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Ground Water/Surface Water Interaction for the Moab, Utah, Site

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1.0 Introduction

During completion of the *Site Observational Work Plan for the Moab, Utah, Site* (SOWP; DOE 2003), it was recognized that an understanding of ground water and surface water interactions are of great importance because a major remedial objective at the Moab site is to be protective of surface water quality. Because previous data were not collected specifically to understand this relationship, only tentative conclusions could be drawn in the SOWP regarding the effect of ground water discharge on surface water quality. Since that time data have been collected to specifically support such an evaluation. Pending a decision regarding disposition of the tailings pile, a Ground Water Interim Action (Ground Water IA) has been implemented to accelerate near-term improvements in surface water quality. Extraction and injection systems were operating in the highest concentration area of the shallow ammonia plume. Data have been collected in the vicinity of the interim action during times of system operation and during system shutdown. Those data are being used to evaluate the performance of different system configurations (DOE 2005a and 2005b).

The nature of ground water and surface water interactions is dynamic and can be affected by many factors. These factors include river stage, spatial location along the Colorado River, operational status of an extraction or injection system, morphology of the river, distribution of contamination in the ground water system and local flow velocities within the river.

The relationship between surface water and ground water is further complicated at the Moab site because of a local briny ground water zone that appears to exert some influence on both ground water flow and contaminant distribution. The major contaminant that has been of concern at the Moab site is ammonia. This constituent is found in high concentrations in ground water and is the site-related contaminant that has the highest toxicity to fish in the river. Therefore much of the discussion here focuses on ammonia.

Also relevant to the discussion of ground water/surface water interaction is total dissolved solids (TDS) content of ground water. As described in the SOWP, ground water with TDS concentrations >35,000 milligrams per liter (mg/L) is designated as brine (Hanshaw and Hill 1969). The SOWP referred to the surface corresponding to the 35,000 mg/L TDS concentration as the saltwater interface, also simply the "interface." In more recent reports it has been referred to as the "brine surface." Ammonia concentrations in ground water in the vicinity of the interim action have been shown to steadily increase from the water table down to just below the brine surface. Below that surface ammonia concentrations typically show a decreasing trend. However, in some locations, ammonia concentrations remain relatively large for several feet below the brine surface before showing decreases.

The conceptual site model presented in the SOWP suggested that the brine surface intersects the riverbed at some location near the west bank of the Colorado River (Figure 1). It was further hypothesized that active ground water treatment based on pumping could effect movement of the brine surface and that this, in turn, could cause changes in concentrations of ammonia discharging to the river. Depending on the location of the brine surface with respect to fish habitat along the river, withdrawal of ground water, in theory, could have either a positive or a negative impact on surface water quality.

2.0 Purpose and Scope

A description and history of the Moab site are discussed in the Moab SOWP along with detailed information on site geology, hydrology, geochemistry, and other characteristics. The purpose of this document is not to repeat that information, but is to provide data acquired since that time and build on the conceptual model presented in the SOWP. Some specific objectives of this analysis are:

- Integrate data collected as part of routine monitoring activities with data collected to assess interim action performance to support optimization of future system modifications and long-term ground water cleanup.
- Test the current conceptual model with respect to the significance of the brine surface and propose modifications to the model as deemed necessary.
- Gain a better understanding of the dilution effect that the Colorado River has on ground water discharge, with an emphasis on ammonia.
- Determine the validity of ground water cleanup goals proposed in the SOWP and suggest refinements as deemed necessary.

3.0 Background

As noted above, the Ground Water IA has been in operation at the Moab site both for the removal and treatment of ground water during certain times, and injection of river water during others. This system was installed during the summer of 2003 and initial pumping took place in July 2003. Various data were collected during operation and shutdown of the pumping system. The data collected in 2003 were evaluated in the performance report for the interim action (DOE 2004c). Additional data were collected during 2004 in accordance with the *Surface Water and Ground Water Monitoring Plan for the Moab, Utah, Site* (DOE 2004a) and the *Interim Action Expansion Work Plan* (DOE 2004b). Some of these data were from routine monitoring events and other data were for monthly sampling in the vicinity of the interim action pumping and injection wells (Configurations 1 and 2—see DOE 2005a and 2005b). Some samples represent baseline samples and others were collected during operation of the interim action. Attachment 1 is a location map showing all ground water and surface water locations sampled in 2004. The map includes all of the wells comprising the Configuration 1, 2, and baseline networks and the locations of cross sections presented in subsequent figures. A summary of all of the sampling events for the interim action and baseline area and routine sampling is presented in Table 1. Table 2 lists each sampling location, type and objective, and collocated samples if applicable.

As discussed above, ground water quality is of greatest concern for the potential impacts it can have on surface water quality. Data presented in the SOWP suggested that discharge of ground water to the river resulted in ammonia concentrations in surface water that exceeded ambient water quality criteria (AWQC) for the protection of aquatic life. [Note: The AWQC for ammonia are not a single value. The criteria vary with temperature and/or pH. For further discussion refer to the SOWP (DOE 2003).] The Colorado River adjacent to the site is

designated critical habitat for three endangered fishes. One of these species, the Colorado pikeminnow, has been observed in the river both upstream and downstream of the Moab site.

As noted in the SOWP, interpretation of historical data for the site with regard to possible impacts on water quality in fish habitat have been somewhat ambiguous. Lack of good descriptions of surface water physical characteristics (e.g., water depth, flow velocities, connectedness to the main channel) made it difficult to determine if sample locations actually represented potential habitat. It was clear that some sampled locations would not be considered as suitable fish habitat due to lack of sufficient water depths or the fact that they were isolated pools cut off from the main river channel.

A survey of the literature regarding Colorado pikeminnow habitat indicated that the most favorable habitat occurs in backwater areas with fairly shallow and low-velocity water. The recent surface water monitoring plan developed for the site (DOE 2004a) called for sampling areas that could be used by fish and were amenable to physical descriptions for use in future data interpretation. As the sampling plan was being prepared, DOE consulted with fish biologists from other government agencies who were familiar with pikeminnow habitat. During the first routine sampling event, DOE representatives were met in the field by personnel from the Utah Division of Wildlife and the National Park Service who had experience conducting Colorado pikeminnow and pikeminnow habitat surveys. These personnel pointed out where the best potential habitat existed and what characteristics to look for. “Opportunistic” or “habitat” samples were collected from these and similar locations per the *Surface Water and Ground Water Monitoring Plan for the Moab, Utah, Site* (DOE 2004a). In addition, samples were collected in the main channel of the river (“compliance samples”) to determine the potential effect of site ground water discharge on overall quality of the surface water.

Another important issue that was raised during preparation of the SOWP was that of how much dilution occurs as ground water discharges to the river. This is important in establishing cleanup goals for ground water. In support of the SOWP, a limited number of ground water samples were collected where adjacent surface water data were also available. Based on those results it appeared that ground water concentrations were diluted by a factor 10 or more as it discharged to and mixed with river water. The *Surface Water and Ground Water Monitoring Plan for the Moab, Utah, Site* (DOE 2004a) provided for additional sampling of paired, or collocated, ground water and surface water samples at a number of locations to improve estimation of an appropriate dilution factor.

Regular monitoring of the interim actions (Configurations 1 and 2) was conducted before and after implementation of those actions. A detailed discussion of the results from monitoring during 2004 is provided in recent reports on the performance of the ground water interim action (DOE 2005a, b). Some of the results are discussed here as they relate to the objectives of this evaluation.

4.0 Monitoring Results

Results of collocated ground water and surface samples collected during routine monitoring events in May, August, and November of 2004 are presented in Tables 3, 4, and 5. Table 6 presents ammonia results for surface water samples collected during 2004 along with corresponding calculated values for chronic and acute ambient water quality criteria. Sampling results are compared with those criteria in ratio form—a ratio >1 signifies that a criterion is exceeded. Table 7 summarizes locations where ammonia criteria were exceeded and provides descriptions of ambient surface water conditions at the time of sampling. Table 8 provides results of habitat and in-stream compliance sampling.

Figures 2, 3, and 4 show collocated ground water and surface water sampling results for May, August and November, respectively. Locations exceeding AWQC are highlighted. Measured concentrations within cross-sections perpendicular to Configurations 1 and 2 of the Ground Water IA under both unstressed and pumping conditions are shown in Figures 5 through 12. Additional cross-sections oriented perpendicular to the riverbank in the baseline area are shown in Figures 13 and 14. Note that the water tables shown on these figures are based on water level data collected for the shallower, fresher water horizon, which are not influenced by the high-density brines below. Sampling results before and after pumping of the two configurations are shown for TDS and ammonia. Results from the baseline area for August are shown, which represents a period of reasonably low river discharge.

TDS concentrations for some sampling locations were estimated from specific conductance data (denoted on the figures as “EST”). Figure 15 shows the relationship between TDS and specific conductance. This relationship is described mathematically as

$$\text{TDS (mgL)} = \text{Specific Conductance } (\mu\text{S/cm}) \times 0.77$$

5.0 Observations and Discussion

Observations made through data evaluation are discussed below. The overall general conceptual site model is considered under both nonpumping (baseline) and pumping (extraction and injection) conditions. Generalizations about the response of the overall system to changes in (1) river stage and (2) interim action configurations are made. On a smaller scale, a discussion is included regarding dilution of contaminated ground water as it discharges to the river under different conditions. Final ground water cleanup objectives are strongly influenced by expected dilution upon discharge to the Colorado River. Finally, on an even smaller scale, processes that may be operating in the hyporheic zone under the river (Figure 1) and potential implications for long-term groundwater/surface water remediation and cleanup goals are considered.

5.1 Conceptual Site Model

Figures 5, 6, 9, and 10 depict measured concentrations during baseline sampling events for Configurations 1 and 2, and Figures 13 and 14 show comparable results for the baseline sampling area. The data presented in these figures generally confirm the conceptual site model presented in the SOWP. Both ammonia and TDS concentrations increase steadily until the

35,000 mg/L TDS brine surface is reached. At that point, while TDS continues to increase with depth, ammonia generally decreases. A plot showing the elevation of the brine surface suggests that it rises steeply in the vicinity of the river and probably intersects the river near its west bank, though control near the river is limited. Based on data presented in the Fall 2004 interim action performance assessment (DOE 2005a), depth to the brine surface also varies along the river's length based on the quantity of ground water flowing toward the river at a given location. This signifies that different quantities of ground water are mixing with river water at different locations along the riverbank.

Results of collocated samples, particularly for ammonia (Tables 3 through 5 and Figures 2 through 4), appear to provide the greatest amount of information regarding ground water and surface water interactions. There are several important things to note in comparing Figures 2 through 4. The May sampling event (Figure 2) was conducted at a time when river flows ranged from about 4,000 to 6,000 cubic feet per second (cfs), whereas during the August event, flows were approximately half that much (about 2,100 to about 2,500 cfs). As a consequence, many of the August surface locations were located much closer to the east bank of the river than were the May samples, particularly in the vicinity of the Configuration 1 interim action. In November, river flows were intermediate between those in May and August and several surface locations shifted accordingly. Additionally, the May sampling event occurred before startup of either interim action configuration, while August and November sampling took place after more than 2 months and 5 months of Configuration 1 pumping, respectively. The November sampling took place after about 4 weeks of Configuration 2 injection testing. Ammonia concentration results for ground water are relatively constant for May, August, and November outside of the interim action area, but do show some changes (both increases and decreases) within the Configurations 1 and 2 well fields.

