0.06	0.004	0.10	0.10	0.01	0.10	0.10	0.05
792	7	0.46	0.10	1.7	1.6	0.10	0.10	0.55	0.65
793	6	8.7	2.8	17.0	14.2	5.6	9.0	9.8	5.0
797 (Bkgrnd)	19	0.08	0.003	0.10	0.10	0.06	0.10	0.10	0.04
798	6	5.1	0.60	22.3	21.7	1.2	1.7	2.7	8.5
850 (Bkgrnd)	24	0.07	0.004	0.10	0.10	0.05	0.10	0.10	0.03
853	11	15.6	0.30	27.0	26.7	11.0	13.0	22.6	8.6
854	11	12.9	2.0	29.8	27.8	5.2	14.0	18.5	9.0
855	11	0.14	0.004	1.0	1.0	0.02	0.10	0.10	0.29
856	10	0.17	0.01	1.0	0.99	0.07	0.10	0.10	0.29
857	10	13.1	3.8	22.5	18.7	9.8	11.8	18.6	6.3
1008	13	20.4	12.0	51.4	39.4	14.0	16.0	17.0	12.4
1009	7	22.8	14.0	29.5	15.5	19.5	25.0	26.2	5.7
1089	14	1.8	0.44	6.0	5.6	0.65	1.0	2.7	1.7
1104	8	1.9	0.74	3.4	2.7	0.95	1.8	2.7	1.1
1105	7	27.2	3.1	51.0	47.9	13.0	25.0	42.5	18.6
1111	9	0.51	0.10	2.0	1.9	0.10	0.10	1.0	0.68
1112	7	41.6	26.0	64.0	38.0	33.0	38.0	48.5	13.2
1113	7	15.3	0.15	98.0	97.9	0.52	1.0	3.5	36.5
1114	11	184	82.0	420	338	90.5	120	260	127
1115	11	195	65.0	380	315	130	180	240	107
1116	4	423	320	520	200	328	425	520	113
1117	10	0.62	0.10	2.0	1.9	0.10	0.41	1.0	0.63
1126	2	93.2	6.4	180	174	49.8	93.2	137	123
1127	2	0.57	0.14	1.0	0.86	0.36	0.57	0.79	0.61
1128	2	260	130	390	260	195	260	325	184
1131	2	0.64	0.28	1.0	0.72	0.46	0.64	0.82	0.51
1132	4	2.2	0.90	6.0	5.1	0.92	1.0	2.3	2.5
1133	3	240	140	420	280	150	160	290	156
1134	4	1.1	0.56	2.0	1.4	0.58	0.85	1.3	0.67
1135	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
1136	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
1137	1	0.78	0.78	0.78	-	0.78	0.78	0.78	-
1138	1	0.42	0.42	0.42	-	0.42	0.42	0.42	-
1139	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
1140	2	20.0	15.0	25.0	10.0	17.5	20.0	22.5	7.1
1141	2	12.5	12.0	13.0	1.0	12.3	12.5	12.8	0.71
1142	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
1143	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-

Table A–2b. Summary Statistics for Ammonia in Floodplain Wells: Descending Sort on Mean

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	658	41.9	0.001	520	520	0.10	2.9	36.3	92.0
1116	4	423	320	520	200	328	425	520	113
608	40	297	99.0	467	368	228	299	402	108
1128	2	260	130	390	260	195	260	325	184
1133	3	240	140	420	280	150	160	290	156
1115	11	195	65.0	380	315	130	180	240	107
1114	11	184	82.0	420	338	90.5	120	260	127
1126	2	93.2	6.4	180	174	49.8	93.2	137	123
610	20	55.8	0.76	134	133	18.8	62.5	85.4	40.0
618	25	53.9	27.0	101	74.0	44.0	47.4	59.3	18.9
615	34	44.6	0.35	155	155	13.5	36.5	57.0	41.3
1112	7	41.6	26.0	64.0	38.0	33.0	38.0	48.5	13.2
614	38	40.1	17.0	68.0	51.0	35.3	40.1	46.3	12.1
1105	7	27.2	3.1	51.0	47.9	13.0	25.0	42.5	18.6
1009	7	22.8	14.0	29.5	15.5	19.5	25.0	26.2	5.7
1008	13	20.4	12.0	51.4	39.4	14.0	16.0	17.0	12.4
1140	2	20.0	15.0	25.0	10.0	17.5	20.0	22.5	7.1
623	6	18.1	0.10	70.0	69.9	0.10	0.55	28.0	29.4
853	11	15.6	0.30	27.0	26.7	11.0	13.0	22.6	8.6
1113	7	15.3	0.15	98.0	97.9	0.52	1.0	3.5	36.5
619	33	15.2	0.01	212	212	0.67	3.0	8.1	38.9
857	10	13.1	3.8	22.5	18.7	9.8	11.8	18.6	6.3
854	11	12.9	2.0	29.8	27.8	5.2	14.0	18.5	9.0
735	28	12.8	0.30	25.0	24.7	9.6	12.6	16.0	5.8
1141	2	12.5	12.0	13.0	1.0	12.3	12.5	12.8	0.71
611	5	10.5	1.6	17.0	15.4	9.0	10.0	15.0	6.0
625	7	10.1	0.10	36.0	35.9	0.10	0.26	17.1	16.7
793	6	8.7	2.8	17.0	14.2	5.6	9.0	9.8	5.0
779	5	6.1	0.96	18.0	17.1	1.3	3.0	7.2	7.1
798	6	5.1	0.60	22.3	21.7	1.2	1.7	2.7	8.5
622	9	3.3	0.08	11.6	11.5	0.10	0.10	8.0	4.7
773	5	3.0	0.19	10.0	9.8	0.79	1.9	2.0	4.0
612	15	2.7	0.02	16.3	16.3	0.09	0.52	2.4	5.0
1132	4	2.2	0.90	6.0	5.1	0.92	1.0	2.3	2.5
1104	8	1.9	0.74	3.4	2.7	0.95	1.8	2.7	1.1
1089	14	1.8	0.44	6.0	5.6	0.65	1.0	2.7	1.7
1134	4	1.1	0.56	2.0	1.4	0.58	0.85	1.3	0.67
1137	1	0.78	0.78	0.78	-	0.78	0.78	0.78	-
775	5	0.69	0.02	2.2	2.2	0.10	0.10	1.0	0.94
1131	2	0.64	0.28	1.0	0.72	0.46	0.64	0.82	0.51
1117	10	0.62	0.10	2.0	1.9	0.10	0.41	1.0	0.63
766	4	0.59	0.10	1.0	0.90	0.35	0.64	0.88	0.41
1127	2	0.57	0.14	1.0	0.86	0.36	0.57	0.79	0.61
1111	9	0.51	0.10	2.0	1.9	0.10	0.10	1.0	0.68
768	5	0.51	0.02	1.3	1.3	0.10	0.10	1.0	0.60
792	7	0.46	0.10	1.7	1.6	0.10	0.10	0.55	0.65
1138	1	0.42	0.42	0.42	-	0.42	0.42	0.42	-
630	20	0.24	0.001	1.9	1.9	0.06	0.09	0.13	0.45
736	24	0.19	0.01	2.0	2.0	0.04	0.10	0.10	0.43
628	20	0.18	0.02	1.2	1.2	0.05	0.08	0.10	0.32
856	10	0.17	0.01	1.0	0.99	0.07	0.10	0.10	0.29
626	21	0.16	0.01	1.0	0.99	0.05	0.08	0.19	0.22
855	11	0.14	0.004	1.0	1.0	0.02	0.10	0.10	0.29
734	23	0.12	0.001	1.0	1.0	0.03	0.10	0.10	0.20
1135	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
1136	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
1139	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
1142	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
1143	1	0.10	0.10	0.10	-	0.10	0.10	0.10	-
797 (Bkgrnd)	19	0.08	0.003	0.10	0.10	0.06	0.10	0.10	0.04
782	6	0.08	0.03	0.10	0.07	0.05	0.10	0.10	0.03
850 (Bkgrnd)	24	0.07	0.004	0.10	0.10	0.05	0.10	0.10	0.03
783	7	0.06	0.004	0.10	0.10	0.01	0.10	0.10	0.05

Manganese

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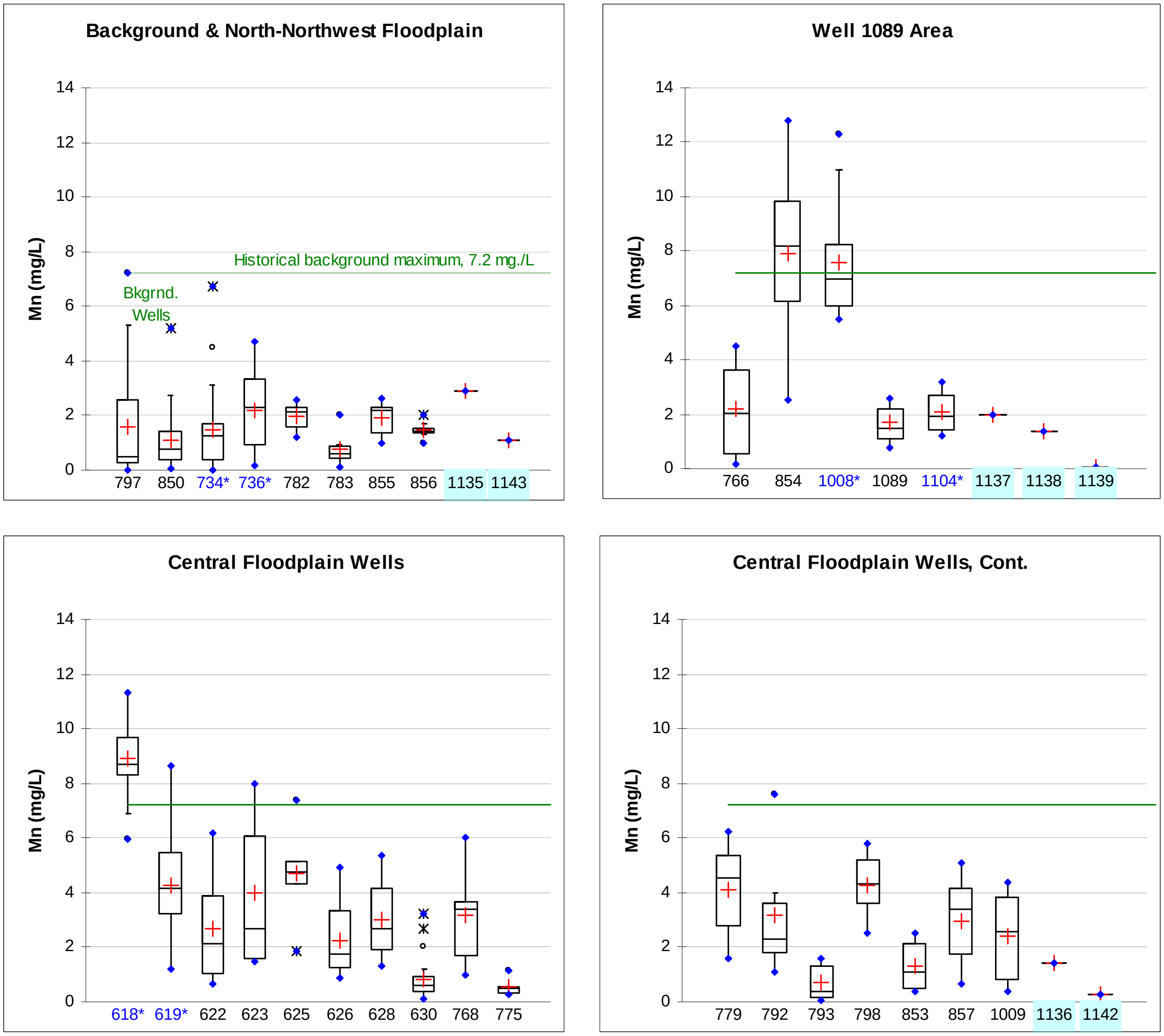

Figure A–3. Historical Distributions of Manganese in Floodplain Monitoring Wells, page 1 of 2†

† The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of manganese for each floodplain well or well grouping; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box. When interpreting these plots, it is important to account for the number of data points (N), listed below and in Table A–1. The greater the number of data points, the more reliable the interpretation of the plots. Well locations are shown in Figure A–1 by subgroup.

0734*	Time trends for COCs plotted in Section 2 of report.
1104	New well added in May 2009 or January 2010.

Background & North-Northwest Floodplain:

Well:	0797	0850	0734*	0736*	0782/0782R	0783/0783R	0855	0856	1135	1143
N:	19	24	26	26	6	7	11	9	1	1

Well 1089 Area:

Well:	0766	0854	1008*	1089	1104*	1137	1138	1139
N:	4	11	12	9	7	1	1	1

Central Floodplain Wells:

Well:	0618*	0619*	0622	0623	0625	0626	0628	0630	0768	0775	0779	0792	0793	0798	0853	0857	1009	1136	1142
N:	21	35	8	5	6	24	23	23	5	5	5	6	5	5	10	10	6	1	1

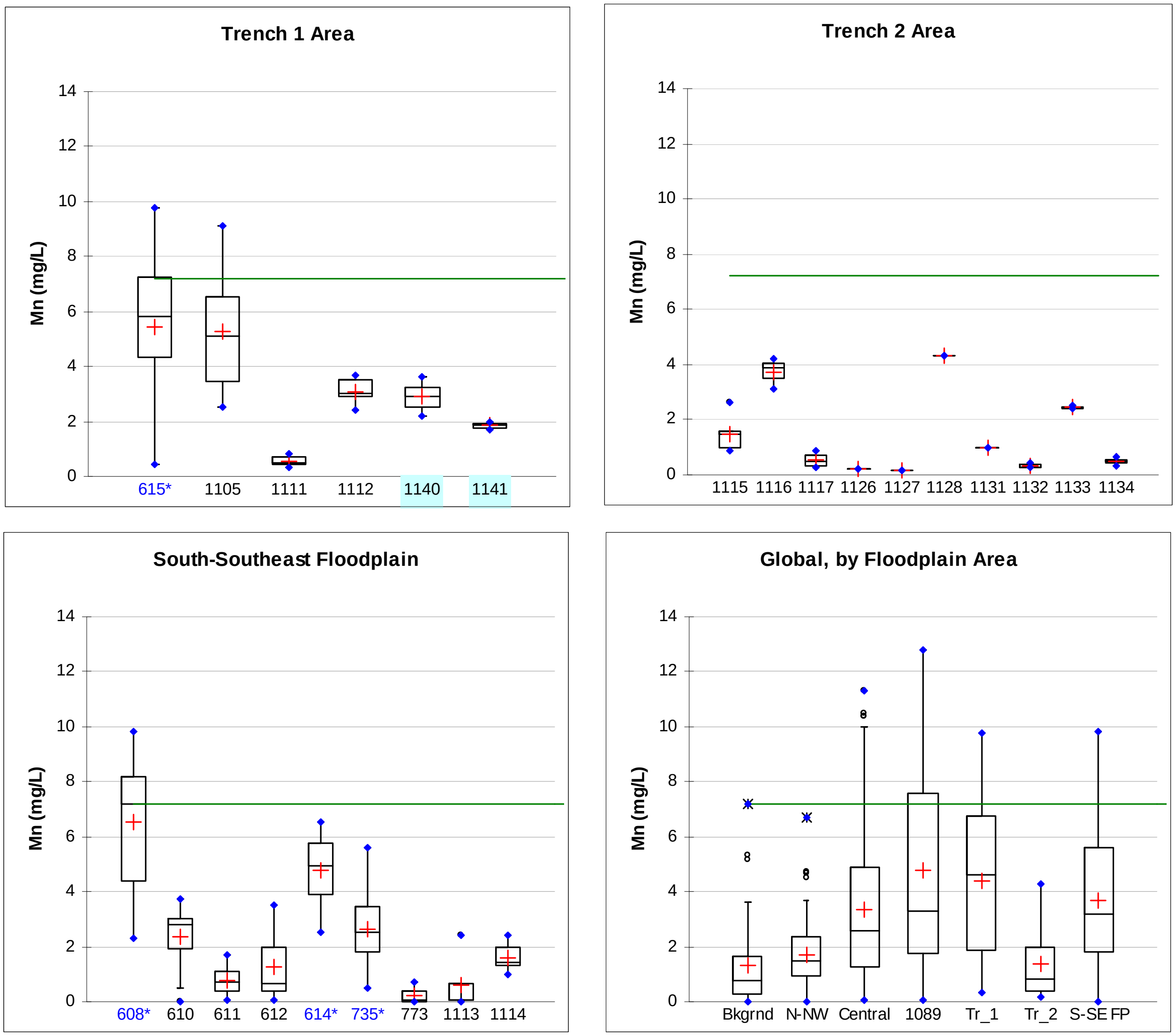

Figure A–3. Historical Distributions of Manganese in Floodplain Monitoring Wells, page 2 of 2[†]

[†] See explanation on preceding page. The number of data points (N) corresponding to each well-specific plot shown above is provided below and in Table A–1.