In contrast to ground water, there are noticeable differences in surface water results among the three sampling periods, particularly with respect to exceedances of AWQC for ammonia. During May, despite highest river flows of the 3 events (which would presumably lead to more dilution), high concentrations of ammonia were observed and acute criteria were exceeded. However, the river locations at which ammonia criteria were exceeded were relatively localized and confined to the areas where the highest concentrations of ammonia in ground water were observed. By contrast, no locations exceeded acute criteria in August, but many locations exceeded chronic criteria, including location 0227-002, located approximately 2,300 ft downstream from the site. Though the chronic criteria for ammonia tend to be lower in the summer because of temperature, the chronic exceedances were attributable to real increases in ammonia concentration in surface water and were not simply an artifact of a changing standard. The November results are more similar to results obtained in May with a few localized high concentrations of ammonia that exceed acute criteria.

The most striking changes in surface water quality among the three sampling events occurred in the vicinity of the interim action. Concentrations were high in May, lower in August, and high again in November. The fact that changes in ammonia concentrations have been observed in wells in the vicinity of the interim action is an indication that operation of the interim actions is changing the subsurface distribution of ammonia. Figures 5 thru 8 show that operation of Configuration 1 has resulted in upconing of the brine surface and increases of ammonia concentration in the vicinity of the extraction wells. The Fall 2004 interim action performance assessment (DOE 2005a) indicates that the capture zone for the extraction system has an

estimated width of 355 ft, which is enough to alter ground water discharge to this area even at low river stage. Large increases in ammonia in observation well 0403 may be the result of brine upconing whereas correspondingly large decreases in the ammonia level at observation well 0407 apparently results from surface water being pulled in from the river (DOE 2005a). It is quite possible that operation of the interim action accounted for reductions of the acute river concentrations of ammonia observed in May. Large decreases in TDS and ammonia levels between prepumping and pumping conditions for shallow piezometers in the vicinity of Configuration 2 (Figures 9 through 12) provide further indication that active remediation can be effective in reducing contaminant discharge to the river.

Locations 0216, 0236 and 0240 are located in the vicinity of the interim action and were sampled at various times during 2004. Table 9 contains analytical results for all 3 locations for selected constituents along with river stage during each sampling event. Location 0216 is adjacent to Configuration 1, location 240 adjacent to the center of Configuration 2, and location 0236 between Configurations 1 and 2. All of these locations are characterized by backwaters or slow moving water and can be considered as representative of suitable habitat for endangered fish as long as waters are connected to the river. All three locations display considerable variability in concentrations of constituents analyzed. At location 0240, which was sampled only twice, all constituents were higher in November than December, despite lower river flows that occurred during the latter event. This may reflect a dilution effect from operation of the Configuration 2 injection system.

Location 0236 was sampled at a greater frequency than any other surface water location. Ammonia concentrations at this location exceeded the acute AWQC in May, prior to interim action startup. In September, after several months of extraction system operation of Configuration 1, concentrations decreased to levels below chronic AWQC, despite the occurrence of low river flows that would serve to cut the location off from the main river channel. However, concentrations increased in October and remained above acute AWQC through December during operation of Configuration 2 extraction and injection. Highest concentrations of all constituents were observed in November 2004. This may represent the flushing out of contaminated ground water through the initial phases of injection. However, subsequent decreases in all constituents during flows that would serve to isolate the location from the main channel are an indication that discharge of fresh, injected water may be having an effect in the area. While concentrations of most constituents are still high compared to background, concentrations of sulfate, TDS, and uranium observed in December were the lowest of any sampling period at this location. Field specific conductance data collected in January 2005 indicates that TDS at this location continued to drop. River flows at the time were still below 3,500 cfs. The 3-month time lag before effects of extraction were seen in ground water (DOE 2005a) may also occur before positive effects of injection are seen in surface water. This is supported by data from shallow piezometers adjacent to Configuration 2, which all displayed declines in TDS concentrations between December 2004 and January 2005.

At location 0216, concentrations of constituents in surface water were lowest during highest river flows and highest during low flows. However, concentrations also varied considerable between June and November, when river flow varied only marginally. Concentrations of analytes were generally lower at the end of this period than during the initial sampling event and this may represent the continued operation of Configuration 1 extraction wells.

Historical data from locations in the vicinity of the interim action show wide ranges of ammonia concentration in surface water as do recent samples collected prior to interim action implementation. This variability is most likely due to the changing nature of the shoreline in the area, caused, in part, by the local presence of sandbars. Pools and backwaters with varying water velocities and changing influxes of river and ground water are common. The hydraulic processes contributing to the formation of these features can change dramatically over a short period of time.

Figures 16 through 24 comprise photographs showing the degree to which water movement, volume, and depth can vary at a surface sampling location (0236). Over a nearly two-month period (mid-September to early November), water volume and physical characteristics of this location changed significantly as river flows range from 2,990 to 5,760 cfs. At flows of about 3,500 cfs, location 0236 becomes cut off from the river both upstream and downstream. At this point it would no longer be considered suitable habitat, but the location was still sampled to yield information regarding interim action performance. Figure 25 shows changes in ammonia concentration and river discharge rates over the period shown in Figures 16 through 24. This graph shows no apparent correlation between ammonia concentration and river discharge rate. During the May sampling event, when river flows and ammonia concentrations were both high, seining for fish was conducted during the sampling event. Many fish were collected at location 0236 and all fish were alive (none were endangered species). During the November sampling event, equally high ammonia concentrations were identified at the same location, though river flows were much lower. However, at this time, numerous dead minnows were observed in the vicinity of the location. The existence of both healthy and dead fish at the same location in the presence of equal ammonia concentrations indicates that ammonia concentration alone may not account for fish health or mortality.

Outside the influence of the interim action, changes in concentration of surface water from May to August to November appear to be mainly a function of river flow conditions, at least in areas where the shoreline does not shift appreciably with changing water flows. Surface water samples collocated with wells 0492, TP-17, TP-18, and TP-19 had concentrations in August that were, for the most part, roughly twice what they were in May for most constituents, despite the fact that ground water samples from those locations varied little in chemistry between monitoring events (see Tables 3 and 4). Concentrations in November, when river flow were intermediate between those in May and August, were likewise intermediate between those previous events (Table 5).

A look at habitat and in-stream “compliance” sampling (Table 8) indicates that mainstream concentrations of surface water in the Colorado River are generally low and in compliance with ammonia AWQC. Habitat samples, however, mostly exceeded ammonia AWQC. This may be because of the low velocities present in suitable habitat areas or the generally shallower nature of these areas compared to the main river channel. Hyporheic zone processes may be more important in these areas as well (see Section 5.3).

5.2 Dilution Factor

Based on an analysis presented in the SOWP, it was proposed that a dilution factor of 10 might be generally acceptable for discharge of ground water to the river at the Moab site. An evaluation of dilution factors calculated for collocated samples collected in 2004 indicates that this factor still appears to be reasonable. Tables 3 and 4 present calculated dilution factors for selected constituents. With a few exceptions, it does appear that a dilution factor of greater than 10 applies in most instances, even during periods of low water. With respect to ammonia, a dilution factor of less than 10 was calculated in only 2 instances—collocations 0226/TP-17 and 0227/TP-18. Ammonia levels in surface water samples from both of these locations exceeded chronic AWQC during the August sampling round even though ground water concentrations were relatively low (3.4 and 3.5 mg/L).

Wells TP-17 and TP-18 are shallow and contain very high TDS (>90,000 mg/L). Thus briny ground water occurs at the water table in these locations. The conceptual model for the site (DOE 2003) suggests that discharge of brine to the river is relatively insignificant in comparison to discharge of less saline ground water. In most areas close to the river, discharges of ammonia to the river within the brine are surmised as being of the magnitude as those resulting from molecular diffusion, which are very small. However, this model does not explain why ammonia concentrations at surface location 0226-002 (collocated with well TP-17) were relatively high in August (1.3 mg/L) and were of the same magnitude as the ammonia level at the surface location 1,000 ft upstream (CR-3-002). The shallow well collocated at CR-3 (0492) had a TDS concentration of 40,000 mg/L, indicating that the brine surface is very close to the water table in this area. Ammonia in well 0492 had concentrations of 70 and 82 mg/L in 2004, which were much higher than concentrations observed at TP-17 and TP-18. This latter set of results suggests that ammonia concentrations in the river adjacent to the brine cannot always be anticipated using a simple dilution factor. Additionally, data from surface location CR-3 (recent and historical) indicates that chloride at this location is generally higher than most other surface locations and may be indicative of brine discharge. Indeed, it is possible that other factors are affecting ground water and surface water mixing and, therefore, resulting contaminant concentrations in the river. These factors potentially include: (1) advective-dispersive transport of ammonia in the river itself, (2) abiotic or biologically-mediated chemical reactions in the hyporheic zone (see following section), and (3) advective transfer of brine to surface water due to hydraulic instabilities created at the brine/river water contact.

The potential for brine to transfer relatively quickly into surface water was further supported by results of a pair of samples collected along the river in January 2003. One of the samples was collected from a seep identified along the bank of the river (location 0206 on Attachment 1) and the other was taken at an adjacent location in the river (location 0207 on Attachment 1). River flows were low at the time of sample collection: 1,820 cfs at the Cisco gaging station. The TDS concentration in the seep water, estimated using specific conductance data, was 41,181 mg/L and the concentration of ammonia was 2.79 mg/L. This seep, therefore, represented surface manifestation of the brine zone and provided an indication that some brine does flow into the river. The adjacent river sample (location 0207) had a much lower estimated TDS concentration of 1947 mg/L, but a higher ammonia concentration at 5.85 mg/L. Uranium concentrations at the time for the seep and river were 3.93 and 0.041 mg/L, respectively. These results indicated a complex relationship, in which brine does discharge directly to the river in some instances. As

suggested in the 2004 performance assessment of the interim action (DOE 2005a) a detailed understanding of hyporheic zone processes and their effects on mixing of high salinity ground water with river water may help to explain why some dissolved constituents are affected more than others.

It may be of some significance that, of the surface water locations that have been sampled on a routine basis, location CR-3 has consistently shown the most elevated concentrations of ammonia. This may be related to the local proximity of the brine surface (and therefore high ammonia concentrations) to the water table. At such a location, it is possible that non-briny ground water containing high levels of ammonia can discharge relatively quickly to the river and mix with brine in the process.

It is also of note that surface water transect sampling by Shepherd Miller Inc. during 2000 (SMI 2001) indicated detectable levels of ammonia along transects into the river, from location CR-3 to location CR-5, to distances up to 50 ft from the river's edge. Samples collected from transect CR-4, located approximately adjacent to well TP-18, remained relatively uniform in ammonia concentration across the entire transect, ranging from 0.29 mg/L to 0.40 mg/L ammonia. These values were within the lower range of the chronic AWQC for ammonia. Given that this transect was located more than 1,500 ft south of the Moab site's south boundary, the observed ammonia levels suggested that it is possible for naturally occurring ammonia in brine to mix with surface water without any influence from the Moab site. Ground water concentrations of ammonia at TP-17 and TP-18 (and seep 0206) are very close to the target goal of 3 mg/L proposed in the SOWP and are within a range believed to be representative of background based on sampling of brines in the Matheson Wildlife Preserve across the river from the Moab site (Gardner and Solomon 2003). Because these locations are a significant distance from the ammonia plume stemming from the tailings pile, and because surface locations adjacent to these areas have exceeded the AWQC, additional study regarding brine-river interactions may be warranted—to better understand natural background concentrations in brine and to determine the effect that brine discharge has on the diluting ability of the river. If ground water concentrations in these areas do represent background concentrations of ammonia and are causing the concentrations observed in the river, the processes involved likely affect the overall conceptual model for the site and may influence ground water cleanup objectives. The assumption was made in the SOWP that reducing concentrations of ammonia in ground water to the target goal would result in compliance with both acute and chronic AWQC at and downstream of the site and may no longer be valid.

5.3 Hyporheic Zone

In addition to providing useful information regarding the depth of the brine surface in ground water near the Colorado River, the Fall 2004 performance assessment of the Ground Water IA (DOE 2005a) identified the presence of a hyporheic zone below and immediately adjacent to the river. This zone comprises a volume of subsurface material in which surface water from the river infiltrates the riverbed and mixes with ambient ground water (Winter et al. 1998). In a water body that gains in net flow due to ground water discharge, such as the river in the vicinity of the Moab site, the river water infiltrating the subsurface in one area must eventually discharge back to the river at another location. Between these two locations and within the hyporheic zone,

several abiotic and biologically mediated chemical reactions are facilitated that can strongly influence the dissolved concentrations of ground water constituents that eventually become part of the river flow. The Fall 2004 performance assessment (DOE 2005a) presented multiple lines of evidence to indicate that such chemical reactions occur below the Colorado River in the vicinity of Moab Valley.

The depth of a hyporheic zone can vary depending on the nature of the sediments underlying the affected river, but zone depths approaching 6 to 7 ft are relatively common. To determine the chemical nature of ambient ground water discharging to the river, wells and piezometers installed through the riverbed must be deep enough such that they fully penetrate and are screened solely below the hyporheic zone. During 2004 multiple piezometers were installed in riverbed areas adjacent to the Ground Water IA well fields (DOE 2005a) and the baseline monitoring area with the intent of characterizing this ambient chemistry. Because previous investigations of ground water salinity at the site (DOE 2003) had indicated that brine would likely be found below the river, it was expected that the approximate base of the hyporheic zone could be delineated once TDS concentrations of greater than 35,000 mg/L were identified. Unfortunately, none of the floodplain piezometers, which ranged in depth from about 1 to 4 ft below the riverbed, was deep enough to identify this interface. As a consequence, the upper surface of the brine below the river could not be accurately located in the cross-sections presented in Figures 5 through 14, though results suggest it is very close to the surface (evidenced by concentrations exceeding 20,000 mg/L TDS in several of the very shallow piezometers).

The Fall 2004 IA performance assessment report (DOE 2005a) suggested that negative oxidation reduction potential (ORP) results obtained in some of the interim action wells were due to mixing of ground and surface waters and stimulation of bacterial action that produced reducing conditions. This is possibly true for those shallow wells where contaminant decreases were also observed as a result of river water being pulled into the system. However, negative ORP values are not uncommon in ground water in the vicinity of the site, particularly in briny water. For example, wells ATP-1S and ATP1-D at 36 and 88 ft depths, respectively, have consistently displayed negative ORP values as have other deep wells to the north of and beneath the tailings pile. Negative values have also been obtained from samples from wells TP-17, 18, and 19, which are all installed into the brine. It is possible that minor amounts of hydrocarbon from the Paradox formation are present in the brine and deeper ground water and that bacterial degradation of the hydrocarbon has produced reducing conditions. Negative ORP values are present in shallow wells in the Matheson Preserve, as well as surface location 0217, adjacent to the preserve.

Sampling of wells in the unstressed baseline area north of the interim actions shows that ORP can vary naturally, both temporally and spatially. Samples collected from wells in this area mostly have positive ORP values, but some are negative (as low as -53 mV). Some of this variability may be related to accuracy of measurement, but it may also reflect the natural heterogeneity of ground water/surface water interactions. A review of the nature of the ground water/surface water interface (Dahm et al., 1998) elaborates on the many factors influencing solute behavior in this complex system. They note that the hyporheic zone often contains strong redox gradients that can affect the distribution of constituents such as sulfate, metals, and ammonia—all constituents present in ground water at the Moab site.

The chemistry of the ground water/surface water interface is influenced by not only discharge of ground water to surface water and surface water to ground water, but also by channel morphology and streambed composition. Dahm et al., (1998) identify three "compartments" in the ground water/surface water interface system: (1) the riparian zone, which is heavily vegetated and only covered by water during flooding; (2) the parafluvial zone, which is periodically inundated and dry due to normal fluctuations in river stage; and (3) the surface zone, which always contains water. The area in the vicinity of the Moab interim action and where the main contaminant plume discharges are considered to be part of the parafluvial compartment. Here mixing of ground water and surface water is most complex and variable with some parts of the surface water system gaining, some losing, and some with little net exchange. In addition, this part of the Colorado River channel would be considered to be relatively unconstrained, a factor which further effects greater degrees of ground water/surface water exchange (Dahm et al., 1998).

The Configuration 2 injection performance assessment report (DOE 2005b) noted that concentrations of some contaminants actually increased with corresponding increases in river stage, which is inconsistent with the concept that increased flow would produce increased dilution. However, a similar situation described for nitrogen concentrations in an unconstrained stream in the Cascades Mountains of Oregon was attributed to leaching of previously dry sediments during high river stages (Dahm et al., 1998). This points out the importance of regular river discharge variations in cycling certain constituents in ground water/surface water systems. Salt crusts are commonly observed along the banks of the Colorado River in the vicinity of the Moab site, particularly in the area where the interim action is located. Dissolution of these crusts as water rises, particularly in slow-moving backwater areas, could be a contributor to surface water quality in addition to ground water discharge. Therefore surface water chemistry is controlled by a large number of interacting processes.

Undoubtedly hyporheic zone processes play an important role in controlling surface water quality, particularly in a localized manner. It may be possible to enhance certain processes in this zone to affect a particular response in surface water quality (e.g., attenuate contaminants in ground water to improve surface water quality). However, so many factors influence hyporheic zone reactions, all of which vary naturally in response to the ambient system, that any effective enhancement needs to be robust enough to function under these temporally and spatially changing conditions.

6.0 Conclusions

The following general conclusions can be reached regarding ground water/surface water interactions at the Moab site:

- The general conceptual model for the site, as presented in the SOWP, appears to be valid. TDS concentration increases in ground water with depth; ammonia concentration above the brine increases with depth and then generally begins to decrease some distance below the brine surface.
- During the summer of 2004, interim action extraction appeared to have a positive effect on surface water quality in areas that had the highest exceedances of ammonia criteria during the

spring sampling. However factors other than interim action pumping may have influenced the ammonia levels in surface water, particularly since many sample locations shifted farther away from the well fields in the summer due to reduced river flows.

- One surface location adjacent to the interim action (0216) actually showed an increase in ammonia over the period of interim action pumping; however, these increases were accompanied by a corresponding decrease in river flows. River stage appears to exert a large degree of influence on surface water quality.
- Approximately 30 percent of surface water samples collected during 2004 exceeded acute or chronic ammonia criteria; most areas sampled to represent fish habitat exceeded ammonia criteria.
- All but one in-stream compliance sample collected during 2004 were below AWQC for ammonia and indicate that discharge of site-related ground water is not degrading the overall water quality of the river. Contaminants in ground water rapidly mix with and diluted by river water upon discharge. The one compliance sample that exceeded the ammonia criteria was collected when river stage was at the lowest observed during the sampling period.
- Generally it appears that the one order-of-magnitude dilution factor used in the SOWP remains valid where the main plume discharges to the river. However, at some other locations monitored in 2004, little dilution appears to have occurred.
- Samples from wells TP-17 and TP-18 have ammonia concentrations just slightly higher than the tentatively established cleanup goal of 3 mg/L. Both of these wells sample brine in a portion of the aquifer where little to no inflow of freshwater is observed. Studies indicate that natural concentrations of ammonia in the brine associated with this portion of the Colorado River may be in the 2 to 5 mg/L range (Gardner and Solomon 2003). During high river flows, surface water adjacent to wells TP-17 and TP-18 did not display elevated concentrations of ammonia. However at low river flows, ammonia concentrations exceeded chronic criteria at numerous locations ranging along the river's bank from just south of Moab Wash to location 0227-02 adjacent to well TP-18. If ground water concentrations of ammonia in wells TP-17 and TP-18 are (1) in the range of natural background in brine, and (2) are causing corresponding levels seen in surface water, cleanup to background levels in brine might still result in surface water quality above the chronic AWQC. Data collected in 2003 from a seep in the vicinity of these locations indicates that, at least during certain low river stages, brine with ammonia on the order of 3 mg/L discharges directly to the river.
- Limited data were obtained from the shallow piezometers adjacent to the river (floodplain piezometers). This constrained the ability to accurately identify the intersection of the brine surface with the river and thus determine the influence the brine might have with respect to surface water quality. Similarly, data were insufficient to track movement of the brine surface below the river in response to changes in river discharge rates or interim action operations.
- Hyporheic zone processes can have a marked effect on surface water quality. These processes would be expected to operate most strongly and complexly in portions of a stream with a morphology similar to the Colorado River in the vicinity of the interim action area. This complicates the interpretation of cause-and effect relationships as pertains to surface water chemistry.