Trench 1 Area Wells:

Well:	0615*	1105	1111	1112	1140	1141
N:	31	6	6	5	2	2

Trench 2 Area Wells:

Well:	1115	1116	1117	1126	1127	1128	1131	1132	1133	1134
N:	6	3	6	1	1	1	1	3	2	3

South-Southeast Floodplain Wells:

Well:	0608*	0610	0611	0612	0614*	0735*	0773	1113	1114
N:	40	23	4	15	36	29	5	4	6

Table A–3a. Summary Statistics for Manganese in Floodplain Monitoring Wells, Sort on Well ID

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	621	3.2	0.001	12.8	12.8	1.1	2.5	4.7	2.7
608	40	6.5	2.3	9.9	7.6	4.4	7.2	8.2	2.3
610	23	2.4	0.01	3.7	3.7	1.9	2.8	3.0	1.0
611	4	0.8	0.07	1.7	1.7	0.40	0.69	1.1	0.70
612	15	1.3	0.04	3.5	3.5	0.41	0.66	2.0	1.2
614	36	4.8	2.5	6.6	4.1	3.9	4.9	5.8	1.2
615	31	5.4	0.46	9.8	9.3	4.3	5.8	7.2	2.9
618	21	8.9	6.0	11.3	5.3	8.3	8.7	9.7	1.3
619	35	4.3	1.2	8.7	7.5	3.2	4.2	5.5	1.9
622	8	2.7	0.67	6.2	5.5	1.1	2.1	3.9	1.9
623	5	4.0	1.5	8.0	6.5	1.6	2.7	6.1	2.9
625	6	4.7	1.9	7.4	5.5	4.3	4.8	5.1	1.8
626	24	2.2	0.87	4.9	4.0	1.3	1.8	3.4	1.3
628	23	3.0	1.3	5.4	4.1	1.9	2.7	4.1	1.4
630	23	0.8	0.11	3.2	3.1	0.38	0.62	0.91	0.78
734	26	1.5	0.006	6.7	6.7	0.36	1.3	1.7	1.6
735	29	2.6	0.50	5.6	5.1	1.8	2.5	3.5	1.3
736	26	2.2	0.15	4.7	4.6	0.90	2.3	3.3	1.4
766	4	2.2	0.17	4.5	4.4	0.55	2.0	3.7	2.1
768	5	3.1	0.96	6.0	5.0	1.7	3.4	3.7	2.0
773	5	0.2	0.001	0.71	0.71	0.01	0.06	0.39	0.31
775	5	0.6	0.29	1.1	0.84	0.34	0.47	0.55	0.34
779	5	4.1	1.6	6.2	4.6	2.8	4.5	5.3	1.9
782	6	2.0	1.2	2.6	1.4	1.6	2.2	2.3	0.54
783	7	0.8	0.10	2.0	1.9	0.43	0.58	0.87	0.61
792	6	3.2	1.1	7.6	6.5	1.8	2.3	3.6	2.4
793	5	0.7	0.04	1.6	1.6	0.14	0.39	1.3	0.71
797 (Bkgrnd)	19	1.6	0.001	7.2	7.2	0.27	0.50	2.6	2.0
798	5	4.3	2.5	5.8	3.3	3.6	4.3	5.2	1.3
850 (Bkgrnd)	24	1.1	0.07	5.2	5.1	0.40	0.78	1.4	1.1
853	10	1.3	0.41	2.5	2.1	0.48	1.1	2.2	0.91
854	11	7.9	2.5	12.8	10.3	6.1	8.2	9.8	3.5
855	11	1.9	1.0	2.6	1.6	1.4	2.2	2.3	0.57
856	9	1.5	0.99	2.0	1.0	1.4	1.4	1.5	0.28
857	10	3.0	0.67	5.1	4.4	1.7	3.4	4.1	1.6
1008	12	7.6	5.5	12.3	6.8	6.0	7.0	8.2	2.1
1009	6	2.4	0.37	4.4	4.0	0.84	2.6	3.8	1.7
1089	9	1.7	0.77	2.6	1.8	1.1	1.5	2.2	0.66
1104	7	2.1	1.2	3.2	2.0	1.5	1.9	2.7	0.80
1105	6	5.3	2.5	9.1	6.6	3.5	5.1	6.5	2.5
1111	6	0.6	0.34	0.82	0.48	0.44	0.50	0.74	0.20
1112	5	3.1	2.4	3.7	1.3	2.9	3.0	3.5	0.51
1113	4	0.6	0.02	2.4	2.4	0.03	0.04	0.63	1.2
1114	6	1.6	1.0	2.4	1.4	1.3	1.5	2.0	0.53
1115	6	1.5	0.85	2.6	1.8	1.0	1.5	1.6	0.64
1116	3	3.7	3.1	4.2	1.1	3.5	3.9	4.1	0.57
1117	6	0.5	0.30	0.87	0.57	0.35	0.47	0.74	0.25
1126	1	0.2	0.23	0.23	-	0.23	0.23	0.23	-
1127	1	0.1	0.14	0.14	-	0.14	0.14	0.14	-
1128	1	4.3	4.3	4.3	-	4.3	4.3	4.3	-
1131	1	1.0	1.0	1.0	-	1.0	1.0	1.0	-
1132	3	0.3	0.29	0.45	0.16	0.30	0.30	0.38	0.09
1133	2	2.5	2.4	2.5	0.10	2.4	2.5	2.5	0.07
1134	3	0.5	0.34	0.63	0.29	0.42	0.49	0.56	0.15
1135	1	2.9	2.9	2.9	-	2.9	2.9	2.9	-
1136	1	1.4	1.4	1.4	-	1.4	1.4	1.4	-
1137	1	2.0	2.0	2.0	-	2.0	2.0	2.0	-
1138	1	1.4	1.4	1.4	-	1.4	1.4	1.4	-
1139	1	0.1	0.08	0.08	-	0.08	0.08	0.08	-
1140	2	2.9	2.2	3.6	1.4	2.6	2.9	3.3	0.99
1141	2	1.9	1.7	2.0	0.30	1.8	1.9	1.9	0.21
1142	1	0.3	0.29	0.29	-	0.29	0.29	0.29	-
1143	1	1.1	1.1	1.1	-	1.1	1.1	1.1	-

Table A–3b. Summary Statistics for Manganese in Floodplain Wells: Descending Sort on Mean

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	621	3.2	0.001	12.8	12.8	1.1	2.5	4.7	2.7
618	21	8.9	6.0	11.3	5.3	8.3	8.7	9.7	1.3
854	11	7.9	2.5	12.8	10.3	6.1	8.2	9.8	3.5
1008	12	7.6	5.5	12.3	6.8	6.0	7.0	8.2	2.1
608	40	6.5	2.3	9.9	7.6	4.4	7.2	8.2	2.3
615	31	5.4	0.46	9.8	9.3	4.3	5.8	7.2	2.9
1105	6	5.3	2.5	9.1	6.6	3.5	5.1	6.5	2.5
614	36	4.8	2.5	6.6	4.1	3.9	4.9	5.8	1.2
625	6	4.7	1.9	7.4	5.5	4.3	4.8	5.1	1.8
1128	1	4.3	4.3	4.3	-	4.3	4.3	4.3	-
798	5	4.3	2.5	5.8	3.3	3.6	4.3	5.2	1.3
619	35	4.3	1.2	8.7	7.5	3.2	4.2	5.5	1.9
779	5	4.1	1.6	6.2	4.6	2.8	4.5	5.3	1.9
623	5	4.0	1.5	8.0	6.5	1.6	2.7	6.1	2.9
1116	3	3.7	3.1	4.2	1.1	3.5	3.9	4.1	0.57
792	6	3.2	1.1	7.6	6.5	1.8	2.3	3.6	2.4
768	5	3.1	0.96	6.0	5.0	1.7	3.4	3.7	2.0
1112	5	3.1	2.4	3.7	1.3	2.9	3.0	3.5	0.51
628	23	3.0	1.3	5.4	4.1	1.9	2.7	4.1	1.4
857	10	3.0	0.67	5.1	4.4	1.7	3.4	4.1	1.6
1135	1	2.9	2.9	2.9	-	2.9	2.9	2.9	-
1140	2	2.9	2.2	3.6	1.4	2.6	2.9	3.3	0.99
622	8	2.7	0.67	6.2	5.5	1.1	2.1	3.9	1.9
735	29	2.6	0.50	5.6	5.1	1.8	2.5	3.5	1.3
1133	2	2.5	2.4	2.5	0.10	2.4	2.5	2.5	0.07
1009	6	2.4	0.37	4.4	4.0	0.84	2.6	3.8	1.7
610	23	2.4	0.01	3.7	3.7	1.9	2.8	3.0	1.0
626	24	2.2	0.87	4.9	4.0	1.3	1.8	3.4	1.3
736	26	2.2	0.15	4.7	4.6	0.90	2.3	3.3	1.4
766	4	2.2	0.17	4.5	4.4	0.55	2.0	3.7	2.1
1104	7	2.1	1.2	3.2	2.0	1.5	1.9	2.7	0.80
1137	1	2.0	2.0	2.0	-	2.0	2.0	2.0	-
782	6	2.0	1.2	2.6	1.4	1.6	2.2	2.3	0.54
855	11	1.9	1.0	2.6	1.6	1.4	2.2	2.3	0.57
1141	2	1.9	1.7	2.0	0.30	1.8	1.9	1.9	0.21
1089	9	1.7	0.77	2.6	1.8	1.1	1.5	2.2	0.66
1114	6	1.6	1.0	2.4	1.4	1.3	1.5	2.0	0.53
797 (Bkgrnd)	19	1.6	0.001	7.2	7.2	0.27	0.50	2.6	2.0
1115	6	1.5	0.85	2.6	1.8	1.0	1.5	1.6	0.64
734	26	1.5	0.006	6.7	6.7	0.36	1.3	1.7	1.6
856	9	1.5	0.99	2.0	1.0	1.4	1.4	1.5	0.28
1136	1	1.4	1.4	1.4	-	1.4	1.4	1.4	-
1138	1	1.4	1.4	1.4	-	1.4	1.4	1.4	-
853	10	1.3	0.41	2.5	2.1	0.48	1.1	2.2	0.91
612	15	1.3	0.04	3.5	3.5	0.41	0.66	2.0	1.2
1143	1	1.1	1.1	1.1	-	1.1	1.1	1.1	-
850 (Bkgrnd)	24	1.1	0.07	5.2	5.1	0.40	0.78	1.4	1.1
1131	1	1.0	1.0	1.0	-	1.0	1.0	1.0	-
630	23	0.8	0.11	3.2	3.1	0.38	0.62	0.91	0.78
611	4	0.8	0.07	1.7	1.7	0.40	0.69	1.1	0.70
783	7	0.8	0.10	2.0	1.9	0.43	0.58	0.87	0.61
793	5	0.7	0.04	1.6	1.6	0.14	0.39	1.3	0.71
1113	4	0.6	0.02	2.4	2.4	0.03	0.04	0.63	1.2
1111	6	0.6	0.34	0.82	0.48	0.44	0.50	0.74	0.20
775	5	0.6	0.29	1.1	0.84	0.34	0.47	0.55	0.34
1117	6	0.5	0.30	0.87	0.57	0.35	0.47	0.74	0.25
1134	3	0.5	0.34	0.63	0.29	0.42	0.49	0.56	0.15
1132	3	0.3	0.29	0.45	0.16	0.30	0.30	0.38	0.09
1142	1	0.3	0.29	0.29	-	0.29	0.29	0.29	-
773	5	0.2	0.001	0.71	0.71	0.01	0.06	0.39	0.31
1126	1	0.2	0.23	0.23	-	0.23	0.23	0.23	-
1127	1	0.1	0.14	0.14	-	0.14	0.14	0.14	-
1139	1	0.1	0.08	0.08	-	0.08	0.08	0.08	-

Cutoff for historical background maximum, 7.2 mg/L, denoted by blue dashed line above.

Nitrate

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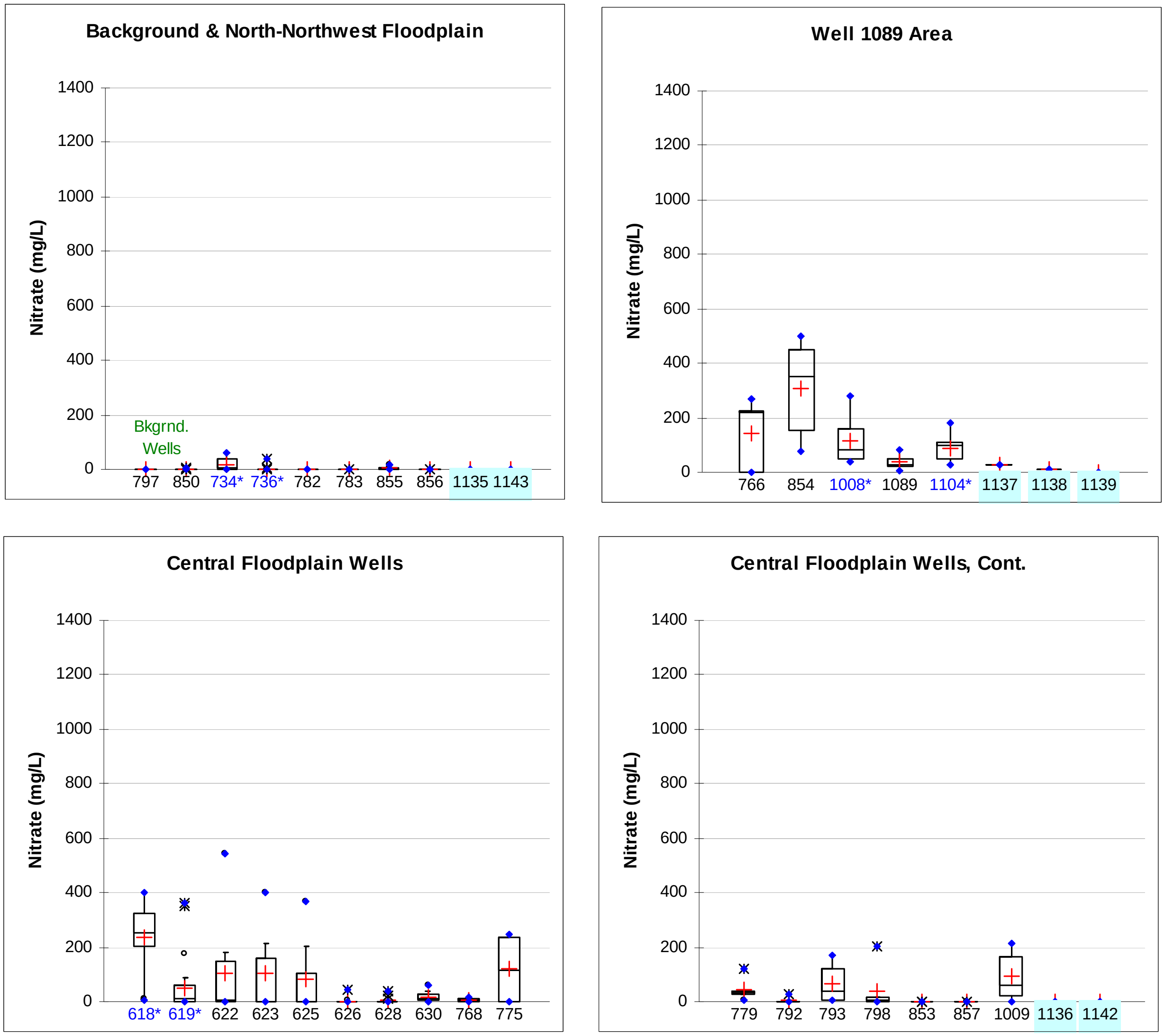

Figure A–4. Historical Distributions of Nitrate in Floodplain Monitoring Wells, page 1 of 2[†]

[†] The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of nitrate for each floodplain well or well grouping; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box. When interpreting these plots, it is important to account for the number of data points (N), listed below and in Table A–1. The greater the number of data points, the more reliable the interpretation of the plots. Well locations are shown in Figure A–1 by subgroup.