Figures

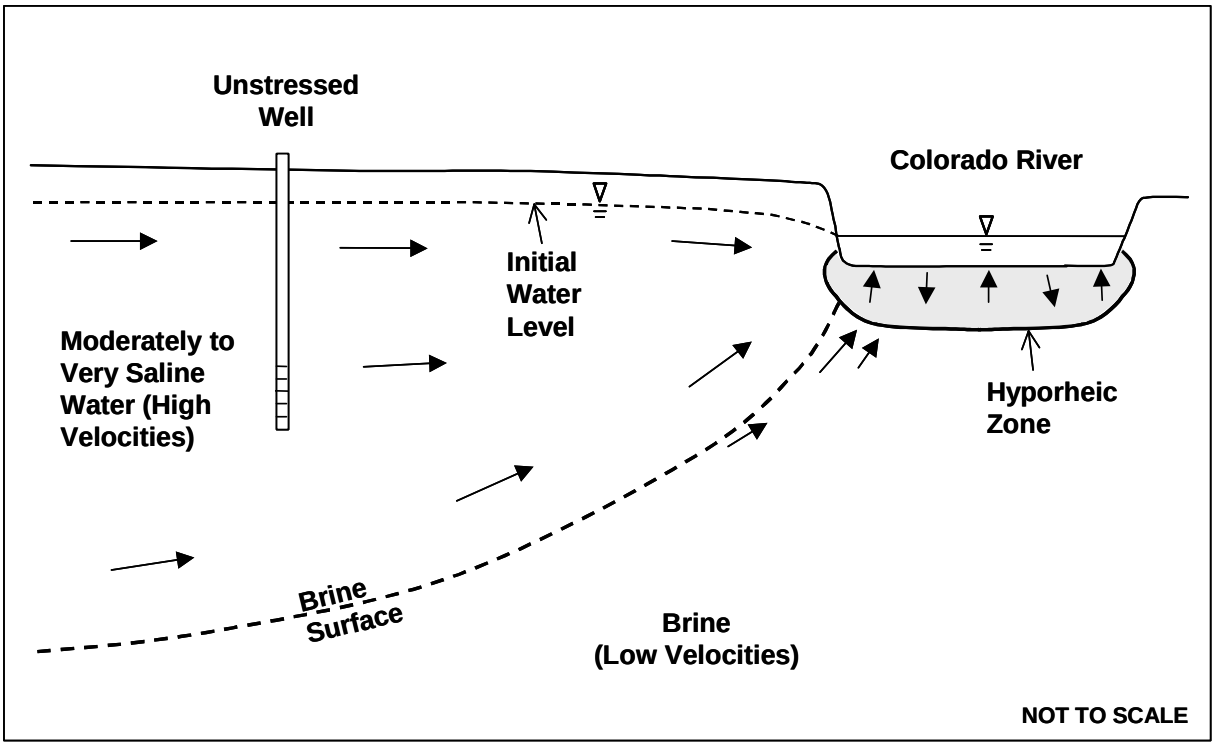
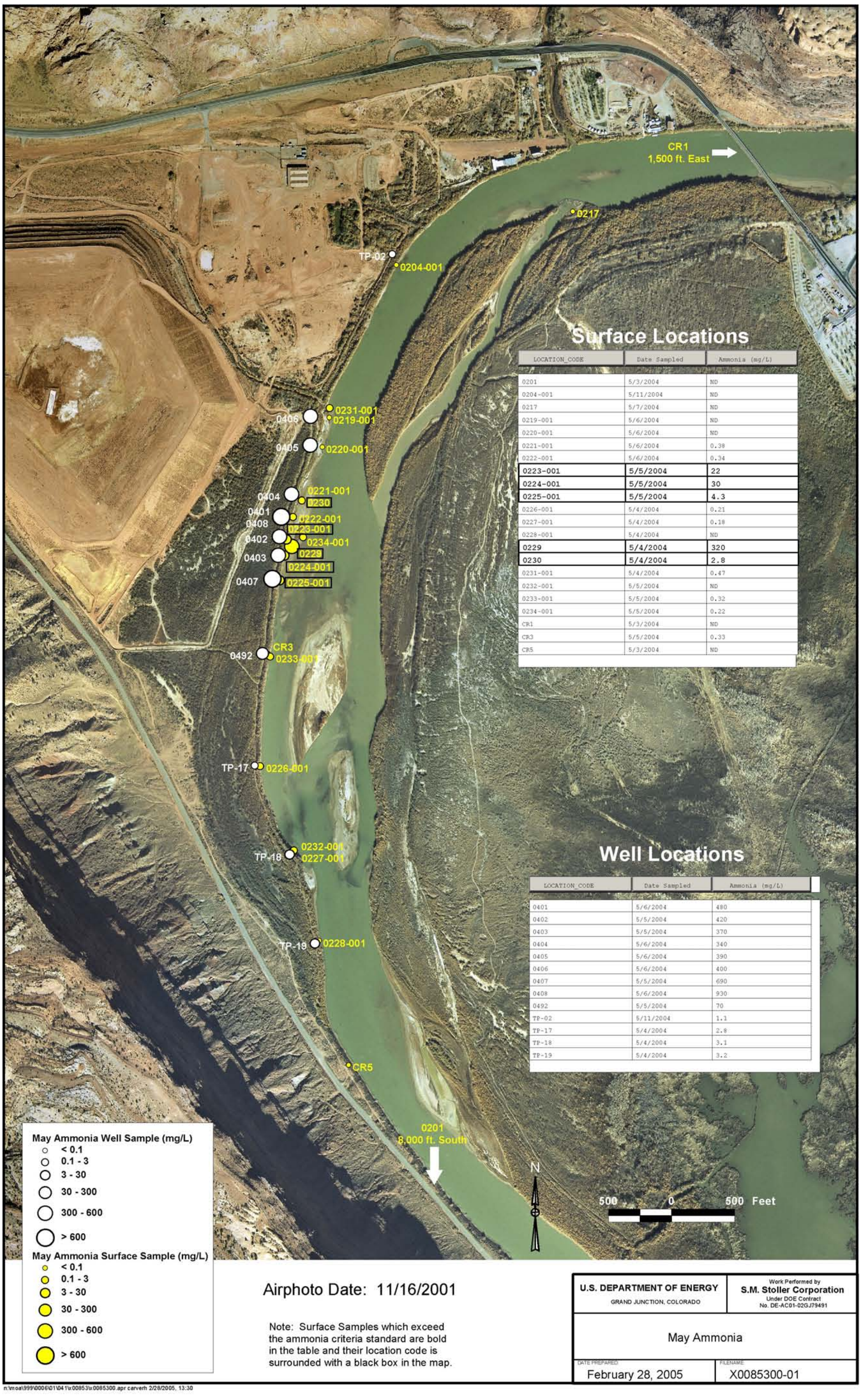


Figure 1. Site Conceptual Model Showing Ground Water Discharge to the Colorado River



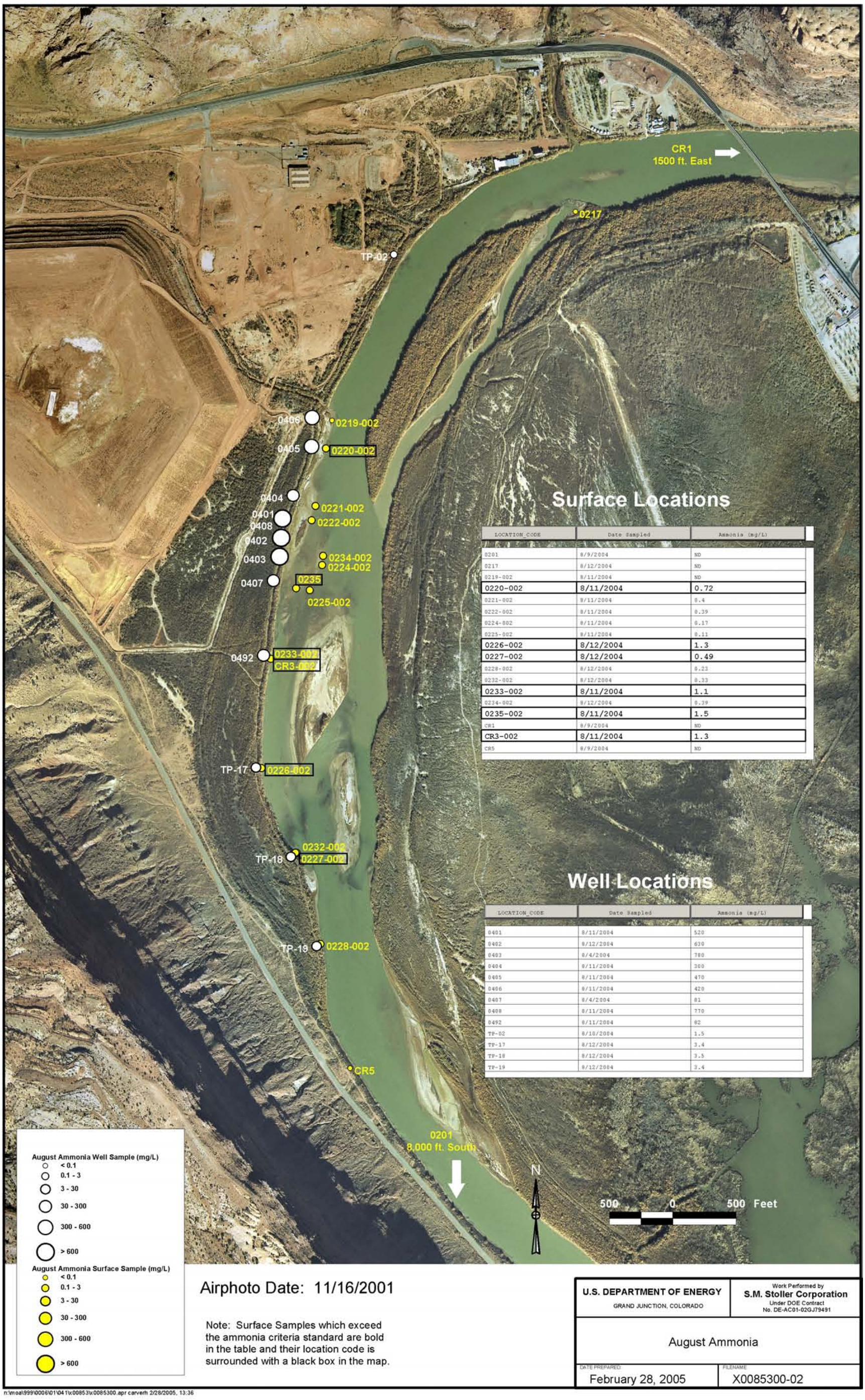
Surface Locations

LOCATION_CODE	Date Sampled	Ammonia (mg/L)
0201	5/3/2004	ND
0204-001	5/11/2004	ND
0217	5/7/2004	ND
0219-001	5/6/2004	ND
0220-001	5/6/2004	ND
0221-001	5/6/2004	0.38
0222-001	5/6/2004	0.34
0223-001	**5/5/2004**	**22**
0224-001	**5/5/2004**	**30**
0225-001	**5/5/2004**	**4.3**
0226-001	5/4/2004	0.21
0227-001	5/4/2004	0.18
0228-001	5/4/2004	ND
0229	**5/4/2004**	**320**
0230	**5/4/2004**	**2.8**
0231-001	5/4/2004	0.47
0232-001	5/5/2004	ND
0233-001	5/5/2004	0.32
0234-001	5/5/2004	0.22
CR1	5/3/2004	ND
CR3	5/5/2004	0.33
CR5	5/3/2004	ND

Well Locations

LOCATION_CODE	Date Sampled	Ammonia (mg/L)
0401	5/6/2004	480
0402	5/5/2004	420
0403	5/5/2004	370
0404	5/6/2004	340
0405	5/6/2004	390
0406	5/6/2004	400
0407	5/5/2004	690
0408	5/6/2004	930
0492	5/5/2004	70
TP-02	5/11/2004	1.1
TP-17	5/4/2004	2.8
TP-18	5/4/2004	3.1
TP-19	5/4/2004	3.2

Figure 2. Ammonia Data for May 2004



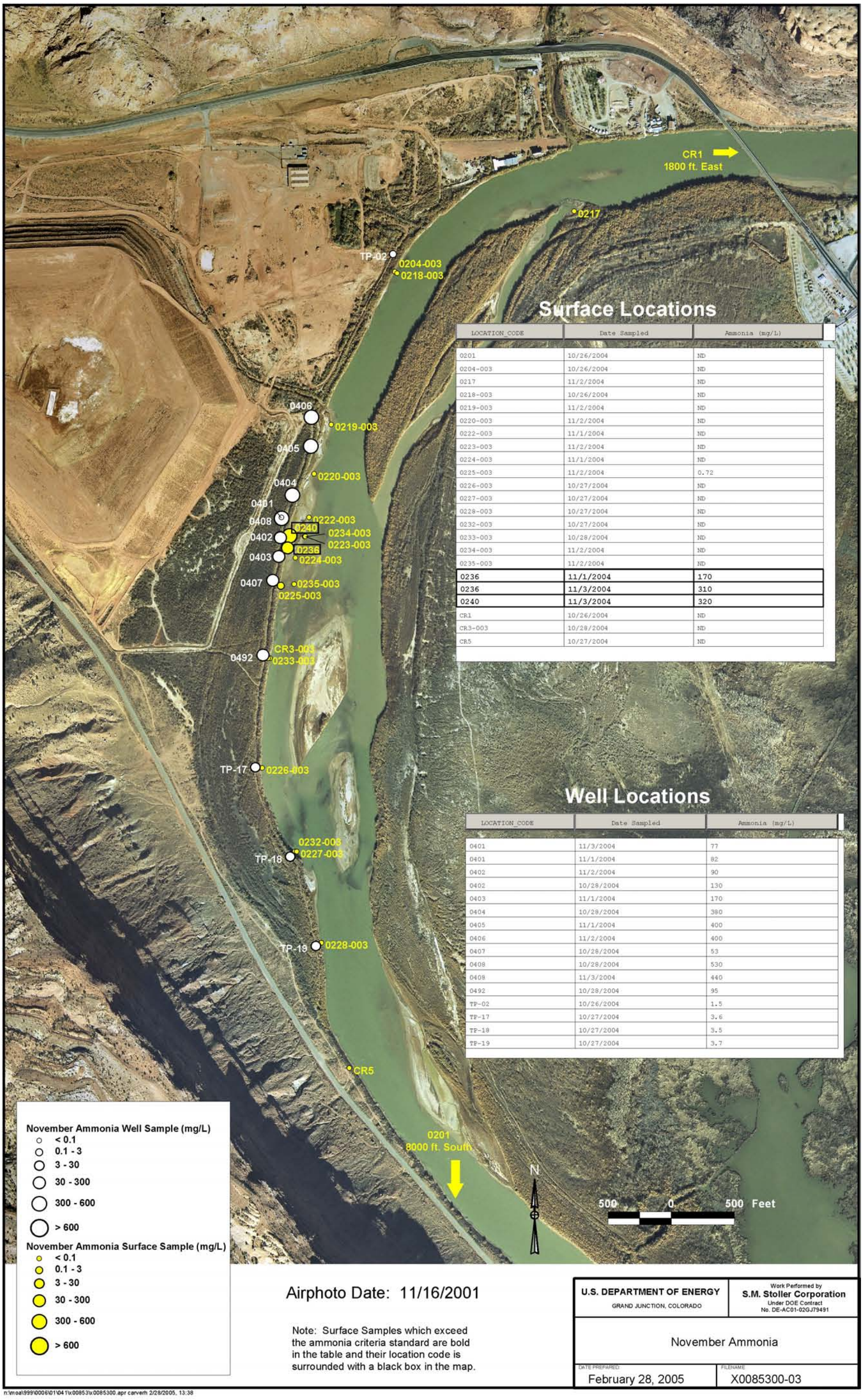
Surface Locations

LOCATION_CODE	Date Sampled	Ammonia (mg/L)
0201	8/9/2004	ND
0217	8/12/2004	ND
0219-002	8/11/2004	ND
0220-002	**8/11/2004**	**0.72**
0221-002	8/11/2004	0.4
0222-002	8/11/2004	0.39
0224-002	8/11/2004	0.17
0225-002	8/11/2004	0.11
0226-002	**8/12/2004**	**1.3**
0227-002	**8/12/2004**	**0.49**
0228-002	8/12/2004	0.23
0232-002	8/12/2004	0.33
0233-002	**8/11/2004**	**1.1**
0234-002	8/12/2004	0.39
0235-002	**8/11/2004**	**1.5**
CR1	8/9/2004	ND
CR3-002	**8/11/2004**	**1.3**
CR5	8/9/2004	ND

Well Locations

LOCATION_CODE	Date Sampled	Ammonia (mg/L)
0401	8/11/2004	520
0402	8/12/2004	630
0403	8/4/2004	780
0404	8/11/2004	300
0405	8/11/2004	470
0406	8/11/2004	420
0407	8/4/2004	81
0408	8/11/2004	770
0492	8/11/2004	82
TP-02	8/10/2004	1.5
TP-17	8/12/2004	3.4
TP-18	8/12/2004	3.5
TP-19	8/12/2004	3.4

Figure 3. Ammonia Data for August 2004



Surface Locations

LOCATION_CODE	Date Sampled	Ammonia (mg/L)
0201	10/26/2004	ND
0204-003	10/26/2004	ND
0217	11/2/2004	ND
0218-003	10/26/2004	ND
0219-003	11/2/2004	ND
0220-003	11/2/2004	ND
0222-003	11/1/2004	ND
0223-003	11/2/2004	ND
0224-003	11/1/2004	ND
0225-003	11/2/2004	0.72
0226-003	10/27/2004	ND
0227-003	10/27/2004	ND
0228-003	10/27/2004	ND
0232-003	10/27/2004	ND
0233-003	10/28/2004	ND
0234-003	11/2/2004	ND
0235-003	11/2/2004	ND
0236	**11/1/2004**	**170**
0236	**11/3/2004**	**310**
0240	**11/3/2004**	**320**
CR1	10/26/2004	ND
CR3-003	10/28/2004	ND
CR5	10/27/2004	ND

Well Locations

LOCATION_CODE	Date Sampled	Ammonia (mg/L)
0401	11/3/2004	77
0401	11/1/2004	82
0402	11/2/2004	90
0402	10/28/2004	130
0403	11/1/2004	170
0404	10/28/2004	380
0405	11/1/2004	400
0406	11/2/2004	400
0407	10/28/2004	53
0408	10/28/2004	530
0408	11/3/2004	440
0492	10/28/2004	95
TP-02	10/26/2004	1.5
TP-17	10/27/2004	3.6
TP-18	10/27/2004	3.5
TP-19	10/27/2004	3.7