0734*	Time trends for COCs plotted in Section 2 of report.
1104	New well added in May 2009 or January 2010.

Background & North-Northwest Floodplain:

Well:	0797	0850	0734*	0736*	0782/0782R	0783/0783R	0855	0856	1135	1143
N:	19	24	25	25	6	7	12	10	1	1

Well 1089 Area:

Well:	0766	0854	1008*	1089	1104*	1137	1138	1139
N:	5	12	13	22	10	1	1	1

Central Floodplain Wells:

Well:	0618*	0619*	0622	0623	0625	0626	0628	0630	0768	0775	0779	0792	0793	0798	0853	0857	1009	1136	1142
N:	27	35	9	6	7	24	23	22	6	6	6	7	6	6	11	11	7	1	1

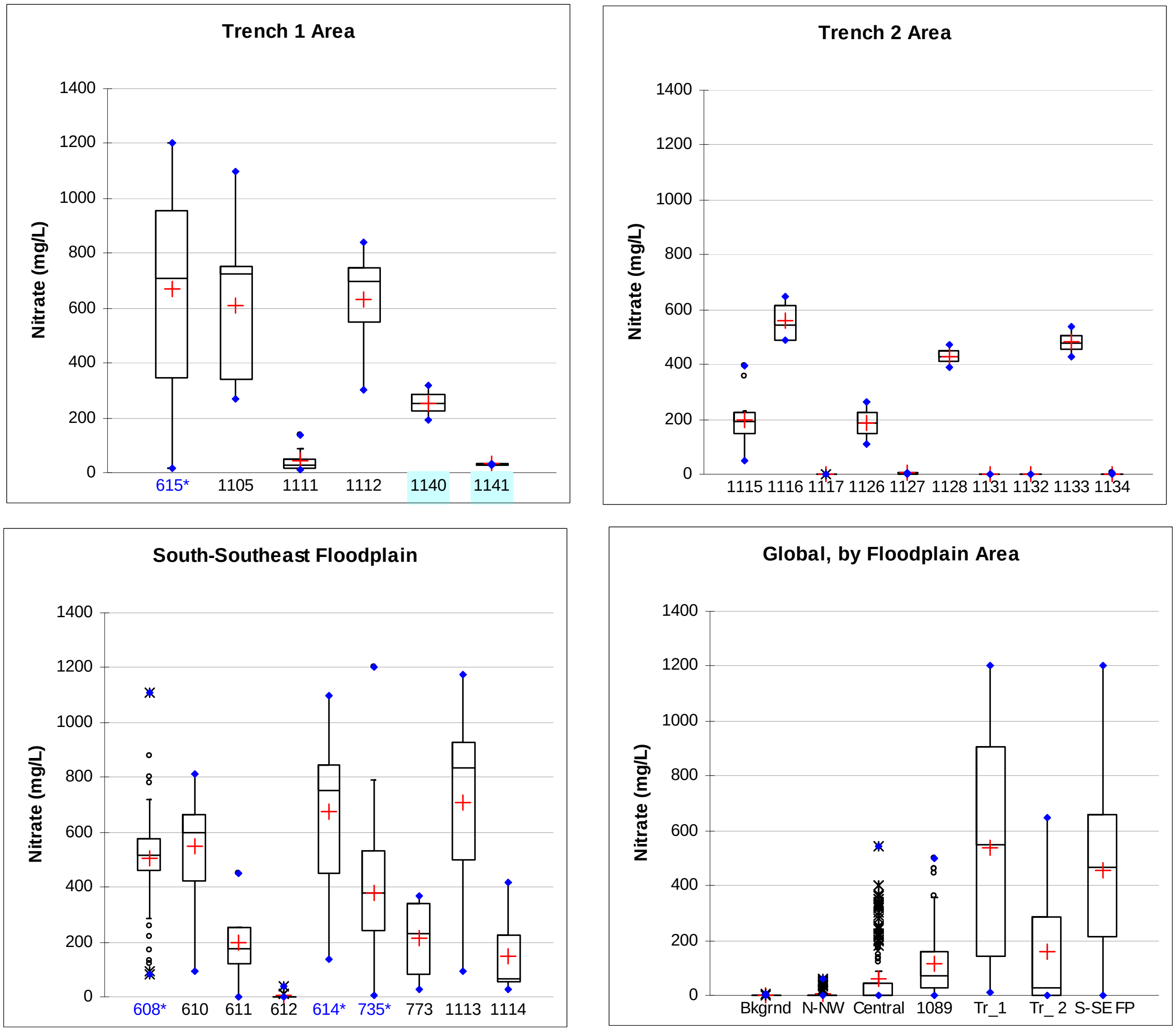

Figure A–4. Historical Distributions of Nitrate in Floodplain Monitoring Wells, page 2 of 2[†]

[†] See explanation on preceding page. The number of data points (N) corresponding to each well-specific plot shown above is provided below and in Table A–1.

Trench 1 Area Wells:

Well:	0615*	1105	1111	1112	1140	1141
N:	36	7	9	7	2	2

Trench 2 Area Wells:

Well:	1115	1116	1117	1126	1127	1128	1131	1132	1133	1134
N:	11	4	10	2	2	2	2	4	3	4

South-Southeast Floodplain Wells:

Well:	0608*	0610	0611	0612	0614*	0735*	0773	1113	1114
N:	43	23	5	15	41	29	6	7	11

Table A–4a. Summary Statistics for Nitrate in Floodplain Monitoring Wells, Sort on Well ID

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	703	205	0.002	1,200	1,200	0.14	36.1	355	290
608	43	503	82.4	1,107	1,025	459	519	575	207
610	23	549	92.6	813	721	424	601	663	183
611	5	200	0.66	452	451	120	178	251	168
612	15	3.9	0.003	36.1	36.1	0.01	0.03	0.73	9.6
614	41	673	138	1,100	962	450	752	847	258
615	36	669	14.0	1,200	1,186	346	707	955	376
618	27	235	6.1	402	396	201	250	327	113
619	35	47.5	0.01	361	361	0.06	10.7	61.9	86.7
622	9	102	0.01	542	542	0.02	3.4	149	179
623	6	102	0.01	400	400	0.02	1.2	160	168
625	7	81.9	0.02	366	366	0.04	2.3	102	146
626	24	2.6	0.01	42.9	42.9	0.13	0.32	1.4	8.7
628	23	3.3	0.002	36.1	36.1	0.05	0.21	1.0	8.8
630	22	16.8	0.02	59.9	59.9	4.3	11.7	25.7	15.4
734	25	17.8	0.01	59.0	58.9	0.40	3.2	36.4	21.0
735	29	380	7.1	1,200	1,193	244	380	530	240
736	25	2.1	0.01	39.5	39.5	0.02	0.08	0.38	7.9
766	5	142	0.09	267	266	2.3	217	224	130
768	6	6.1	0.02	13.9	13.9	0.60	4.9	11.3	6.2
773	6	212	26.0	370	344	83.4	233	340	155
775	6	119	0.05	248	248	0.71	113	237	130
779	6	43.9	4.2	122	118	28.8	34.7	39.4	40.3
782R	6	0.02	0.01	0.03	0.02	0.01	0.01	0.02	0.01
783R	7	0.14	0.01	0.82	0.81	0.01	0.01	0.04	0.30
792	7	4.7	0.01	30.0	30.0	0.03	0.04	1.2	11.2
793	6	66.7	5.1	171	166	7.9	38.0	122	73.4
797 (Bkgrnd)	19	0.04	0.004	0.11	0.11	0.01	0.03	0.06	0.03
798	6	38.6	0.90	203	202	1.5	3.7	15.6	80.9
850 (Bkgrnd)	24	0.23	0.004	3.3	3.3	0.01	0.01	0.02	0.74
853	11	0.08	0.01	0.49	0.48	0.01	0.01	0.04	0.15
854	12	306	76.3	501	425	154	349	448	155
855	12	4.2	0.01	16.9	16.9	0.26	2.2	6.8	5.2
856	10	0.12	0.003	1.0	1.0	0.01	0.02	0.04	0.31
857	11	0.27	0.01	1.9	1.9	0.02	0.05	0.16	0.56
1008	13	115	38.9	282	244	47.0	80.0	160	83.4
1009	7	93.6	0.42	217	216	22.0	60.1	167	90.1
1089	22	36.0	5.4	83.0	77.6	21.0	30.0	51.5	20.9
1104	10	87.4	28.0	180	152	48.8	97.2	108	46.2
1105	7	611	270	1,100	830	340	727	750	305
1111	9	45.7	12.0	139	127	14.0	28.0	51.0	42.7
1112	7	633	300	840	540	550	700	744	181
1113	7	708	96.0	1,175	1,079	500	836	926	370
1114	11	148	27.0	420	393	54.3	65.0	224	129
1115	11	197	48.0	394	346	148	190	227	107
1116	4	558	490	650	160	491	546	613	80.2
1117	10	0.36	0.01	2.3	2.3	0.03	0.08	0.39	0.71
1126	2	187	110	264	154	148	187	225	109
1127	2	4.1	0.01	8.1	8.1	2.0	4.1	6.1	5.7
1128	2	431	392	470	78.5	411	431	450	55.5
1131	2	0.06	0.02	0.10	0.08	0.04	0.06	0.08	0.05
1132	4	0.07	0.01	0.16	0.15	0.01	0.06	0.12	0.07
1133	3	482	430	536	106	455	480	508	52.8
1134	4	0.86	0.01	3.4	3.4	0.01	0.01	0.86	1.7
1135	1	0.01	0.01	0.01	-	0.01	0.01	0.01	-
1136	1	0.01	0.01	0.01	-	0.01	0.01	0.01	-
1137	1	27.0	27.0	27.0	-	27.0	27.0	27.0	-
1138	1	10.0	10.0	10.0	-	10.0	10.0	10.0	-
1139	1	1.9	1.9	1.9	-	1.9	1.9	1.9	-
1140	2	255	190	320	130	223	255	288	91.9
1141	2	31.0	29.0	33.0	4.0	30.0	31.0	32.0	2.8
1142	1	0.01	0.01	0.01	-	0.01	0.01	0.01	-
1143	1	0.01	0.01	0.01	-	0.01	0.01	0.01	-

Table A–4b. Summary Statistics for Nitrate in Floodplain Wells: Descending Sort on Mean

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	703	205	0.002	1,200	1,200	0.14	36.1	355	290
1113	7	708	96.0	1,175	1,079	500	836	926	370
614	41	673	138	1,100	962	450	752	847	258
615	36	669	14.0	1,200	1,186	346	707	955	376
1112	7	633	300	840	540	550	700	744	181
1105	7	611	270	1,100	830	340	727	750	305
1116	4	558	490	650	160	491	546	613	80.2
610	23	549	92.6	813	721	424	601	663	183
608	43	503	82.4	1,107	1,025	459	519	575	207
1133	3	482	430	536	106	455	480	508	52.8
1128	2	431	392	470	78.5	411	431	450	55.5
735	29	380	7.1	1,200	1,193	244	380	530	240
854	12	306	76.3	501	425	154	349	448	155
1140	2	255	190	320	130	223	255	288	91.9
618	27	235	6.1	402	396	201	250	327	113
773	6	212	26.0	370	344	83.4	233	340	155
611	5	200	0.66	452	451	120	178	251	168
1115	11	197	48.0	394	346	148	190	227	107
1126	2	187	110	264	154	148	187	225	109
1114	11	148	27.0	420	393	54.3	65.0	224	129
766	5	142	0.09	267	266	2.3	217	224	130
775	6	119	0.05	248	248	0.71	113	237	130
1008	13	115	38.9	282	244	47.0	80.0	160	83.4
623	6	102	0.01	400	400	0.02	1.2	160	168
622	9	102	0.01	542	542	0.02	3.4	149	179
1009	7	93.6	0.42	217	216	22.0	60.1	167	90.1
1104	10	87.4	28.0	180	152	48.8	97.2	108	46.2
625	7	81.9	0.02	366	366	0.04	2.3	102	146
793	6	66.7	5.1	171	166	7.9	38.0	122	73.4
619	35	47.5	0.01	361	361	0.06	10.7	61.9	86.7
1111	9	45.7	12.0	139	127	14.0	28.0	51.0	42.7
779	6	43.9	4.2	122	118	28.8	34.7	39.4	40.3
798	6	38.6	0.90	203	202	1.5	3.7	15.6	80.9
1089	22	36.0	5.4	83.0	77.6	21.0	30.0	51.5	20.9
1141	2	31.0	29.0	33.0	4.0	30.0	31.0	32.0	2.8
1137	1	27.0	27.0	27.0	-	27.0	27.0	27.0	-
734	25	17.8	0.01	59.0	58.9	0.40	3.2	36.4	21.0
630	22	16.8	0.02	59.9	59.9	4.3	11.7	25.7	15.4
1138	1	10.0	10.0	10.0	-	10.0	10.0	10.0	-
768	6	6.1	0.02	13.9	13.9	0.60	4.9	11.3	6.2
792	7	4.7	0.01	30.0	30.0	0.03	0.04	1.2	11.2
855	12	4.2	0.01	16.9	16.9	0.26	2.2	6.8	5.2
1127	2	4.1	0.01	8.1	8.1	2.0	4.1	6.1	5.7
612	15	3.9	0.003	36.1	36.1	0.01	0.03	0.73	9.6
628	23	3.3	0.002	36.1	36.1	0.05	0.21	1.0	8.8
626	24	2.6	0.01	42.9	42.9	0.13	0.32	1.4	8.7
736	25	2.1	0.01	39.5	39.5	0.02	0.08	0.38	7.9
1139	1	1.9	1.9	1.9	-	1.9	1.9	1.9	-
1134	4	0.86	0.01	3.4	3.4	0.01	0.01	0.86	1.7
1117	10	0.36	0.01	2.3	2.3	0.03	0.08	0.39	0.71
857	11	0.27	0.01	1.9	1.9	0.02	0.05	0.16	0.56
850 (Bkgrnd)	24	0.23	0.004	3.3	3.3	0.01	0.01	0.02	0.74
783R	7	0.14	0.01	0.82	0.81	0.01	0.01	0.04	0.30
856	10	0.12	0.003	1.0	1.0	0.01	0.02	0.04	0.31
853	11	0.08	0.01	0.49	0.48	0.01	0.01	0.04	0.15
1132	4	0.07	0.01	0.16	0.15	0.01	0.06	0.12	0.07
1131	2	0.06	0.02	0.10	0.08	0.04	0.06	0.08	0.05
797 (Bkgrnd)	19	0.04	0.004	0.11	0.11	0.01	0.03	0.06	0.03
782R	6	0.02	0.01	0.03	0.02	0.01	0.01	0.02	0.01
1135	1	0.01	0.01	0.01	-	0.01	0.01	0.01	-
1136	1	0.01	0.01	0.01	-	0.01	0.01	0.01	-
1142	1	0.01	0.01	0.01	-	0.01	0.01	0.01	-
1143	1	0.01	0.01	0.01	-	0.01	0.01	0.01	-

Cutoff for 40 CFR 192 MCL (10 mg/L) denoted by blue dashed line above.

Selenium

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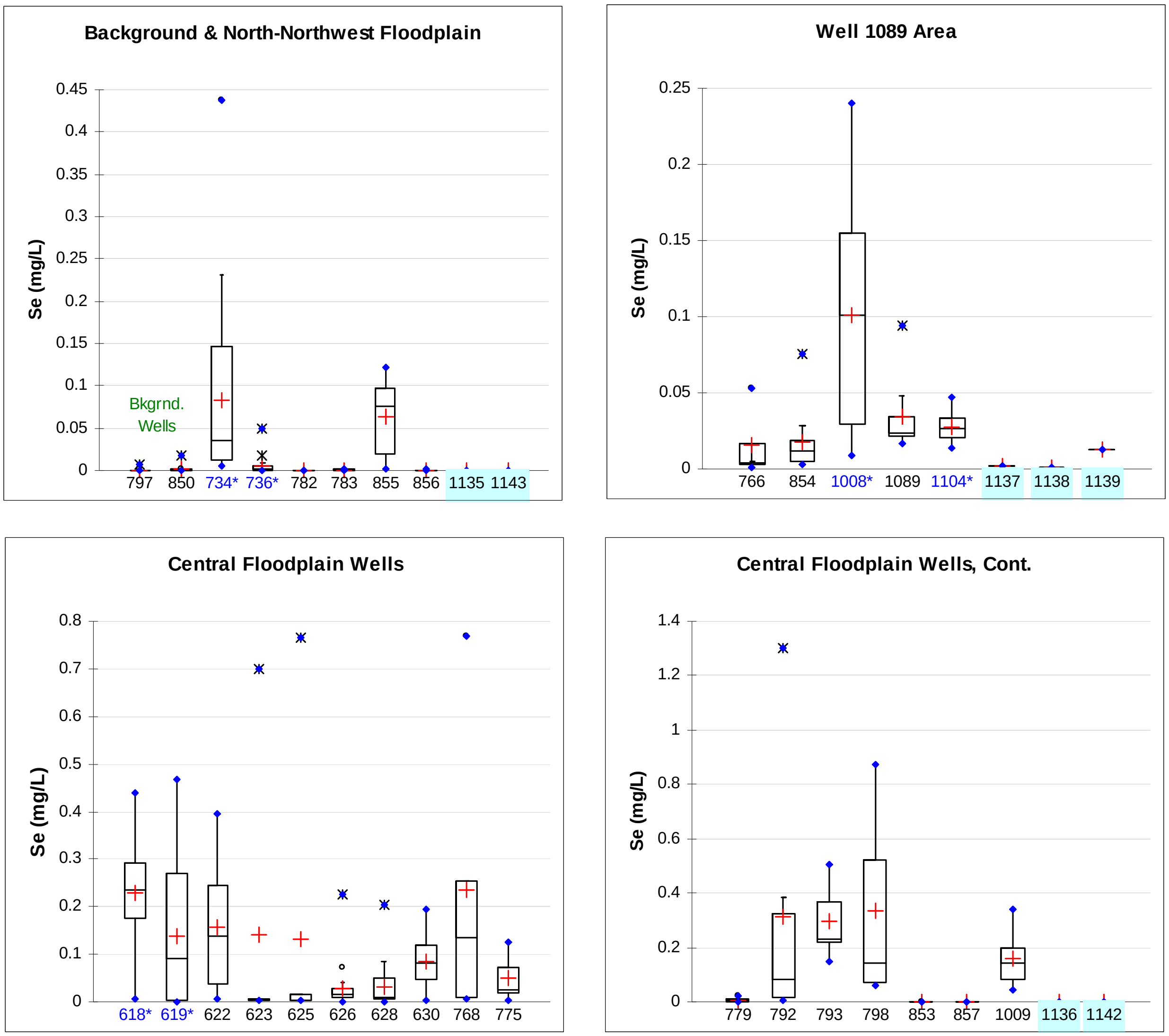

Figure A–5. Historical Distributions of Selenium in Floodplain Monitoring Wells, page 1 of 2†

† The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of selenium for each floodplain well or well grouping; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box. When interpreting these plots, it is important to account for the number of data points (N), listed below and in Table A–1. The greater the number of data points, the more reliable the interpretation of the plots. Well locations are shown in Figure A–1 by subgroup.

0734*	Time trends for COCs plotted in Section 2 of report.
1104	New well added in May 2009 or January 2010.

Background & North-Northwest Floodplain:

Well:	0797	0850	0734*	0736*	0782/0782R	0783/0783R	0855	0856	1135	1143
N:	19	24	27	27	6	7	11	9	1	1

Well 1089 Area:

Well:	0766	0854	1008*	1089	1104*	1137	1138	1139
N:	4	11	12	9	7	1	1	1

Central Floodplain Wells:

Well:	0618*	0619*	0622	0623	0625	0626	0628	0630	0768	0775	0779	0792	0793	0798	0853	0857	1009	1136	1142
N:	22	35	8	5	6	24	23	23	5	5	5	6	5	5	10	10	6	1	1

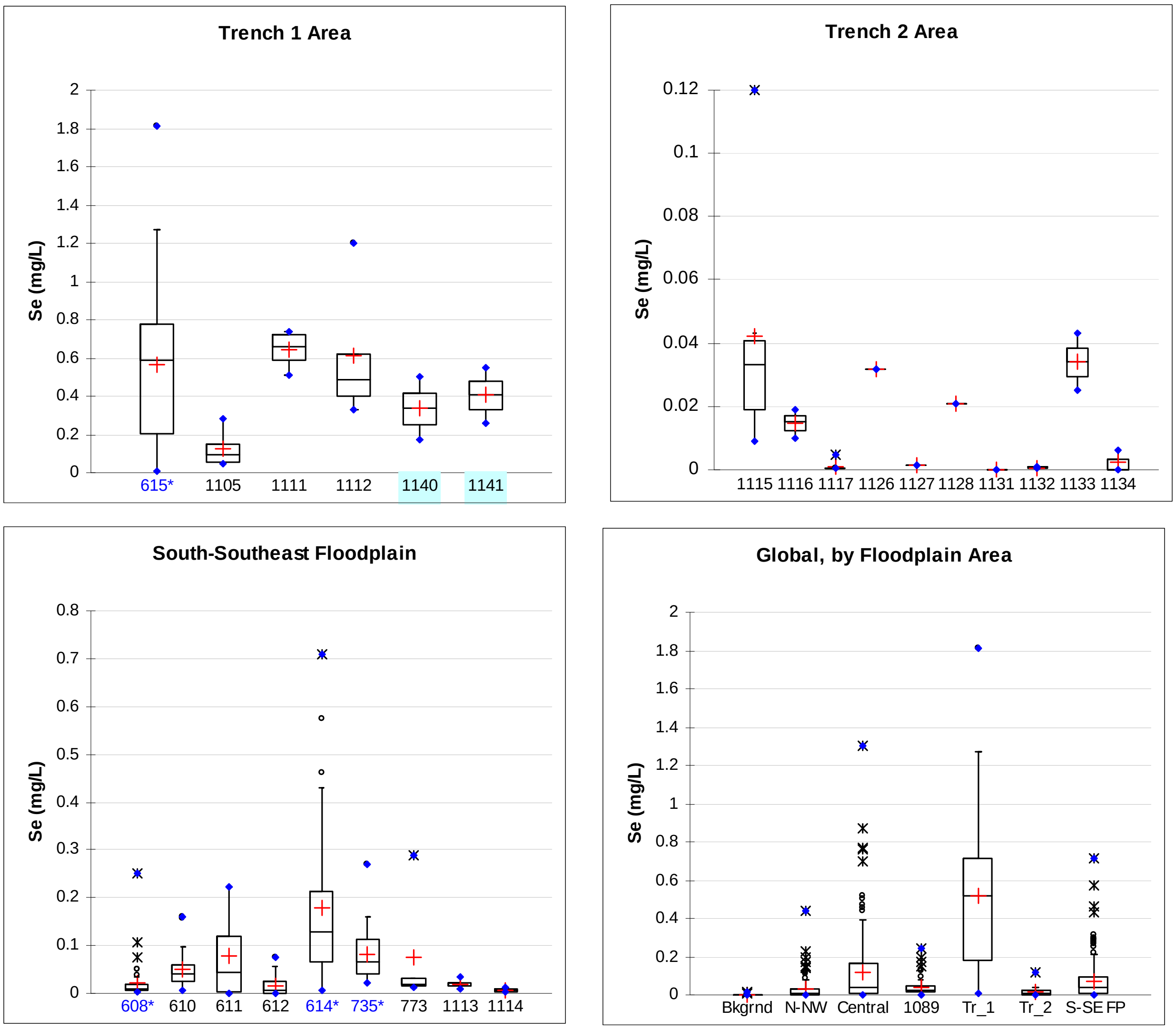

Figure A–5. Historical Distributions of Selenium in Floodplain Monitoring Wells, page 2 of 2[†]

[†] See explanation on preceding page. The number of data points (N) corresponding to each well-specific plot shown above is provided below and in Table A–1.

Trench 1 Area Wells:

Well:	0615*	1105	1111	1112	1140	1141
N:	31	6	6	5	2	2

Trench 2 Area Wells:

Well:	1115	1116	1117	1126	1127	1128	1131	1132	1133	1134
N:	6	3	6	1	1	1	1	3	2	3

South-Southeast Floodplain Wells:

Well:	0608*	0610	0611	0612	0614*	0735*	0773	1113	1114
N:	40	23	4	15	37	30	5	4	6

Table A–5a. Summary Statistics for Selenium in Floodplain Monitoring Wells, Sort on Well ID

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	626	0.11	0.0001	1.8	1.8	0.004	0.03	0.12	0.20
608	40	0.02	0.004	0.25	0.25	0.006	0.008	0.02	0.04
610	23	0.05	0.005	0.16	0.16	0.024	0.04	0.06	0.04
611	4	0.08	0.001	0.22	0.22	0.004	0.04	0.12	0.10
612	15	0.02	0.0001	0.08	0.08	0.0007	0.005	0.02	0.02
614	37	0.18	0.005	0.71	0.71	0.066	0.13	0.21	0.16
615	31	0.57	0.005	1.8	1.8	0.21	0.59	0.78	0.42
618	22	0.23	0.005	0.44	0.44	0.18	0.24	0.29	0.10
619	35	0.14	0.0003	0.47	0.47	0.003	0.09	0.27	0.15
622	8	0.16	0.006	0.40	0.39	0.037	0.14	0.25	0.14
623	5	0.14	0.002	0.70	0.70	0.002	0.003	0.006	0.31
625	6	0.13	0.002	0.76	0.76	0.002	0.004	0.01	0.31
626	24	0.03	0.0004	0.23	0.22	0.009	0.02	0.03	0.05
628	23	0.03	0.0003	0.20	0.20	0.005	0.01	0.05	0.05
630	23	0.08	0.005	0.20	0.19	0.048	0.08	0.12	0.05
734	27	0.08	0.005	0.44	0.43	0.012	0.04	0.15	0.10
735	30	0.08	0.02	0.27	0.25	0.042	0.07	0.11	0.06
736	27	0.005	0.0001	0.05	0.05	0.0007	0.002	0.005	0.010
766	4	0.02	0.001	0.05	0.05	0.003	0.004	0.02	0.02
768	5	0.23	0.006	0.77	0.76	0.009	0.13	0.25	0.32
773	5	0.07	0.01	0.29	0.28	0.017	0.02	0.03	0.12
775	5	0.05	0.004	0.12	0.12	0.019	0.02	0.07	0.05
779	5	0.008	0.001	0.02	0.02	0.002	0.004	0.009	0.009
782	6	0.0002	0.0001	0.0004	0.0003	0.0001	0.0001	0.0003	0.0001
783	7	0.001	0.0004	0.002	0.001	0.0004	0.0004	0.001	0.0005
792	6	0.31	0.006	1.3	1.3	0.015	0.08	0.33	0.51
793	5	0.30	0.15	0.51	0.36	0.22	0.23	0.37	0.14
797 (Bkgrnd)	19	0.001	0.0001	0.007	0.007	0.0001	0.0004	0.0007	0.002
798	5	0.33	0.06	0.87	0.81	0.070	0.14	0.52	0.36
850 (Bkgrnd)	24	0.001	0.0001	0.02	0.02	0.0002	0.0004	0.001	0.004
853	10	0.0003	0.0001	0.001	0.001	0.0001	0.0001	0.0004	0.0004
854	11	0.02	0.003	0.08	0.07	0.005	0.01	0.02	0.02
855	11	0.06	0.003	0.12	0.12	0.020	0.08	0.10	0.04
856	9	0.001	0.0002	0.001	0.001	0.0004	0.0006	0.0008	0.0003
857	10	0.001	0.0001	0.001	0.001	0.0002	0.0003	0.0009	0.0005
1008	12	0.10	0.009	0.24	0.23	0.030	0.10	0.15	0.08
1009	6	0.16	0.05	0.34	0.29	0.081	0.14	0.20	0.11
1089	9	0.03	0.02	0.09	0.08	0.022	0.02	0.03	0.02
1104	7	0.03	0.01	0.05	0.03	0.021	0.03	0.03	0.01
1105	6	0.12	0.05	0.28	0.23	0.058	0.09	0.15	0.09
1111	6	0.65	0.51	0.74	0.23	0.59	0.66	0.73	0.09
1112	5	0.61	0.33	1.2	0.87	0.40	0.49	0.62	0.35
1113	4	0.02	0.009	0.03	0.02	0.014	0.02	0.02	0.01
1114	6	0.007	0.004	0.01	0.007	0.005	0.006	0.009	0.003
1115	6	0.04	0.009	0.12	0.11	0.019	0.03	0.04	0.04
1116	3	0.01	0.01	0.02	0.009	0.013	0.02	0.02	0.005
1117	6	0.001	0.0003	0.005	0.004	0.0005	0.0005	0.0005	0.002
1126	1	0.03	0.03	0.03	-	0.032	0.03	0.03	-
1127	1	0.001	0.001	0.001	-	0.001	0.001	0.001	-
1128	1	0.02	0.02	0.02	-	0.021	0.02	0.02	-
1131	1	0.0002	0.0002	0.0002	-	0.0002	0.0002	0.0002	-
1132	3	0.001	0.0004	0.001	0.0005	0.0006	0.0008	0.0008	0.0002
1133	2	0.03	0.03	0.04	0.02	0.030	0.03	0.04	0.01
1134	3	0.002	0.0001	0.006	0.006	0.0001	0.0002	0.003	0.004
1135	1	0.0005	0.0005	0.0005	-	0.0005	0.0005	0.0005	-
1136	1	0.0001	0.0001	0.0001	-	0.0001	0.0001	0.0001	-
1137	1	0.002	0.002	0.002	-	0.002	0.002	0.002	-
1138	1	0.001	0.001	0.001	-	0.001	0.001	0.001	-
1139	1	0.01	0.01	0.01	-	0.013	0.01	0.01	-
1140	2	0.34	0.17	0.50	0.33	0.25	0.34	0.42	0.23
1141	2	0.41	0.26	0.55	0.29	0.33	0.41	0.48	0.21
1142	1	0.003	0.003	0.003	-	0.003	0.003	0.003	-
1143	1	0.0005	0.0005	0.0005	-	0.0005	0.0005	0.0005	-

Table A–5b. Summary Statistics for Selenium in Floodplain Wells: Descending Sort on Mean