Figure 4. Ammonia Data for November 2004

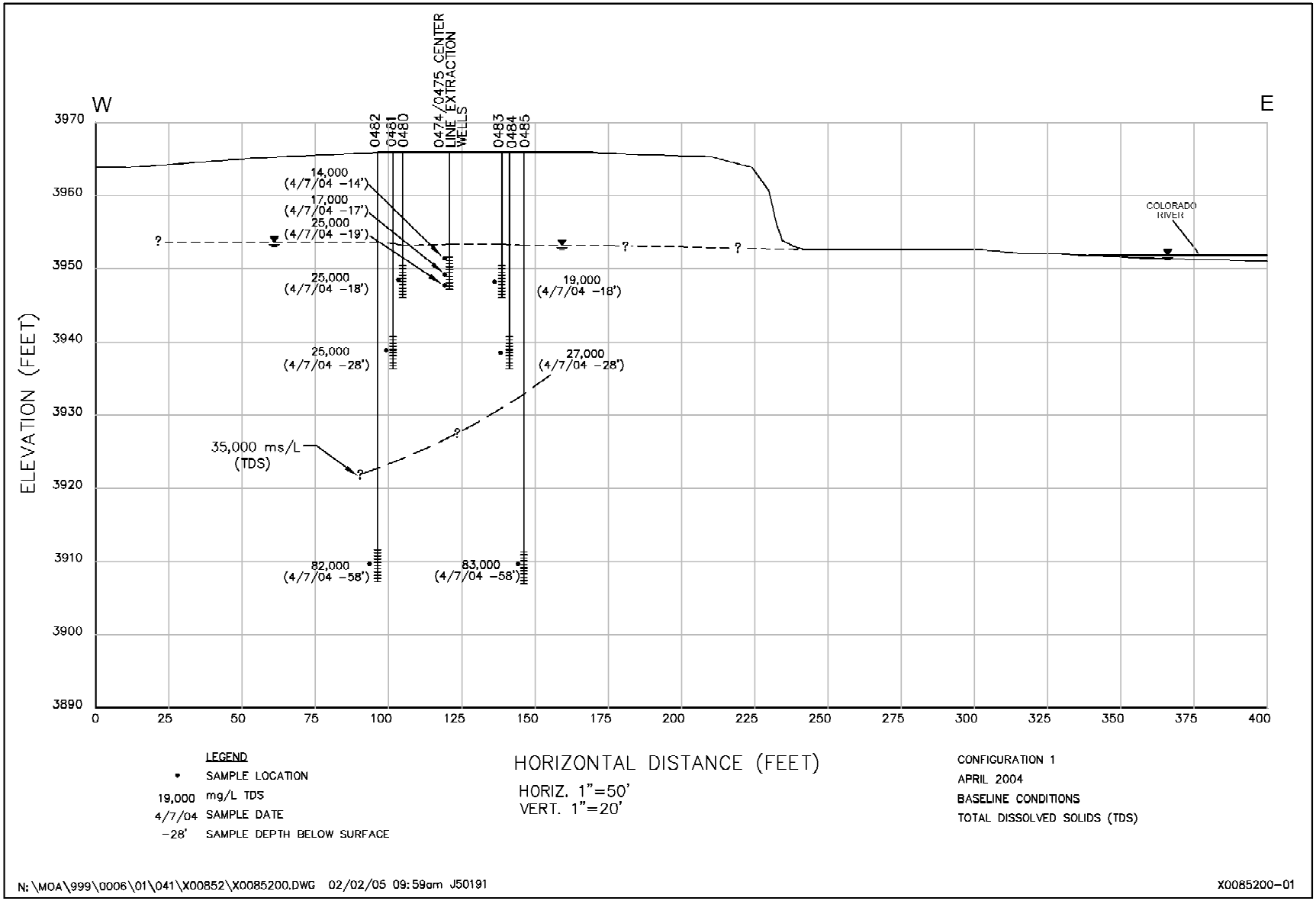


Figure 5. Configuration 1 Baseline TDS Concentrations

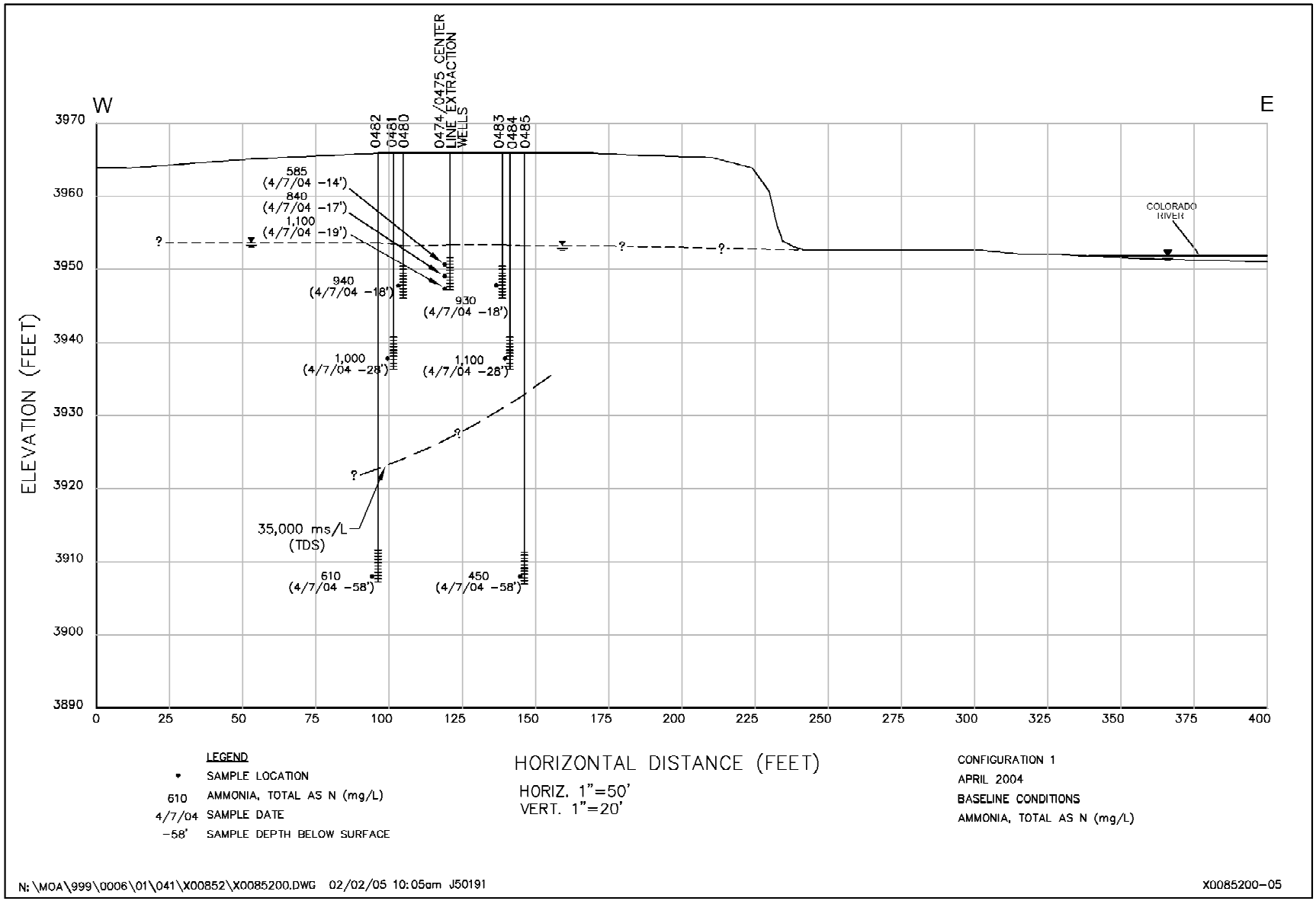


Figure 6. Configuration 1 Baseline Ammonia Concentrations

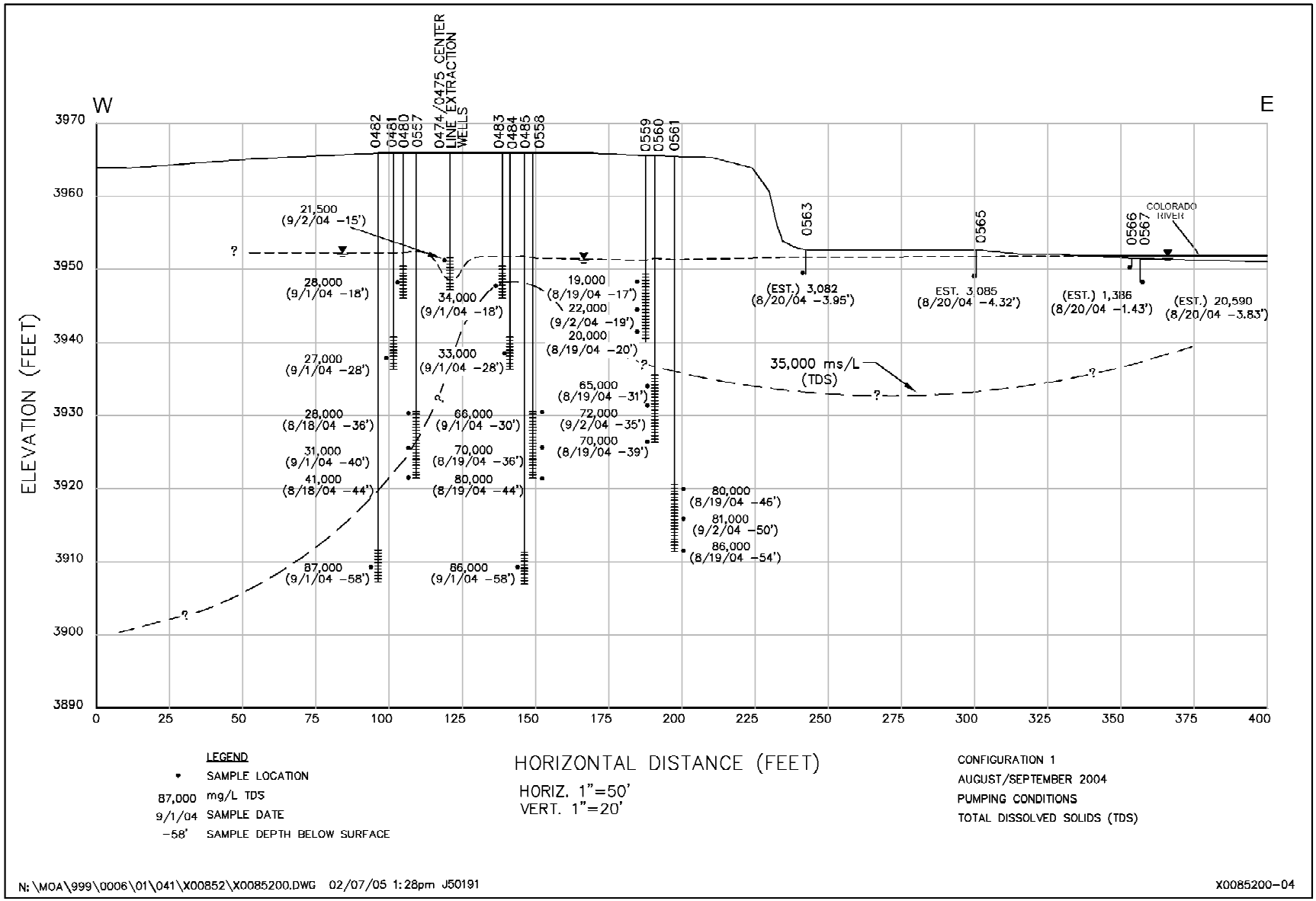


Figure 7. Configuration 1 Pumping TDS Concentrations