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	626	0.11	0.0001	1.8	1.8	0.004	0.03	0.12	0.20
1111	6	0.65	0.51	0.74	0.23	0.59	0.66	0.73	0.09
1112	5	0.61	0.33	1.2	0.87	0.40	0.49	0.62	0.35
615	31	0.57	0.005	1.8	1.8	0.21	0.59	0.78	0.42
1141	2	0.41	0.26	0.55	0.29	0.33	0.41	0.48	0.21
1140	2	0.34	0.17	0.50	0.33	0.25	0.34	0.42	0.23
798	5	0.33	0.06	0.87	0.81	0.070	0.14	0.52	0.36
792	6	0.31	0.006	1.3	1.3	0.015	0.08	0.33	0.51
793	5	0.30	0.15	0.51	0.36	0.22	0.23	0.37	0.14
768	5	0.23	0.006	0.77	0.76	0.009	0.13	0.25	0.32
618	22	0.23	0.005	0.44	0.44	0.18	0.24	0.29	0.10
614	37	0.18	0.005	0.71	0.71	0.066	0.13	0.21	0.16
1009	6	0.16	0.05	0.34	0.29	0.081	0.14	0.20	0.11
622	8	0.16	0.006	0.40	0.39	0.037	0.14	0.25	0.14
623	5	0.14	0.002	0.70	0.70	0.002	0.003	0.006	0.31
619	35	0.14	0.0003	0.47	0.47	0.003	0.09	0.27	0.15
625	6	0.13	0.002	0.76	0.76	0.002	0.004	0.01	0.31
1105	6	0.12	0.05	0.28	0.23	0.058	0.09	0.15	0.09
1008	12	0.10	0.009	0.24	0.23	0.030	0.10	0.15	0.08
630	23	0.08	0.005	0.20	0.19	0.048	0.08	0.12	0.05
734	27	0.08	0.005	0.44	0.43	0.012	0.04	0.15	0.10
735	30	0.08	0.02	0.27	0.25	0.042	0.07	0.11	0.06
611	4	0.08	0.001	0.22	0.22	0.004	0.04	0.12	0.10
773	5	0.07	0.01	0.29	0.28	0.017	0.02	0.03	0.12
855	11	0.06	0.003	0.12	0.12	0.020	0.08	0.10	0.04
610	23	0.05	0.005	0.16	0.16	0.024	0.04	0.06	0.04
775	5	0.05	0.004	0.12	0.12	0.019	0.02	0.07	0.05
1115	6	0.04	0.009	0.12	0.11	0.019	0.03	0.04	0.04
1089	9	0.03	0.02	0.09	0.08	0.022	0.02	0.03	0.02
1133	2	0.03	0.03	0.04	0.02	0.030	0.03	0.04	0.01
628	23	0.03	0.0003	0.20	0.20	0.005	0.01	0.05	0.05
1126	1	0.03	0.03	0.03	-	0.032	0.03	0.03	-
1104	7	0.03	0.01	0.05	0.03	0.021	0.03	0.03	0.01
626	24	0.03	0.0004	0.23	0.22	0.009	0.02	0.03	0.05
608	40	0.02	0.004	0.25	0.25	0.006	0.008	0.02	0.04
1128	1	0.02	0.02	0.02	-	0.021	0.02	0.02	-
1113	4	0.02	0.009	0.03	0.02	0.014	0.02	0.02	0.01
854	11	0.02	0.003	0.08	0.07	0.005	0.01	0.02	0.02
612	15	0.02	0.0001	0.08	0.08	0.0007	0.005	0.02	0.02
766	4	0.02	0.001	0.05	0.05	0.003	0.004	0.02	0.02
1116	3	0.01	0.01	0.02	0.009	0.013	0.02	0.02	0.005
1139	1	0.01	0.01	0.01	-	0.013	0.01	0.01	-
779	5	0.008	0.001	0.02	0.02	0.002	0.004	0.009	0.009
1114	6	0.007	0.004	0.01	0.007	0.005	0.006	0.009	0.003
736	27	0.005	0.0001	0.05	0.05	0.0007	0.002	0.005	0.010
1142	1	0.003	0.003	0.003	-	0.003	0.003	0.003	-
1134	3	0.002	0.0001	0.006	0.006	0.0001	0.0002	0.003	0.004
1137	1	0.002	0.002	0.002	-	0.002	0.002	0.002	-
850 (Bkgrnd)	24	0.001	0.0001	0.02	0.02	0.0002	0.0004	0.001	0.004
1127	1	0.001	0.001	0.001	-	0.001	0.001	0.001	-
1138	1	0.001	0.001	0.001	-	0.001	0.001	0.001	-
1117	6	0.001	0.0003	0.005	0.004	0.0005	0.0005	0.0005	0.002
797 (Bkgrnd)	19	0.001	0.0001	0.007	0.007	0.0001	0.0004	0.0007	0.002
783	7	0.001	0.0004	0.002	0.001	0.0004	0.0004	0.001	0.0005
1132	3	0.001	0.0004	0.001	0.0005	0.0006	0.0008	0.0008	0.0002
856	9	0.001	0.0002	0.001	0.001	0.0004	0.0006	0.0008	0.0003
857	10	0.001	0.0001	0.001	0.001	0.0002	0.0003	0.0009	0.0005
1143	1	0.0005	0.0005	0.0005	-	0.0005	0.0005	0.0005	-
1135	1	0.0005	0.0005	0.0005	-	0.0005	0.0005	0.0005	-
853	10	0.0003	0.0001	0.001	0.001	0.0001	0.0001	0.0004	0.0004
1131	1	0.0002	0.0002	0.0002	-	0.0002	0.0002	0.0002	-
782	6	0.0002	0.0001	0.0004	0.0003	0.0001	0.0001	0.0003	0.0001
1136	1	0.0001	0.0001	0.0001	-	0.0001	0.0001	0.0001	-

Cutoffs for 40 CFR 192 (0.01 mg/L) and EPA Safe Drinking Water Act MCL (0.05 mg/L) denoted by blue dashed lines above.

Strontium

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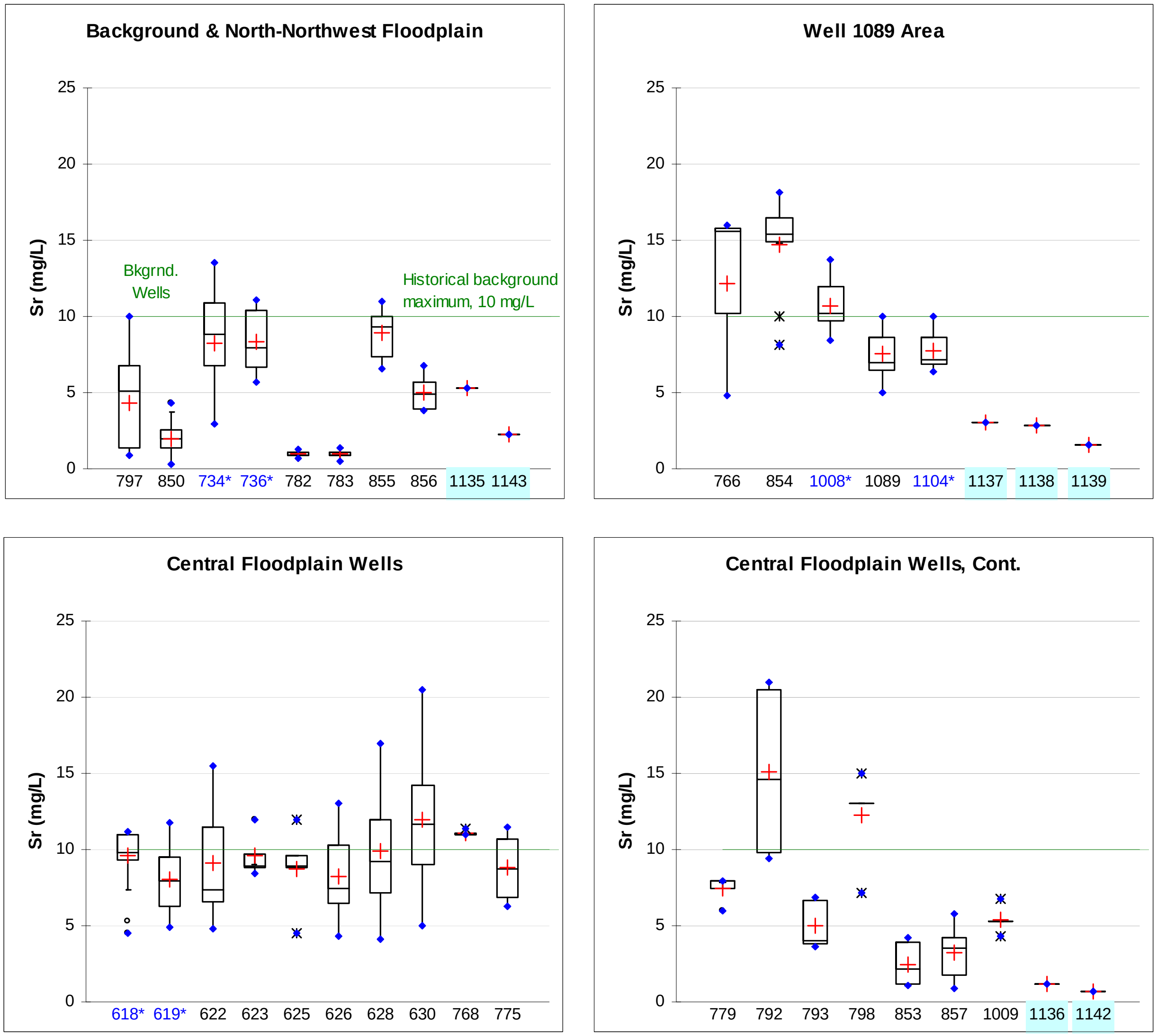

Figure A–6. Historical Distributions of Strontium in Floodplain Monitoring Wells, page 1 of 2[†]

[†] The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of strontium for each floodplain well or well grouping; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box. When interpreting these plots, it is important to account for the number of data points (N), listed below and in Table A–1. The greater the number of data points, the more reliable the interpretation of the plots. Well locations are shown in Figure A–1 by subgroup.

0734*	Time trends for COCs plotted in Section 2 of report.
1104	New well added in May 2009 or January 2010.

Background & North-Northwest Floodplain:

Well:	0797	0850	0734*	0736*	0782/0782R	0783/0783R	0855	0856	1135	1143
N:	19	24	25	25	5	6	10	9	1	1

Well 1089 Area:

Well:	0766	0854	1008*	1089	1104*	1137	1138	1139
N:	3	10	11	9	7	1	1	1

Central Floodplain Wells:

Well:	0618*	0619*	0622	0623	0625	0626	0628	0630	0768	0775	0779	0792	0793	0798	0853	0857	1009	1136	1142
N:	21	34	7	4	5	22	21	22	4	4	4	6	5	5	10	9	5	1	1

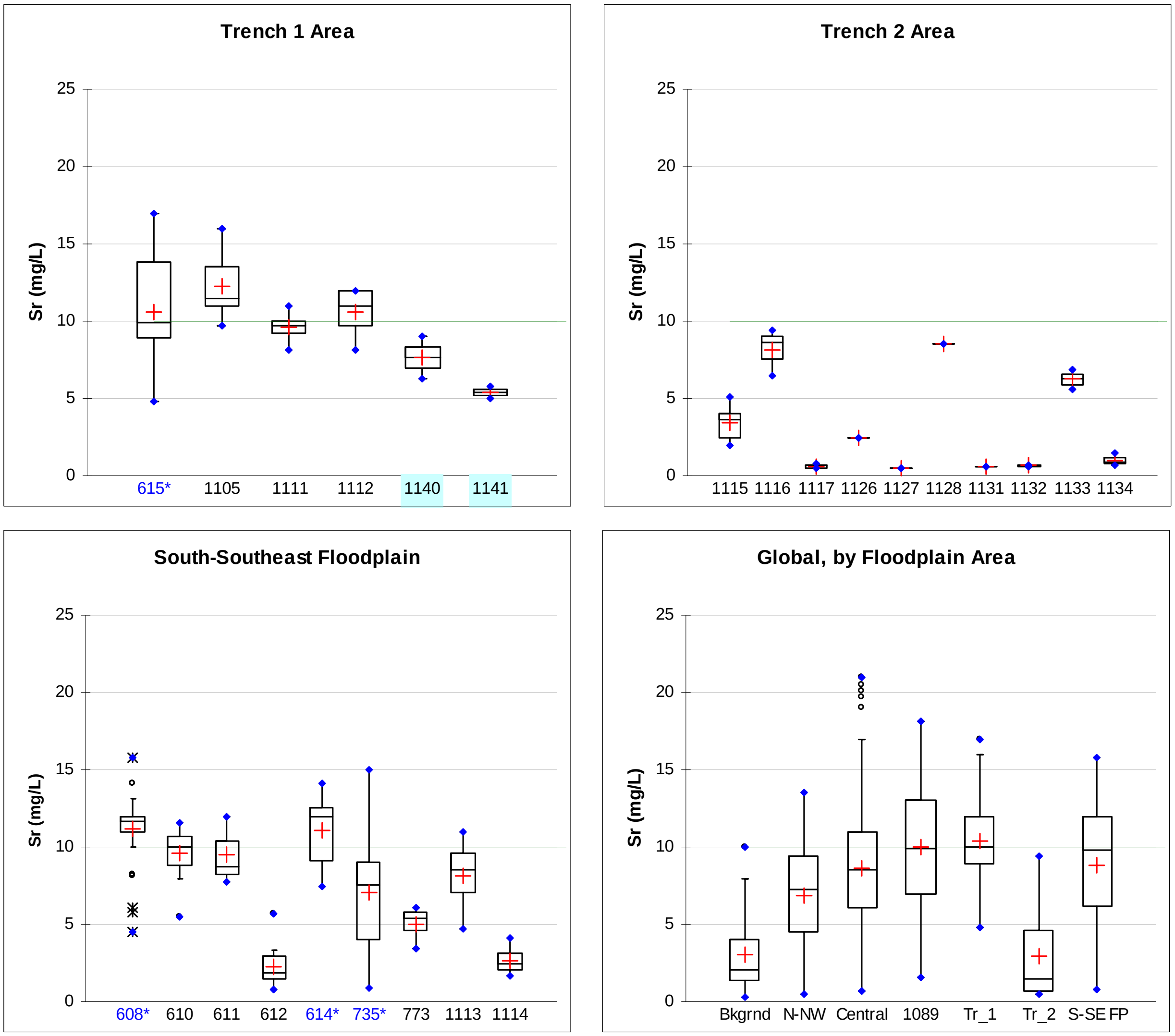

Figure A–6. Historical Distributions of Strontium in Floodplain Monitoring Wells, page 2 of 2†

† See explanation on preceding page. The number of data points (N) corresponding to each well-specific plot shown above is provided below and in Table A–1.

Trench 1 Area Wells:

Well:	0615*	1105	1111	1112	1140	1141
N:	30	6	6	5	2	2

Trench 2 Area Wells:

Well:	1115	1116	1117	1126	1127	1128	1131	1132	1133	1134
N:	6	3	6	1	1	1	1	3	2	3

South-Southeast Floodplain Wells:

Well:	0608*	0610	0611	0612	0614*	0735*	0773	1113	1114
N:	38	21	3	14	36	28	4	4	6

Table A–6a. Summary Statistics for Strontium in Floodplain Monitoring Wells, Sort on Well ID

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	590	8.0	0.3	21.0	20.8	5.2	8.4	11.0	4.1
608	38	11.2	4.5	15.8	11.3	11.0	11.7	12.0	2.2
610	21	9.6	5.5	11.6	6.1	8.8	10.0	10.7	1.4
611	3	9.5	7.7	12.0	4.3	8.2	8.7	10.4	2.3
612	14	2.2	0.8	5.6	4.9	1.5	1.9	2.9	1.3
614	36	11.1	7.5	14.1	6.6	9.1	12.0	12.5	1.9
615	30	10.6	4.8	17.0	12.2	9.0	9.9	13.8	3.1
618	21	9.6	4.5	11.2	6.7	9.3	9.8	11.0	1.9
619	34	8.0	4.9	11.8	6.9	6.3	8.0	9.5	2.0
622	7	9.1	4.8	15.5	10.7	6.6	7.3	11.5	4.4
623	4	9.6	8.4	12.0	3.6	8.8	9.0	9.8	1.6
625	5	8.8	4.5	12.0	7.5	8.8	8.9	9.6	2.7
626	22	8.2	4.3	13.0	8.7	6.5	7.4	10.3	2.5
628	21	9.9	4.1	17.0	12.9	7.2	9.2	12.0	3.4
630	22	12.0	5.0	20.5	15.5	9.0	11.7	14.3	4.5
734	25	8.3	2.9	13.5	10.6	6.8	8.8	10.9	3.0
735	28	7.1	0.9	15.0	14.1	4.0	7.5	9.0	3.6
736	25	8.3	5.7	11.1	5.4	6.7	8.0	10.4	1.8
766	3	12.1	4.8	16.0	11.2	10.2	15.6	15.8	6.4
768	4	11.1	11.0	11.4	0.4	11.0	11.0	11.1	0.2
773	4	5.0	3.4	6.0	2.6	4.6	5.4	5.8	1.2
775	4	8.8	6.3	11.5	5.2	6.9	8.8	10.7	2.5
779	4	7.4	6.0	8.0	2.0	7.4	7.9	7.9	1.0
782	5	1.0	0.7	1.3	0.6	0.9	0.9	1.1	0.2
783	6	1.0	0.5	1.4	0.9	0.8	0.9	1.1	0.3
792	6	15.1	9.4	21.0	11.6	9.9	14.7	20.5	5.8
793	5	5.0	3.6	6.8	3.2	3.8	4.0	6.7	1.6
797 (Bkgrnd)	19	4.3	0.8	10.0	9.2	1.4	5.1	6.8	3.0
798	5	12.2	7.2	15.0	7.8	13.0	13.0	13.0	2.9
850 (Bkgrnd)	24	2.0	0.3	4.3	4.1	1.4	2.0	2.5	1.0
853	10	2.5	1.1	4.2	3.1	1.2	2.2	3.9	1.4
854	10	14.7	8.1	18.1	10.0	14.9	15.4	16.4	3.2
855	10	8.9	6.6	11.0	4.4	7.4	9.3	10.0	1.6
856	9	5.0	3.8	6.8	3.0	4.0	4.9	5.7	1.0
857	9	3.3	0.9	5.8	4.8	1.8	3.6	4.2	1.7
1008	11	10.7	8.4	13.7	5.3	9.8	10.2	12.0	1.6
1009	5	5.4	4.3	6.8	2.5	5.3	5.3	5.3	0.9
1089	9	7.6	5.0	10.0	5.0	6.5	7.0	8.6	1.7
1104	7	7.8	6.4	10.0	3.6	6.9	7.2	8.6	1.5
1105	6	12.3	9.7	16.0	6.3	11.0	11.5	13.5	2.3
1111	6	9.6	8.1	11.0	2.9	9.2	9.7	10.0	1.0
1112	5	10.6	8.1	12.0	3.9	9.7	11.0	12.0	1.7
1113	4	8.2	4.7	11.0	6.3	7.0	8.5	9.7	2.7
1114	6	2.7	1.7	4.1	2.4	2.0	2.5	3.1	0.9
1115	6	3.4	2.0	5.1	3.1	2.5	3.7	4.0	1.2
1116	3	8.2	6.5	9.4	2.9	7.6	8.6	9.0	1.5
1117	6	0.6	0.5	0.7	0.3	0.5	0.7	0.7	0.1
1126	1	2.5	2.5	2.5	-	2.5	2.5	2.5	-
1127	1	0.5	0.5	0.5	-	0.5	0.5	0.5	-
1128	1	8.5	8.5	8.5	-	8.5	8.5	8.5	-
1131	1	0.5	0.5	0.5	-	0.5	0.5	0.5	-
1132	3	0.6	0.6	0.7	0.2	0.6	0.7	0.7	0.1
1133	2	6.3	5.6	6.9	1.3	5.9	6.3	6.6	0.9
1134	3	1.0	0.6	1.5	0.9	0.8	0.9	1.2	0.4
1135	1	5.3	5.3	5.3	-	5.3	5.3	5.3	-
1136	1	1.2	1.2	1.2	-	1.2	1.2	1.2	-
1137	1	3.0	3.0	3.0	-	3.0	3.0	3.0	-
1138	1	2.8	2.8	2.8	-	2.8	2.8	2.8	-
1139	1	1.6	1.6	1.6	-	1.6	1.6	1.6	-
1140	2	7.7	6.3	9.0	2.7	7.0	7.7	8.3	1.9
1141	2	5.4	5.0	5.8	0.8	5.2	5.4	5.6	0.6
1142	1	0.7	0.7	0.7	-	0.7	0.7	0.7	-
1143	1	2.3	2.3	2.3	-	2.3	2.3	2.3	-