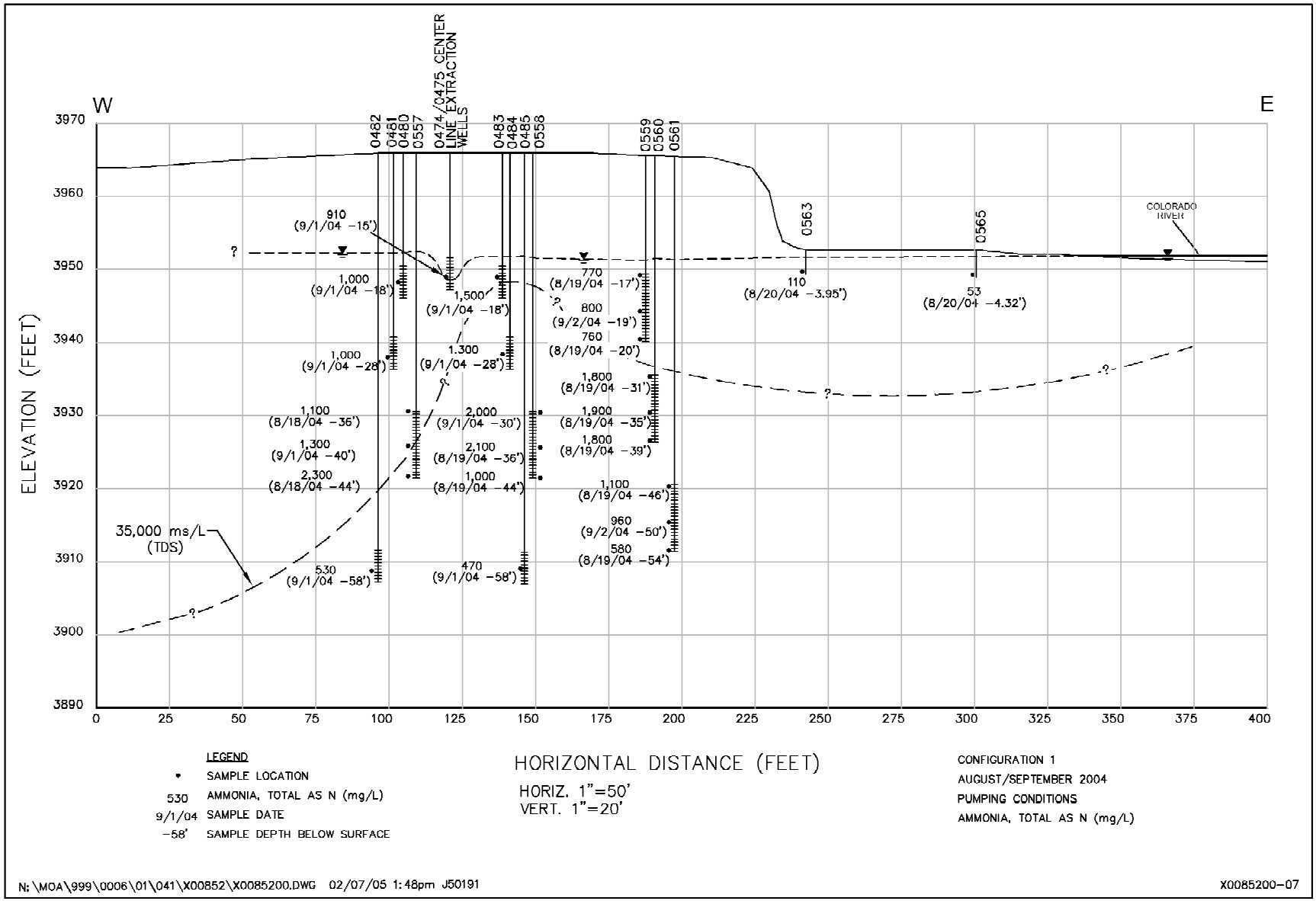


Figure 8. Configuration 1 Pumping Ammonia Concentrations

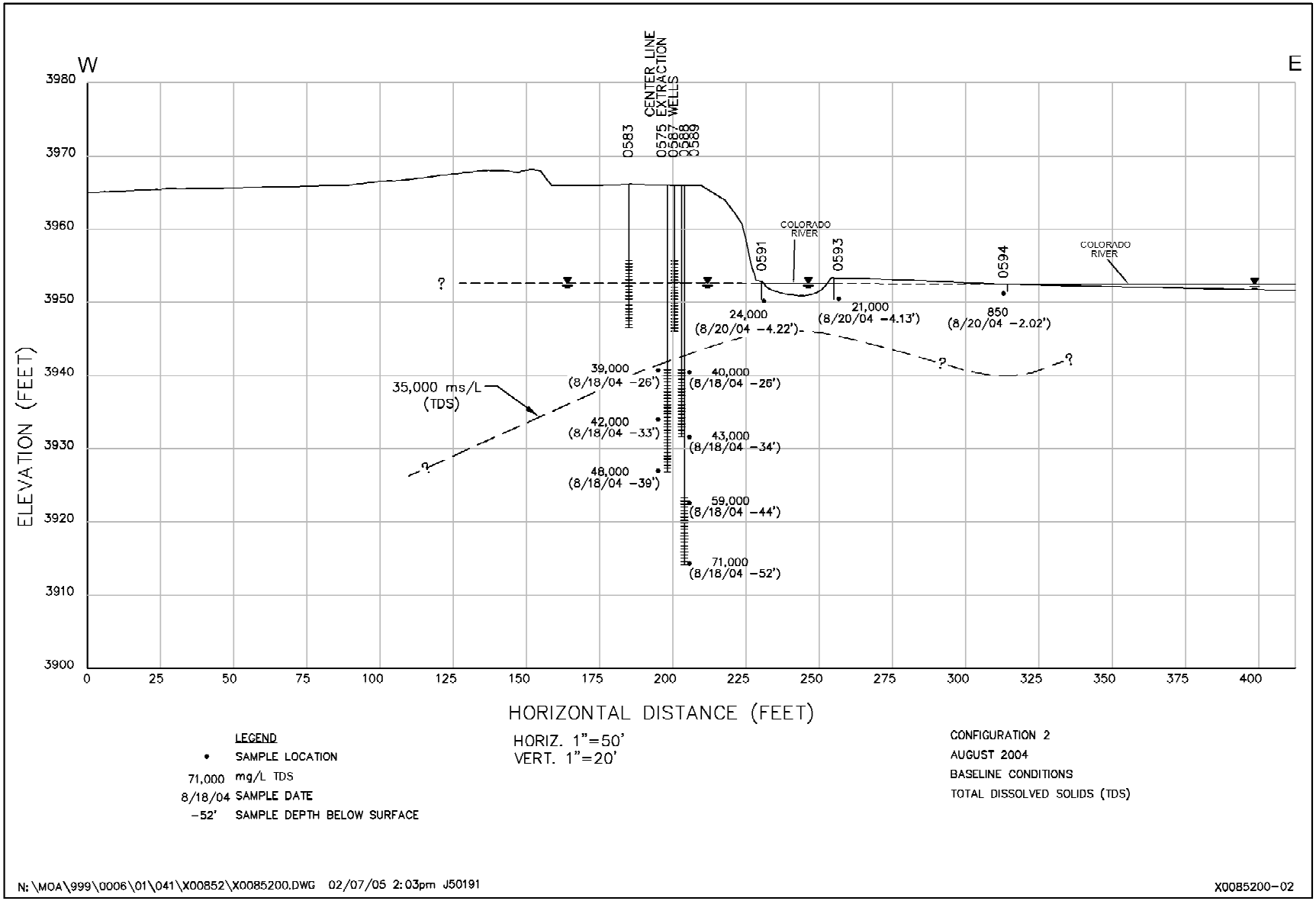


Figure 9. Configuration 2 Baseline TDS Concentrations

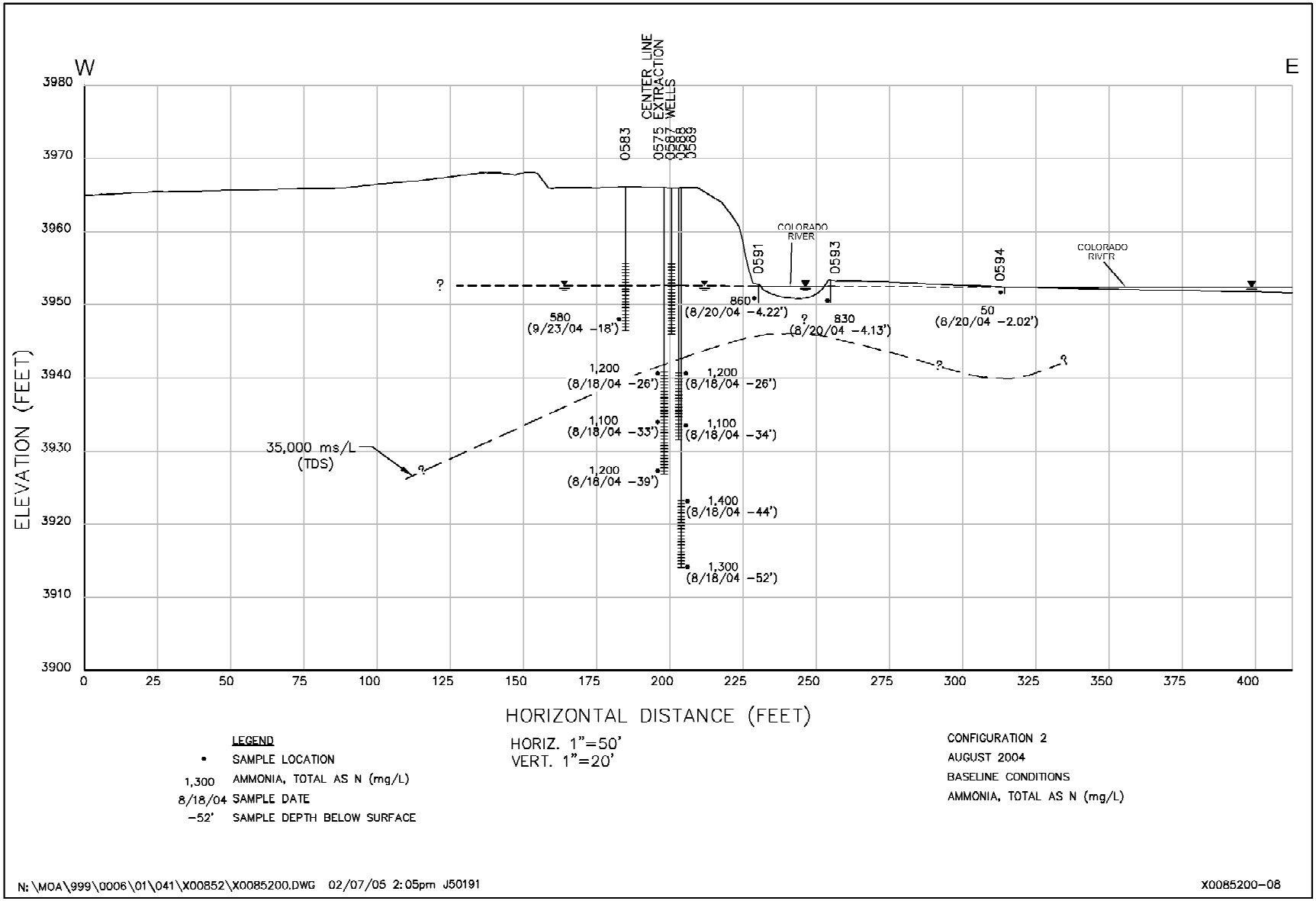


Figure 10. Configuration 2 Baseline Ammonia Concentrations

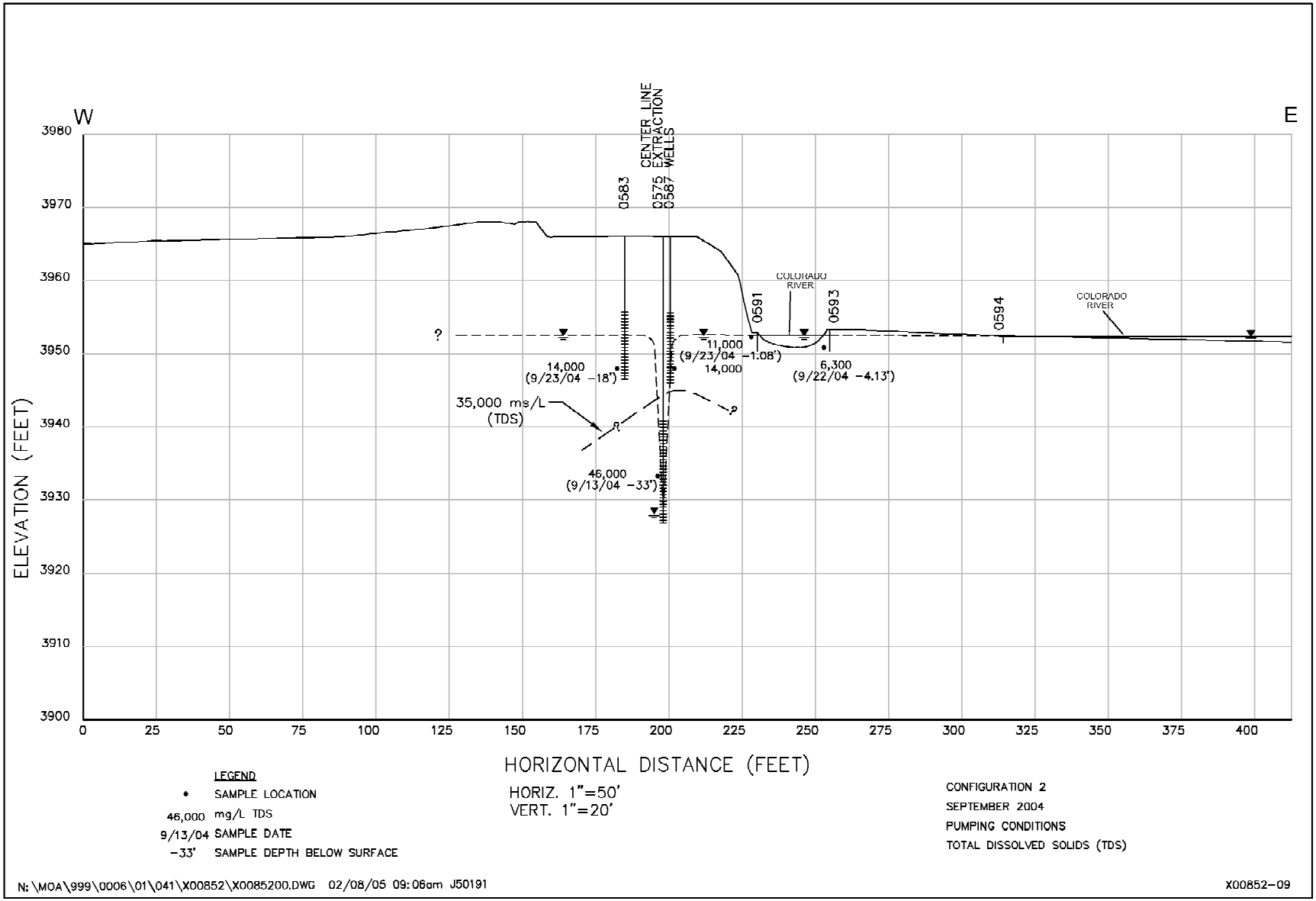