Table A–6b. Summary Statistics for Strontium in Floodplain Wells: Descending Sort on Mean

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	590	8.0	0.3	21.0	20.8	5.2	8.4	11.0	4.1
792	6	15.1	9.4	21.0	11.6	9.9	14.7	20.5	5.8
854	10	14.7	8.1	18.1	10.0	14.9	15.4	16.4	3.2
1105	6	12.3	9.7	16.0	6.3	11.0	11.5	13.5	2.3
798	5	12.2	7.2	15.0	7.8	13.0	13.0	13.0	2.9
766	3	12.1	4.8	16.0	11.2	10.2	15.6	15.8	6.4
630	22	12.0	5.0	20.5	15.5	9.0	11.7	14.3	4.5
608	38	11.2	4.5	15.8	11.3	11.0	11.7	12.0	2.2
614	36	11.1	7.5	14.1	6.6	9.1	12.0	12.5	1.9
768	4	11.1	11.0	11.4	0.4	11.0	11.0	11.1	0.2
1008	11	10.7	8.4	13.7	5.3	9.8	10.2	12.0	1.6
615	30	10.6	4.8	17.0	12.2	9.0	9.9	13.8	3.1
1112	5	10.6	8.1	12.0	3.9	9.7	11.0	12.0	1.7
628	21	9.9	4.1	17.0	12.9	7.2	9.2	12.0	3.4
1111	6	9.6	8.1	11.0	2.9	9.2	9.7	10.0	1.0
610	21	9.6	5.5	11.6	6.1	8.8	10.0	10.7	1.4
623	4	9.6	8.4	12.0	3.6	8.8	9.0	9.8	1.6
618	21	9.6	4.5	11.2	6.7	9.3	9.8	11.0	1.9
611	3	9.5	7.7	12.0	4.3	8.2	8.7	10.4	2.3
622	7	9.1	4.8	15.5	10.7	6.6	7.3	11.5	4.4
855	10	8.9	6.6	11.0	4.4	7.4	9.3	10.0	1.6
775	4	8.8	6.3	11.5	5.2	6.9	8.8	10.7	2.5
625	5	8.8	4.5	12.0	7.5	8.8	8.9	9.6	2.7
1128	1	8.5	8.5	8.5	-	8.5	8.5	8.5	-
736	25	8.3	5.7	11.1	5.4	6.7	8.0	10.4	1.8
734	25	8.3	2.9	13.5	10.6	6.8	8.8	10.9	3.0
626	22	8.2	4.3	13.0	8.7	6.5	7.4	10.3	2.5
1113	4	8.2	4.7	11.0	6.3	7.0	8.5	9.7	2.7
1116	3	8.2	6.5	9.4	2.9	7.6	8.6	9.0	1.5
619	34	8.0	4.9	11.8	6.9	6.3	8.0	9.5	2.0
1104	7	7.8	6.4	10.0	3.6	6.9	7.2	8.6	1.5
1140	2	7.7	6.3	9.0	2.7	7.0	7.7	8.3	1.9
1089	9	7.6	5.0	10.0	5.0	6.5	7.0	8.6	1.7
779	4	7.4	6.0	8.0	2.0	7.4	7.9	7.9	1.0
735	28	7.1	0.9	15.0	14.1	4.0	7.5	9.0	3.6
1133	2	6.3	5.6	6.9	1.3	5.9	6.3	6.6	0.9
1141	2	5.4	5.0	5.8	0.8	5.2	5.4	5.6	0.6
1009	5	5.4	4.3	6.8	2.5	5.3	5.3	5.3	0.9
1135	1	5.3	5.3	5.3	-	5.3	5.3	5.3	-
773	4	5.0	3.4	6.0	2.6	4.6	5.4	5.8	1.2
793	5	5.0	3.6	6.8	3.2	3.8	4.0	6.7	1.6
856	9	5.0	3.8	6.8	3.0	4.0	4.9	5.7	1.0
797 (Bkgrnd)	19	4.3	0.8	10.0	9.2	1.4	5.1	6.8	3.0
1115	6	3.4	2.0	5.1	3.1	2.5	3.7	4.0	1.2
857	9	3.3	0.9	5.8	4.8	1.8	3.6	4.2	1.7
1137	1	3.0	3.0	3.0	-	3.0	3.0	3.0	-
1138	1	2.8	2.8	2.8	-	2.8	2.8	2.8	-
1114	6	2.7	1.7	4.1	2.4	2.0	2.5	3.1	0.9
1126	1	2.5	2.5	2.5	-	2.5	2.5	2.5	-
853	10	2.5	1.1	4.2	3.1	1.2	2.2	3.9	1.4
1143	1	2.3	2.3	2.3	-	2.3	2.3	2.3	-
612	14	2.2	0.8	5.6	4.9	1.5	1.9	2.9	1.3
850 (Bkgrnd)	24	2.0	0.3	4.3	4.1	1.4	2.0	2.5	1.0
1139	1	1.6	1.6	1.6	-	1.6	1.6	1.6	-
1136	1	1.2	1.2	1.2	-	1.2	1.2	1.2	-
1134	3	1.0	0.6	1.5	0.9	0.8	0.9	1.2	0.4
782	5	1.0	0.7	1.3	0.6	0.9	0.9	1.1	0.2
783	6	1.0	0.5	1.4	0.9	0.8	0.9	1.1	0.3
1142	1	0.7	0.7	0.7	-	0.7	0.7	0.7	-
1132	3	0.6	0.6	0.7	0.2	0.6	0.7	0.7	0.1
1117	6	0.6	0.5	0.7	0.3	0.5	0.7	0.7	0.1
1131	1	0.5	0.5	0.5	-	0.5	0.5	0.5	-
1127	1	0.5	0.5	0.5	-	0.5	0.5	0.5	-

Cutoff for historical background maximum of 10 mg/L (in well 0797) denoted by blue dashed line above.
All values are below EPA's risk-based screening level for groundwater (22 mg/L); see Section 1.2 of main report.

Sulfate

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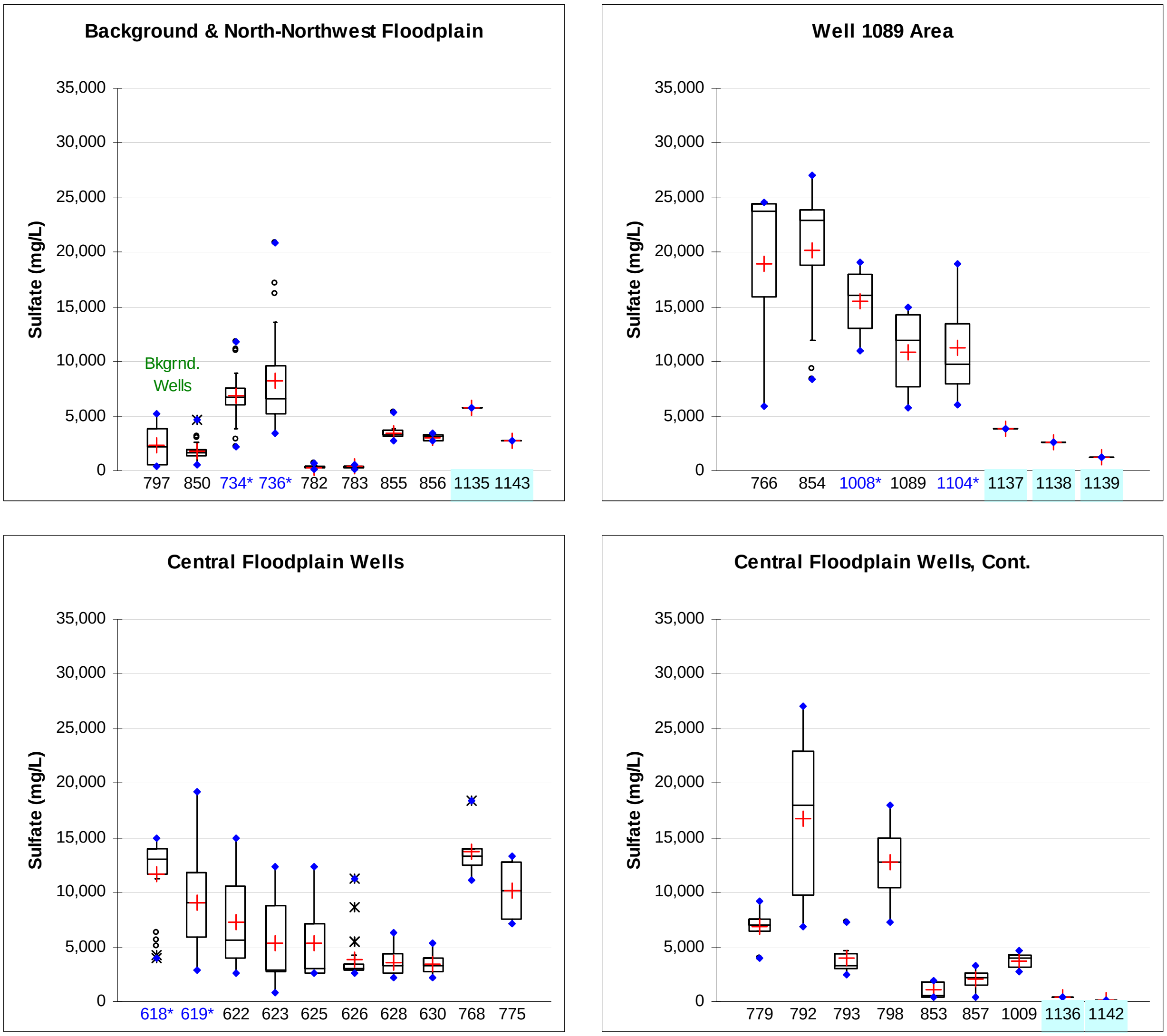

Figure A–7. Historical Distributions of Sulfate in Floodplain Monitoring Wells, page 1 of 2†

† The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of sulfate for each floodplain well or well grouping; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box. When interpreting these plots, it is important to account for the number of data points (N), listed below and in Table A–1. The greater the number of data points, the more reliable the interpretation of the plots. Well locations are shown in Figure A–1 by subgroup.

0734*	Time trends for COCs plotted in Section 2 of report.
1104	New well added in May 2009 or January 2010.

Background & North-Northwest Floodplain:

Well:	0797	0850	0734*	0736*	0782/0782R	0783/0783R	0855	0856	1135	1143
N:	18	24	25	26	6	7	12	10	1	1

Well 1089 Area:

Well:	0766	0854	1008*	1089	1104*	1137	1138	1139
N:	5	12	13	21	10	1	1	1

Central Floodplain Wells:

Well:	0618*	0619*	0622	0623	0625	0626	0628	0630	0768	0775	0779	0792	0793	0798	0853	0857	1009	1136	1142
N:	26	36	9	6	7	25	24	24	6	6	6	7	6	6	11	11	7	1	1

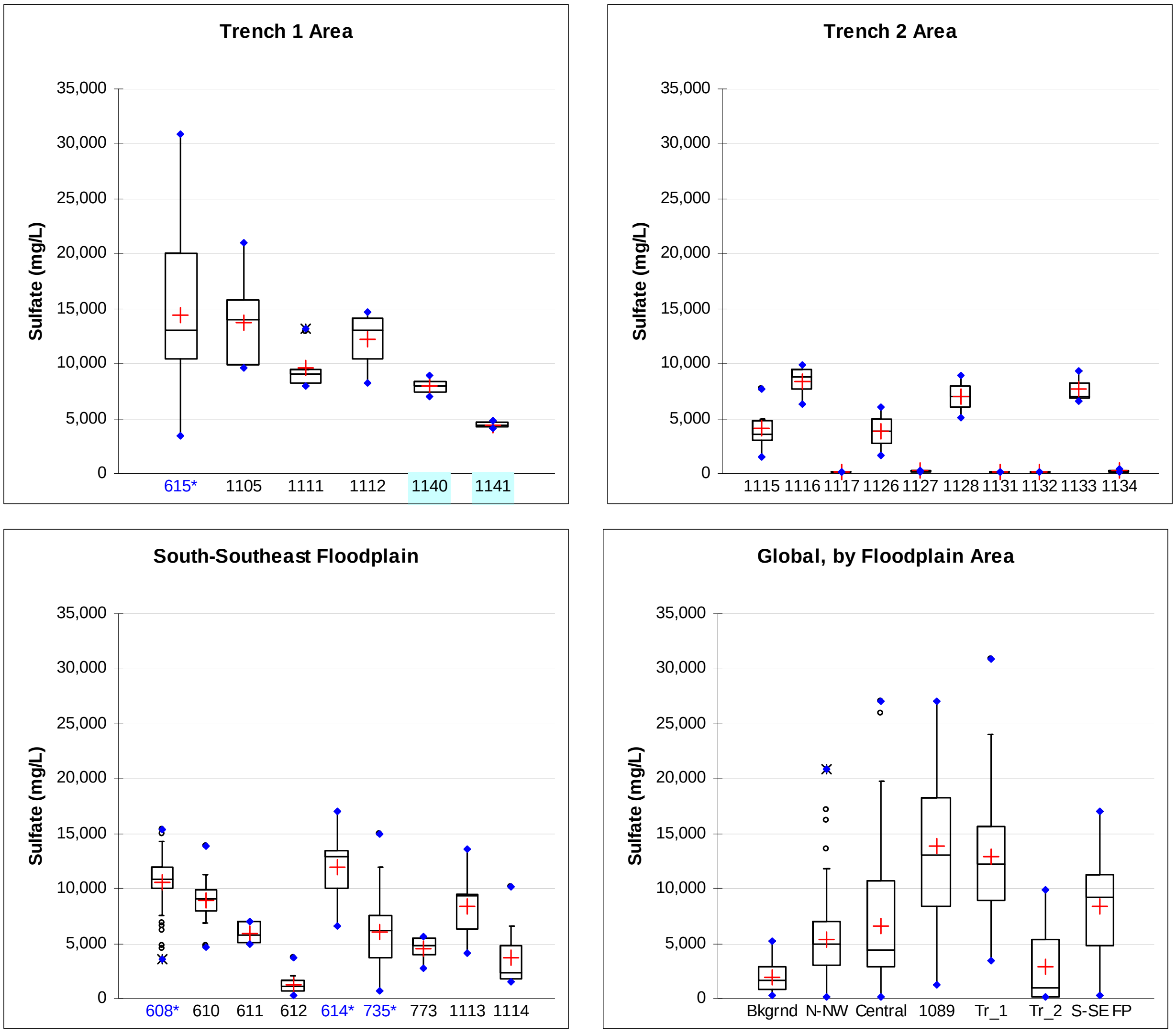

Figure A–7. Historical Distributions of Sulfate in Floodplain Monitoring Wells, page 2 of 2†

† See explanation on preceding page. The number of data points (N) corresponding to each well-specific plot shown above is provided below and in Table A–1.

Trench 1 Area Wells:

Well:	0615*	1105	1111	1112	1140	1141
N:	37	7	9	7	2	2

Trench 2 Area Wells:

Well:	1115	1116	1117	1126	1127	1128	1131	1132	1133	1134
N:	11	4	10	2	2	2	2	4	3	4

South-Southeast Floodplain Wells:

Well:	0608*	0610	0611	0612	0614*	0735*	0773	1113	1114
N:	44	24	5	16	41	29	6	7	11

Table A–7a. Summary Statistics for Sulfate in Floodplain Monitoring Wells, Sort on Well ID

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	709	7,622	75	30,868	30,793	3,020	6,600	11,300	5,655
608	44	10,623	3,600	15,400	11,800	10,075	10,870	12,000	2,618
610	24	8,931	4,660	13,800	9,140	8,002	9,010	9,870	2,007
611	5	5,929	4,900	6,964	2,064	5,130	5,700	6,950	983
612	16	1,247	310	3,750	3,440	705	1,090	1,620	874
614	41	11,999	6,630	17,000	10,370	10,000	12,900	13,400	2,660
615	37	14,378	3,500	30,868	27,368	10,400	13,100	20,000	6,437
618	26	11,726	3,960	15,000	11,040	11,608	13,000	14,000	3,466
619	36	9,003	2,900	19,200	16,300	5,850	9,105	11,750	3,933
622	9	7,254	2,600	14,900	12,300	4,022	5,600	10,600	4,175
623	6	5,379	780	12,400	11,620	2,700	2,896	8,723	4,843
625	7	5,343	2,600	12,300	9,700	2,650	2,973	7,115	4,086
626	25	3,857	2,540	11,300	8,760	2,900	3,080	3,490	2,036
628	24	3,598	2,190	6,260	4,070	2,675	3,300	4,420	1,172
630	23	3,442	2,200	5,390	3,190	2,800	3,230	3,955	869
734	25	6,828	2,200	11,800	9,600	6,000	6,700	7,500	2,274
735	29	6,043	707	15,000	14,293	3,700	6,240	7,500	3,648
736	26	8,191	3,480	20,800	17,320	5,200	6,650	9,598	4,366
766	5	18,938	5,900	24,600	18,700	15,990	23,700	24,500	8,129
768	6	13,782	11,100	18,390	7,290	12,550	13,350	14,000	2,503
773	6	4,535	2,800	5,590	2,790	3,950	4,740	5,425	1,118
775	6	10,190	7,100	13,300	6,200	7,553	10,200	12,800	3,053
779	6	6,842	3,950	9,191	5,241	6,425	6,955	7,553	1,737
782	6	330	183	630	447	237	275	363	162
783	7	353	138	610	472	273	340	420	151
792	7	16,739	6,810	27,000	20,190	9,800	18,000	22,883	8,132
793	6	4,025	2,460	7,300	4,840	3,000	3,350	4,442	1,779
797 (Bkgrnd)	18	2,272	427	5,200	4,773	561	2,250	3,900	1,682
798	6	12,699	7,300	18,000	10,700	10,421	12,750	15,000	3,949
850 (Bkgrnd)	24	1,767	610	4,600	3,990	1,335	1,635	1,905	891
853	11	1,053	360	1,980	1,620	422	520	1,765	725
854	12	20,227	8,421	27,000	18,579	18,825	22,950	23,850	6,447
855	12	3,474	2,700	5,300	2,600	3,175	3,228	3,718	669
856	10	3,044	2,691	3,440	749	2,750	3,115	3,238	278
857	11	2,059	470	3,260	2,790	1,567	2,230	2,610	934
1008	13	15,506	11,000	19,100	8,100	13,000	16,000	18,000	2,959
1009	7	3,734	2,700	4,680	1,980	3,100	3,920	4,318	772
1089	21	10,809	5,700	15,000	9,300	7,700	11,983	14,250	3,230
1104	10	11,313	6,100	19,000	12,900	7,950	9,814	13,500	4,653
1105	7	13,738	9,600	21,000	11,400	9,950	14,000	15,834	4,232
1111	9	9,597	7,900	13,185	5,285	8,300	9,000	9,442	1,998
1112	7	12,164	8,300	14,676	6,376	10,450	13,000	14,135	2,457
1113	7	8,377	4,100	13,595	9,495	6,350	9,293	9,476	3,131
1114	11	3,666	1,500	10,093	8,593	1,792	2,400	4,784	2,719
1115	11	4,093	1,500	7,742	6,242	3,044	3,600	4,832	2,088
1116	4	8,430	6,300	9,820	3,520	7,725	8,800	9,505	1,577
1117	10	143	87	200	113	115	145	158	38
1126	2	3,827	1,600	6,053	4,453	2,713	3,827	4,940	3,149
1127	2	206	93	319	226	150	206	263	160
1128	2	7,005	5,109	8,900	3,791	6,057	7,005	7,952	2,681
1131	2	121	75	167	92	98	121	144	65
1132	4	145	110	168	58	133	150	162	26
1133	3	7,665	6,600	9,395	2,795	6,800	7,000	8,198	1,512
1134	4	215	120	410	290	128	166	253	135
1135	1	5,800	5,800	5,800	-	5,800	5,800	5,800	-
1136	1	360	360	360	-	360	360	360	-
1137	1	3,800	3,800	3,800	-	3,800	3,800	3,800	-
1138	1	2,600	2,600	2,600	-	2,600	2,600	2,600	-
1139	1	1,200	1,200	1,200	-	1,200	1,200	1,200	-
1140	2	7,950	7,000	8,900	1,900	7,475	7,950	8,425	1,344
1141	2	4,450	4,100	4,800	700	4,275	4,450	4,625	495
1142	1	150	150	150	-	150	150	150	-
1143	1	2,800	2,800	2,800	-	2,800	2,800	2,800	-

Table A–7b. Summary Statistics for Sulfate in Floodplain Wells: Descending Sort on Mean

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	709	7,622	75	30,868	30,793	3,020	6,600	11,300	5,655
854	12	20,227	8,421	27,000	18,579	18,825	22,950	23,850	6,447
766	5	18,938	5,900	24,600	18,700	15,990	23,700	24,500	8,129
792	7	16,739	6,810	27,000	20,190	9,800	18,000	22,883	8,132
1008	13	15,506	11,000	19,100	8,100	13,000	16,000	18,000	2,959
615	37	14,378	3,500	30,868	27,368	10,400	13,100	20,000	6,437
768	6	13,782	11,100	18,390	7,290	12,550	13,350	14,000	2,503
1105	7	13,738	9,600	21,000	11,400	9,950	14,000	15,834	4,232
798	6	12,699	7,300	18,000	10,700	10,421	12,750	15,000	3,949
1112	7	12,164	8,300	14,676	6,376	10,450	13,000	14,135	2,457
614	41	11,999	6,630	17,000	10,370	10,000	12,900	13,400	2,660
618	26	11,726	3,960	15,000	11,040	11,608	13,000	14,000	3,466
1104	10	11,313	6,100	19,000	12,900	7,950	9,814	13,500	4,653
1089	21	10,809	5,700	15,000	9,300	7,700	11,983	14,250	3,230
608	44	10,623	3,600	15,400	11,800	10,075	10,870	12,000	2,618
775	6	10,190	7,100	13,300	6,200	7,553	10,200	12,800	3,053
1111	9	9,597	7,900	13,185	5,285	8,300	9,000	9,442	1,998
619	36	9,003	2,900	19,200	16,300	5,850	9,105	11,750	3,933
610	24	8,931	4,660	13,800	9,140	8,002	9,010	9,870	2,007
1116	4	8,430	6,300	9,820	3,520	7,725	8,800	9,505	1,577
1113	7	8,377	4,100	13,595	9,495	6,350	9,293	9,476	3,131
736	26	8,191	3,480	20,800	17,320	5,200	6,650	9,598	4,366
1140	2	7,950	7,000	8,900	1,900	7,475	7,950	8,425	1,344
1133	3	7,665	6,600	9,395	2,795	6,800	7,000	8,198	1,512
622	9	7,254	2,600	14,900	12,300	4,022	5,600	10,600	4,175
1128	2	7,005	5,109	8,900	3,791	6,057	7,005	7,952	2,681
779	6	6,842	3,950	9,191	5,241	6,425	6,955	7,553	1,737
734	25	6,828	2,200	11,800	9,600	6,000	6,700	7,500	2,274
735	29	6,043	707	15,000	14,293	3,700	6,240	7,500	3,648
611	5	5,929	4,900	6,964	2,064	5,130	5,700	6,950	983
1135	1	5,800	5,800	5,800	-	5,800	5,800	5,800	
623	6	5,379	780	12,400	11,620	2,700	2,896	8,723	4,843
625	7	5,343	2,600	12,300	9,700	2,650	2,973	7,115	4,086
773	6	4,535	2,800	5,590	2,790	3,950	4,740	5,425	1,118
1141	2	4,450	4,100	4,800	700	4,275	4,450	4,625	495
1115	11	4,093	1,500	7,742	6,242	3,044	3,600	4,832	2,088
793	6	4,025	2,460	7,300	4,840	3,000	3,350	4,442	1,779
626	25	3,857	2,540	11,300	8,760	2,900	3,080	3,490	2,036
1126	2	3,827	1,600	6,053	4,453	2,713	3,827	4,940	3,149
1137	1	3,800	3,800	3,800	-	3,800	3,800	3,800	-
1009	7	3,734	2,700	4,680	1,980	3,100	3,920	4,318	772
1114	11	3,666	1,500	10,093	8,593	1,792	2,400	4,784	2,719
628	24	3,598	2,190	6,260	4,070	2,675	3,300	4,420	1,172
855	12	3,474	2,700	5,300	2,600	3,175	3,228	3,718	669
630	23	3,442	2,200	5,390	3,190	2,800	3,230	3,955	869
856	10	3,044	2,691	3,440	749	2,750	3,115	3,238	278
1143	1	2,800	2,800	2,800	-	2,800	2,800	2,800	-
1138	1	2,600	2,600	2,600	-	2,600	2,600	2,600	-
797 (Bkgrnd)	18	2,272	427	5,200	4,773	561	2,250	3,900	1,682
857	11	2,059	470	3,260	2,790	1,567	2,230	2,610	934
850 (Bkgrnd)	24	1,767	610	4,600	3,990	1,335	1,635	1,905	891
612	16	1,247	310	3,750	3,440	705	1,090	1,620	874
1139	1	1,200	1,200	1,200	-	1,200	1,200	1,200	-
853	11	1,053	360	1,980	1,620	422	520	1,765	725
1136	1	360	360	360	-	360	360	360	-
783	7	353	138	610	472	273	340	420	151
782	6	330	183	630	447	237	275	363	162
1134	4	215	120	410	290	128	166	253	135
1127	2	206	93	319	226	150	206	263	160
1142	1	150	150	150	-	150	150	150	-
1132	4	145	110	168	58	133	150	162	26
1117	10	143	87	200	113	115	145	158	38
1131	2	121	75	167	92	98	121	144	65

Blue dashed lines denote cutoffs for historical maximum background (5,200 mg/L) and SDWA secondary MCL (250 mg/L).

Uranium

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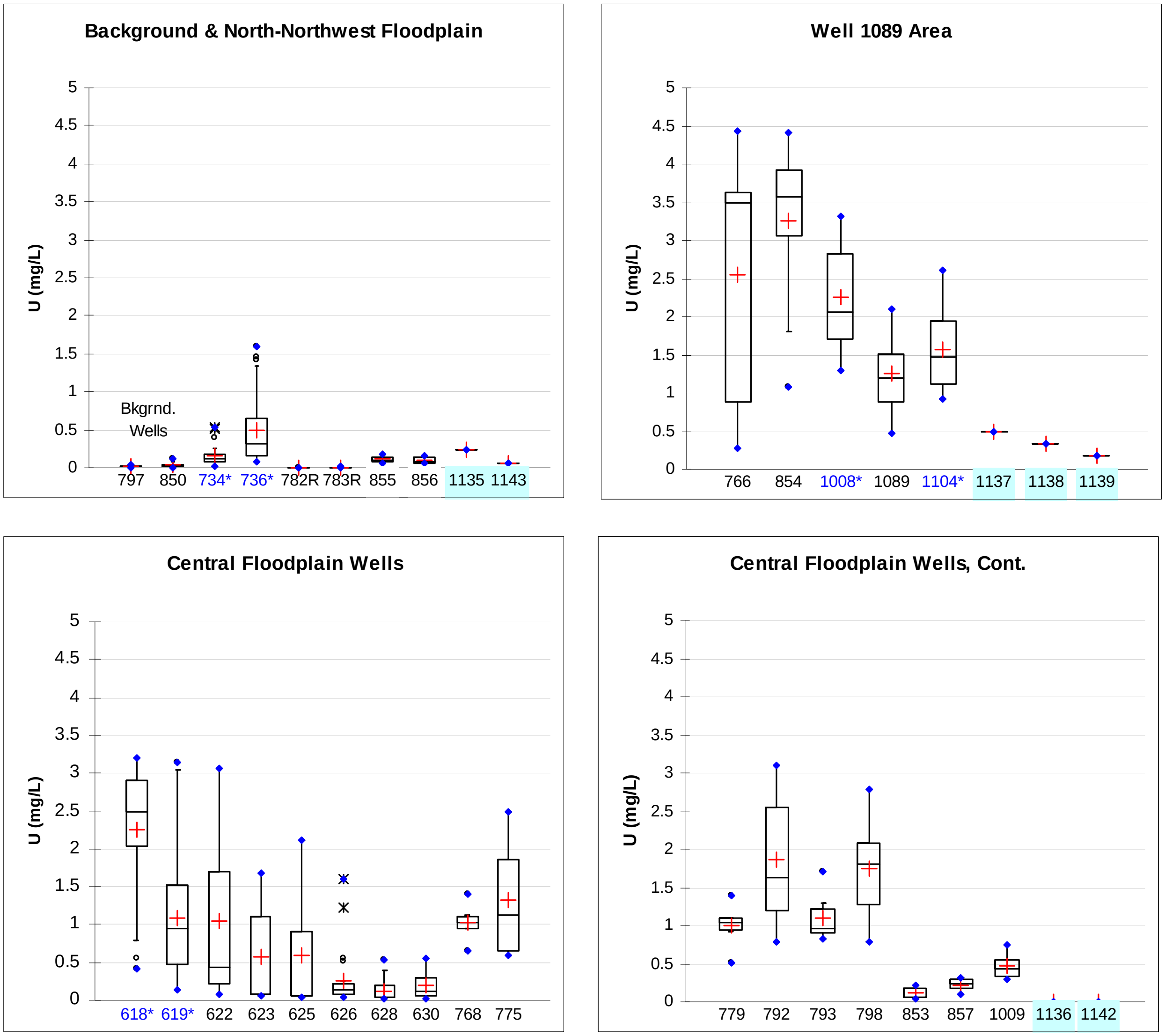

Figure A–8. Historical Distributions of Uranium in Floodplain Monitoring Wells, page 1 of 2†

† The box plots shown above depict the median, the lower and upper quartiles, and the non-outlier range of uranium for each floodplain well or well grouping; points plotted beyond these limits are outliers. The mean is denoted by +, whereas the median line bisects the box. When interpreting these plots, it is important to account for the number of data points (N), listed below and in Table A–1. The greater the number of data points, the more reliable the interpretation of the plots. Well locations are shown in Figure A–1 by subgroup.

0734*	Time trends for COCs plotted in Section 2 of report.
1104	New well added in May 2009 or January 2010.

Background & North-Northwest Floodplain:

Well:	0797	0850	0734*	0736*	0782/0782R	0783/0783R	0855	0856	1135	1143
N:	19	24	28	28	6	7	12	10	1	1

Well 1089 Area:

Well:	0766	0854	1008*	1089	1104*	1137	1138	1139
N:	5	12	13	20	10	1	1	1

Central Floodplain Wells:

Well:	0618*	0619*	0622	0623	0625	0626	0628	0630	0768	0775	0779	0792	0793	0798	0853	0857	1009	1136	1142
N:	26	36	9	6	7	25	24	24	6	6	6	7	6	6	11	11	7	1	1

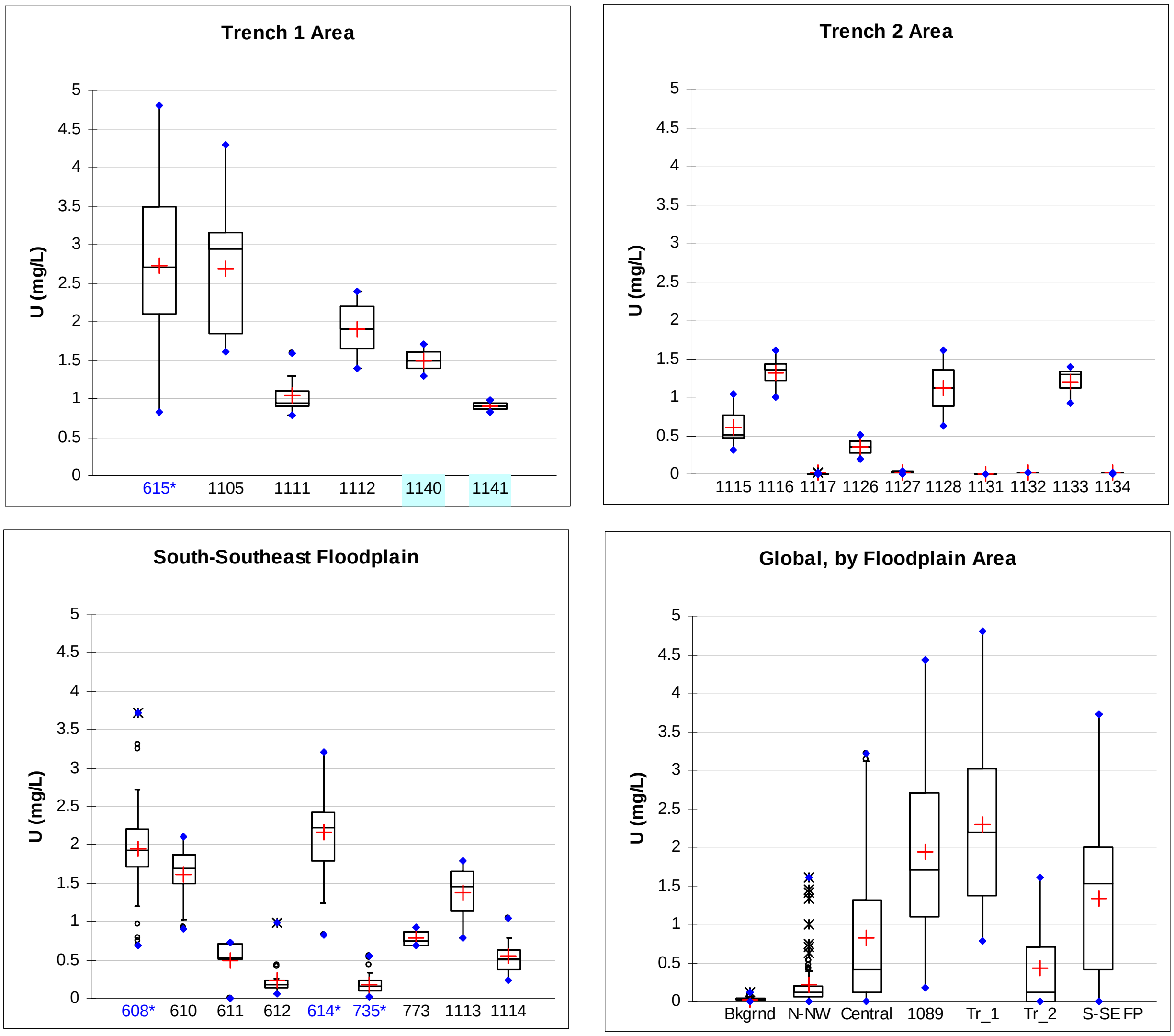

Figure A–8. Historical Distributions of Uranium in Floodplain Monitoring Wells, page 2 of 2†

† See explanation on preceding page. The number of data points (N) corresponding to each well-specific plot shown above is provided below and in Table A–1.

Trench 1 Area Wells:

Well:	0615*	1105	1111	1112	1140	1141
N:	37	7	9	7	2	2

Trench 2 Area Wells:

Well:	1115	1116	1117	1126	1127	1128	1131	1132	1133	1134
N:	11	4	10	2	2	2	2	4	3	4

South-Southeast Floodplain Wells:

Well:	0608*	0610	0611	0612	0614*	0735*	0773	1113	1114
N:	45	24	5	16	41	31	6	7	11

Table A–8a. Summary Statistics for Uranium in Floodplain Monitoring Wells, Sort on Well ID

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	718	1.04	0.002	4.8	4.8	0.11	0.65	1.8	1.1
608	45	1.95	0.69	3.73	3.04	1.72	1.92	2.21	0.62
610	24	1.62	0.90	2.10	1.20	1.50	1.70	1.87	0.36
611	5	0.50	0.01	0.72	0.71	0.52	0.53	0.70	0.29
612	16	0.24	0.05	0.99	0.94	0.13	0.17	0.23	0.23
614	41	2.17	0.83	3.20	2.37	1.80	2.22	2.42	0.52
615	37	2.72	0.83	4.80	3.97	2.10	2.71	3.50	1.05
618	26	2.25	0.42	3.21	2.80	2.03	2.50	2.90	0.89
619	36	1.10	0.13	3.14	3.01	0.48	0.95	1.53	0.79
622	9	1.05	0.07	3.07	3.00	0.22	0.44	1.70	1.12
623	6	0.57	0.06	1.67	1.61	0.07	0.09	1.10	0.77
625	7	0.59	0.04	2.11	2.07	0.06	0.06	0.92	0.84
626	25	0.26	0.04	1.61	1.58	0.08	0.15	0.23	0.38
628	24	0.12	0.02	0.53	0.51	0.03	0.04	0.19	0.14
630	24	0.19	0.03	0.56	0.53	0.06	0.13	0.30	0.17
734	28	0.16	0.02	0.53	0.51	0.08	0.12	0.19	0.13
735	31	0.18	0.02	0.56	0.54	0.10	0.15	0.23	0.13
736	28	0.49	0.07	1.60	1.53	0.15	0.32	0.64	0.46
766	5	2.54	0.27	4.44	4.17	0.88	3.50	3.62	1.84
768	6	1.03	0.66	1.40	0.74	0.95	1.03	1.11	0.24
773	6	0.78	0.68	0.92	0.24	0.68	0.75	0.87	0.11
775	6	1.32	0.59	2.50	1.91	0.64	1.12	1.87	0.82
779	6	1.00	0.52	1.39	0.87	0.94	1.04	1.10	0.29
782	6	0.005	0.003	0.010	0.007	0.003	0.004	0.005	0.003
783	7	0.009	0.007	0.011	0.004	0.008	0.008	0.010	0.001
792	7	1.86	0.79	3.10	2.31	1.21	1.63	2.55	0.89
793	6	1.11	0.83	1.70	0.87	0.90	0.97	1.21	0.33
797 (Bkgrnd)	19	0.02	0.01	0.04	0.03	0.01	0.01	0.03	0.01
798	6	1.74	0.78	2.78	2.00	1.26	1.80	2.08	0.72
850 (Bkgrnd)	24	0.03	0.00	0.12	0.12	0.02	0.02	0.04	0.03
853	11	0.11	0.04	0.22	0.18	0.05	0.06	0.17	0.07
854	12	3.25	1.08	4.42	3.34	3.05	3.58	3.92	1.04
855	12	0.11	0.06	0.18	0.12	0.08	0.10	0.15	0.04
856	10	0.10	0.05	0.16	0.11	0.06	0.08	0.14	0.04
857	11	0.23	0.09	0.31	0.22	0.18	0.23	0.29	0.07
1008	13	2.26	1.30	3.32	2.02	1.70	2.05	2.82	0.67
1009	7	0.47	0.30	0.75	0.45	0.34	0.43	0.56	0.16
1089	20	1.25	0.48	2.10	1.62	0.88	1.20	1.52	0.45
1104	10	1.56	0.93	2.60	1.67	1.13	1.47	1.95	0.55
1105	7	2.69	1.60	4.30	2.70	1.85	2.94	3.15	0.98
1111	9	1.04	0.79	1.59	0.80	0.91	0.94	1.10	0.25
1112	7	1.91	1.40	2.40	1.00	1.65	1.90	2.19	0.38
1113	7	1.38	0.78	1.80	1.02	1.15	1.46	1.66	0.37
1114	11	0.54	0.24	1.05	0.81	0.38	0.52	0.63	0.23
1115	11	0.60	0.31	1.04	0.73	0.46	0.51	0.76	0.25
1116	4	1.32	1.00	1.60	0.60	1.23	1.34	1.44	0.25
1117	10	0.010	0.005	0.020	0.016	0.008	0.009	0.010	0.005
1126	2	0.35	0.20	0.51	0.31	0.28	0.35	0.43	0.22
1127	2	0.02	0.01	0.04	0.03	0.01	0.02	0.03	0.02
1128	2	1.12	0.63	1.60	0.97	0.87	1.12	1.36	0.68
1131	2	0.003	0.002	0.005	0.002	0.003	0.003	0.004	0.002
1132	4	0.018	0.013	0.022	0.009	0.017	0.019	0.021	0.004
1133	3	1.20	0.92	1.38	0.46	1.11	1.30	1.34	0.25
1134	4	0.015	0.010	0.020	0.011	0.012	0.016	0.019	0.005
1135	1	0.24	0.24	0.24	-	0.24	0.24	0.24	-
1136	1	0.007	0.007	0.007	-	0.007	0.007	0.007	-
1137	1	0.49	0.49	0.49	-	0.49	0.49	0.49	-
1138	1	0.34	0.34	0.34	-	0.34	0.34	0.34	-
1139	1	0.18	0.18	0.18	-	0.18	0.18	0.18	-
1140	2	1.50	1.30	1.70	0.40	1.40	1.50	1.60	0.28
1141	2	0.91	0.83	0.98	0.15	0.87	0.91	0.94	0.11
1142	1	0.006	0.006	0.006	-	0.006	0.006	0.006	-
1143	1	0.07	0.07	0.07	-	0.07	0.07	0.07	-

Table A–8b. Summary Statistics for Uranium in Floodplain Wells: Descending Sort on Mean

Well ID	N	Mean	Minimum	Maximum	Range	1st Quartile	Median	3rd Quartile	Stdev (n-1)
All Data	718	1.04	0.002	4.8	4.8	0.11	0.65	1.8	1.1
854	12	3.25	1.08	4.42	3.34	3.05	3.58	3.92	1.04
615	37	2.72	0.83	4.80	3.97	2.10	2.71	3.50	1.05
1105	7	2.69	1.60	4.30	2.70	1.85	2.94	3.15	0.98
766	5	2.54	0.27	4.44	4.17	0.88	3.50	3.62	1.84
1008	13	2.26	1.30	3.32	2.02	1.70	2.05	2.82	0.67
618	26	2.25	0.42	3.21	2.80	2.03	2.50	2.90	0.89
614	41	2.17	0.83	3.20	2.37	1.80	2.22	2.42	0.52
608	45	1.95	0.69	3.73	3.04	1.72	1.92	2.21	0.62
1112	7	1.91	1.40	2.40	1.00	1.65	1.90	2.19	0.38
792	7	1.86	0.79	3.10	2.31	1.21	1.63	2.55	0.89
798	6	1.74	0.78	2.78	2.00	1.26	1.80	2.08	0.72
610	24	1.62	0.90	2.10	1.20	1.50	1.70	1.87	0.36
1104	10	1.56	0.93	2.60	1.67	1.13	1.47	1.95	0.55
1140	2	1.50	1.30	1.70	0.40	1.40	1.50	1.60	0.28
1113	7	1.38	0.78	1.80	1.02	1.15	1.46	1.66	0.37
1116	4	1.32	1.00	1.60	0.60	1.23	1.34	1.44	0.25
775	6	1.32	0.59	2.50	1.91	0.64	1.12	1.87	0.82
1089	20	1.25	0.48	2.10	1.62	0.88	1.20	1.52	0.45
1133	3	1.20	0.92	1.38	0.46	1.11	1.30	1.34	0.25
1128	2	1.12	0.63	1.60	0.97	0.87	1.12	1.36	0.68
793	6	1.11	0.83	1.70	0.87	0.90	0.97	1.21	0.33
619	36	1.10	0.13	3.14	3.01	0.48	0.95	1.53	0.79
622	9	1.05	0.07	3.07	3.00	0.22	0.44	1.70	1.12
1111	9	1.04	0.79	1.59	0.80	0.91	0.94	1.10	0.25
768	6	1.03	0.66	1.40	0.74	0.95	1.03	1.11	0.24
779	6	1.00	0.52	1.39	0.87	0.94	1.04	1.10	0.29
1141	2	0.91	0.83	0.98	0.15	0.87	0.91	0.94	0.11
773	6	0.78	0.68	0.92	0.24	0.68	0.75	0.87	0.11
1115	11	0.60	0.31	1.04	0.73	0.46	0.51	0.76	0.25
625	7	0.59	0.04	2.11	2.07	0.06	0.06	0.92	0.84
623	6	0.57	0.06	1.67	1.61	0.07	0.09	1.10	0.77
1114	11	0.54	0.24	1.05	0.81	0.38	0.52	0.63	0.23
611	5	0.50	0.01	0.72	0.71	0.52	0.53	0.70	0.29
736	28	0.49	0.07	1.60	1.53	0.15	0.32	0.64	0.46
1137	1	0.49	0.49	0.49	-	0.49	0.49	0.49	-
1009	7	0.47	0.30	0.75	0.45	0.34	0.43	0.56	0.16
1126	2	0.35	0.20	0.51	0.31	0.28	0.35	0.43	0.22
1138	1	0.34	0.34	0.34	-	0.34	0.34	0.34	-
626	25	0.26	0.04	1.61	1.58	0.08	0.15	0.23	0.38
1135	1	0.24	0.24	0.24	-	0.24	0.24	0.24	-
612	16	0.24	0.05	0.99	0.94	0.13	0.17	0.23	0.23
857	11	0.23	0.09	0.31	0.22	0.18	0.23	0.29	0.07
630	24	0.19	0.03	0.56	0.53	0.06	0.13	0.30	0.17
735	31	0.18	0.02	0.56	0.54	0.10	0.15	0.23	0.13
1139	1	0.18	0.18	0.18	-	0.18	0.18	0.18	-
734	28	0.16	0.02	0.53	0.51	0.08	0.12	0.19	0.13
628	24	0.12	0.02	0.53	0.51	0.03	0.04	0.19	0.14
855	12	0.11	0.06	0.18	0.12	0.08	0.10	0.15	0.04
853	11	0.11	0.04	0.22	0.18	0.05	0.06	0.17	0.07
856	10	0.10	0.05	0.16	0.11	0.06	0.08	0.14	0.04
1143	1	0.07	0.07	0.07	-	0.07	0.07	0.07	-
850 (Bkgrnd)	24	0.03	0.00	0.12	0.12	0.02	0.02	0.04	0.03
1127	2	0.02	0.01	0.04	0.03	0.01	0.02	0.03	0.02
797 (Bkgrnd)	19	0.02	0.01	0.04	0.03	0.01	0.01	0.03	0.01
1132	4	0.018	0.013	0.022	0.009	0.017	0.019	0.021	0.004
1134	4	0.015	0.010	0.020	0.011	0.012	0.016	0.019	0.005
1117	10	0.010	0.005	0.020	0.016	0.008	0.009	0.010	0.005
783	7	0.009	0.007	0.011	0.004	0.008	0.008	0.010	0.001
1136	1	0.007	0.007	0.007	-	0.007	0.007	0.007	-
1142	1	0.006	0.006	0.006	-	0.006	0.006	0.006	-
782	6	0.005	0.003	0.010	0.007	0.003	0.004	0.005	0.003
1131	2	0.003	0.002	0.005	0.002	0.003	0.003	0.004	0.002

Cutoff for 40 CFR 192 MCL (0.044 mg/L) denoted by blue dashed line above.