Figure 11. Configuration 2 Pumping TDS Concentrations

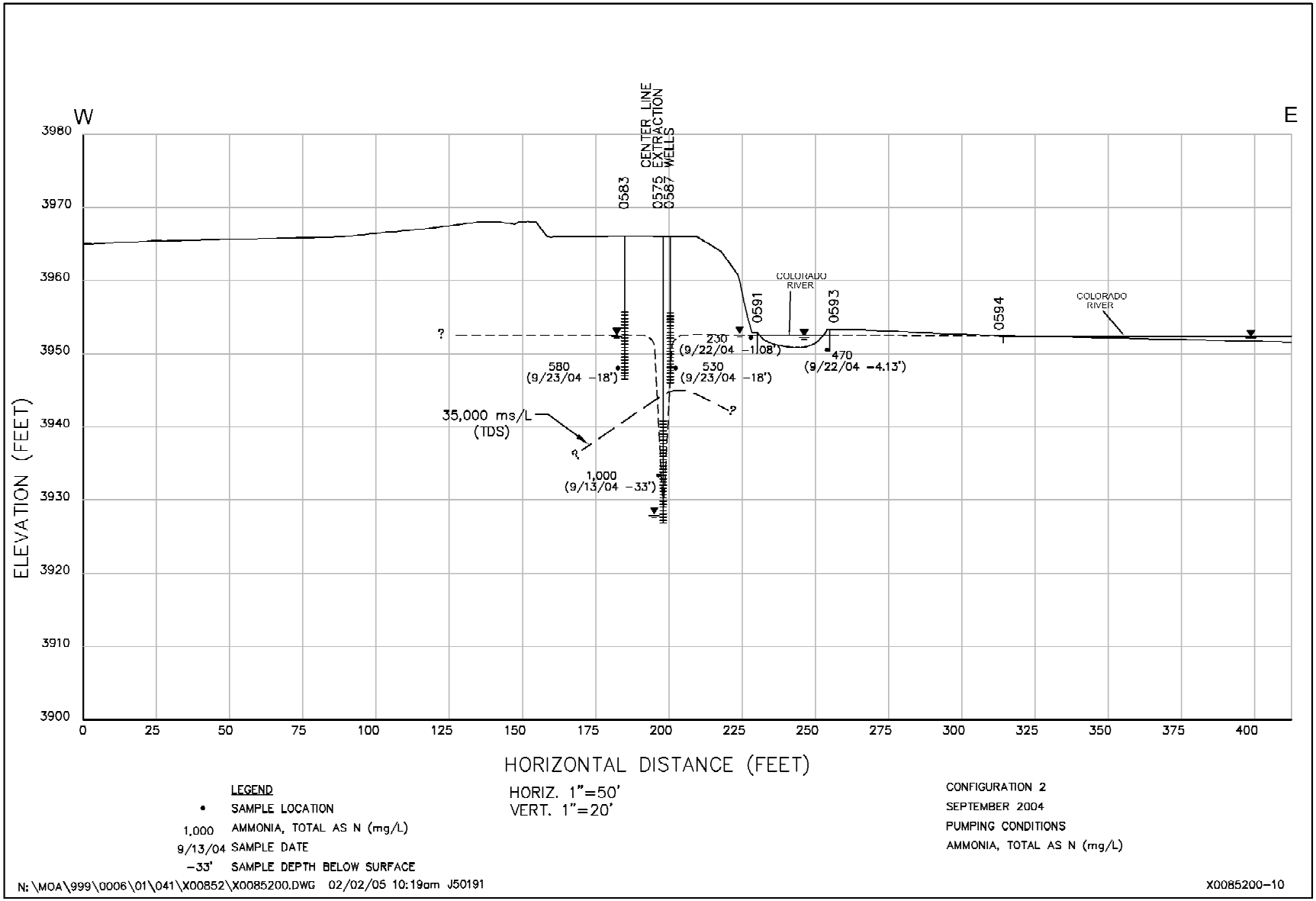


Figure 12. Configuration 2 Pumping Ammonia Concentrations

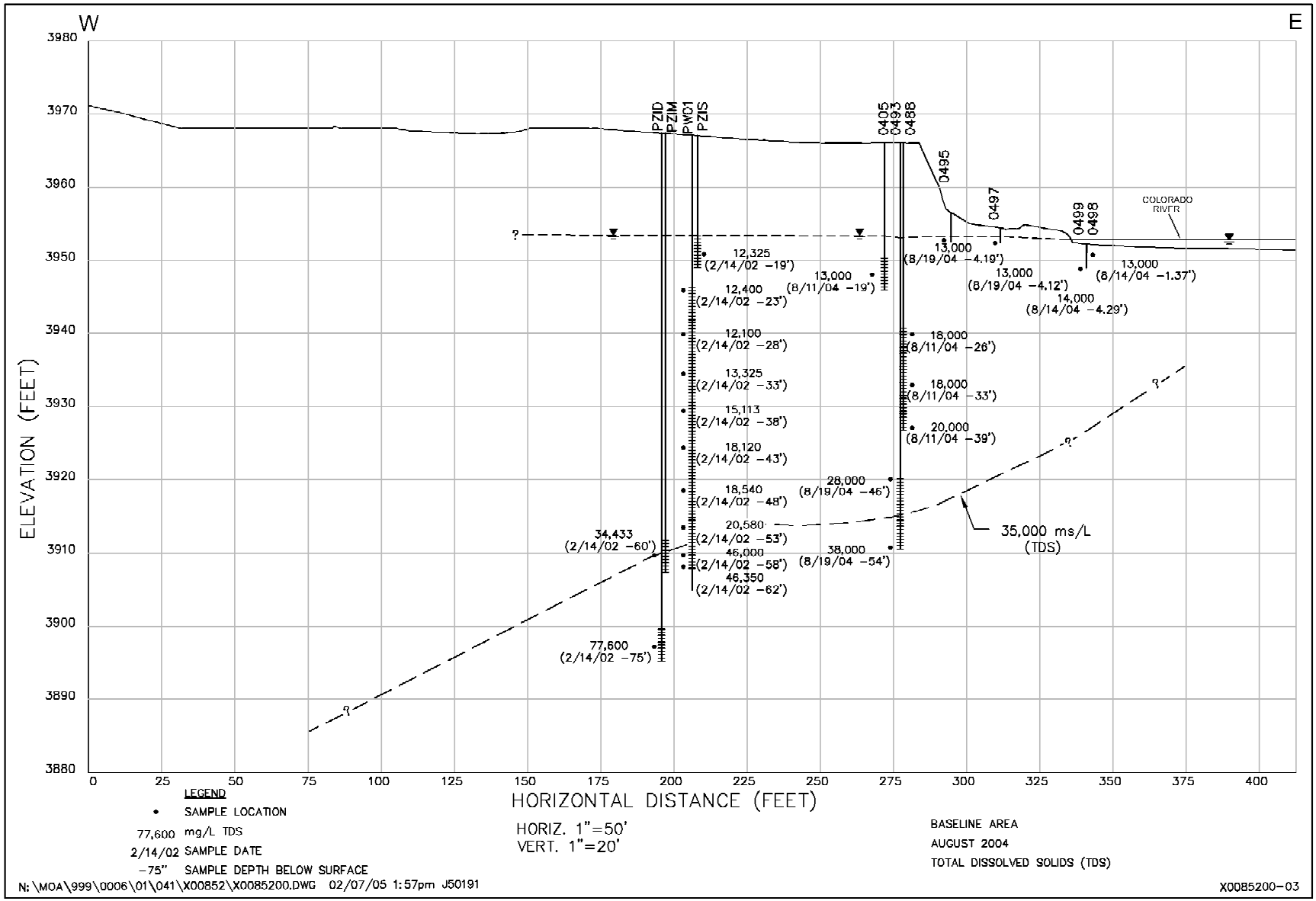


Figure 13. Baseline Area August TDS Concentrations

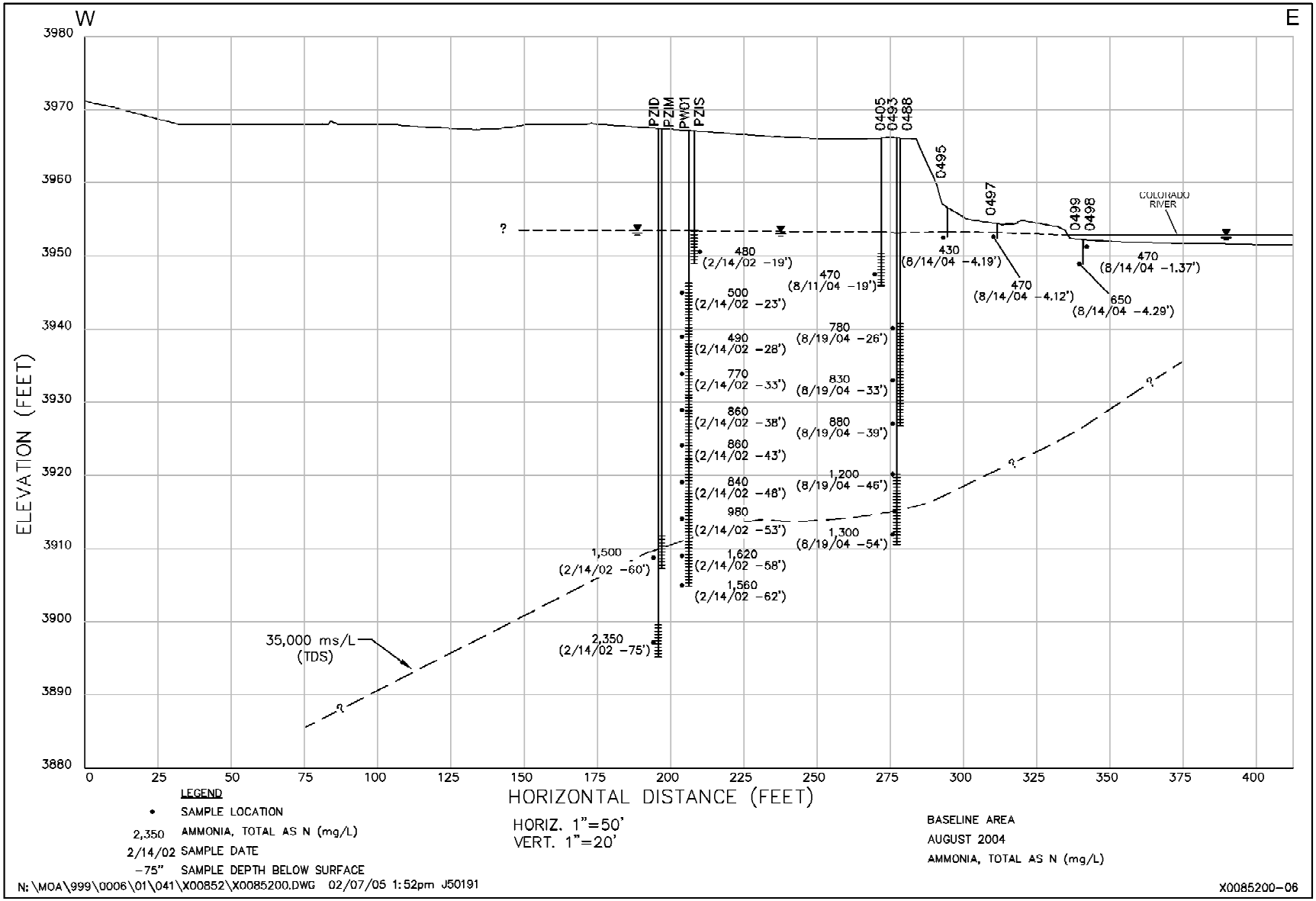


Figure 14. Baseline Area August Ammonia Concentrations

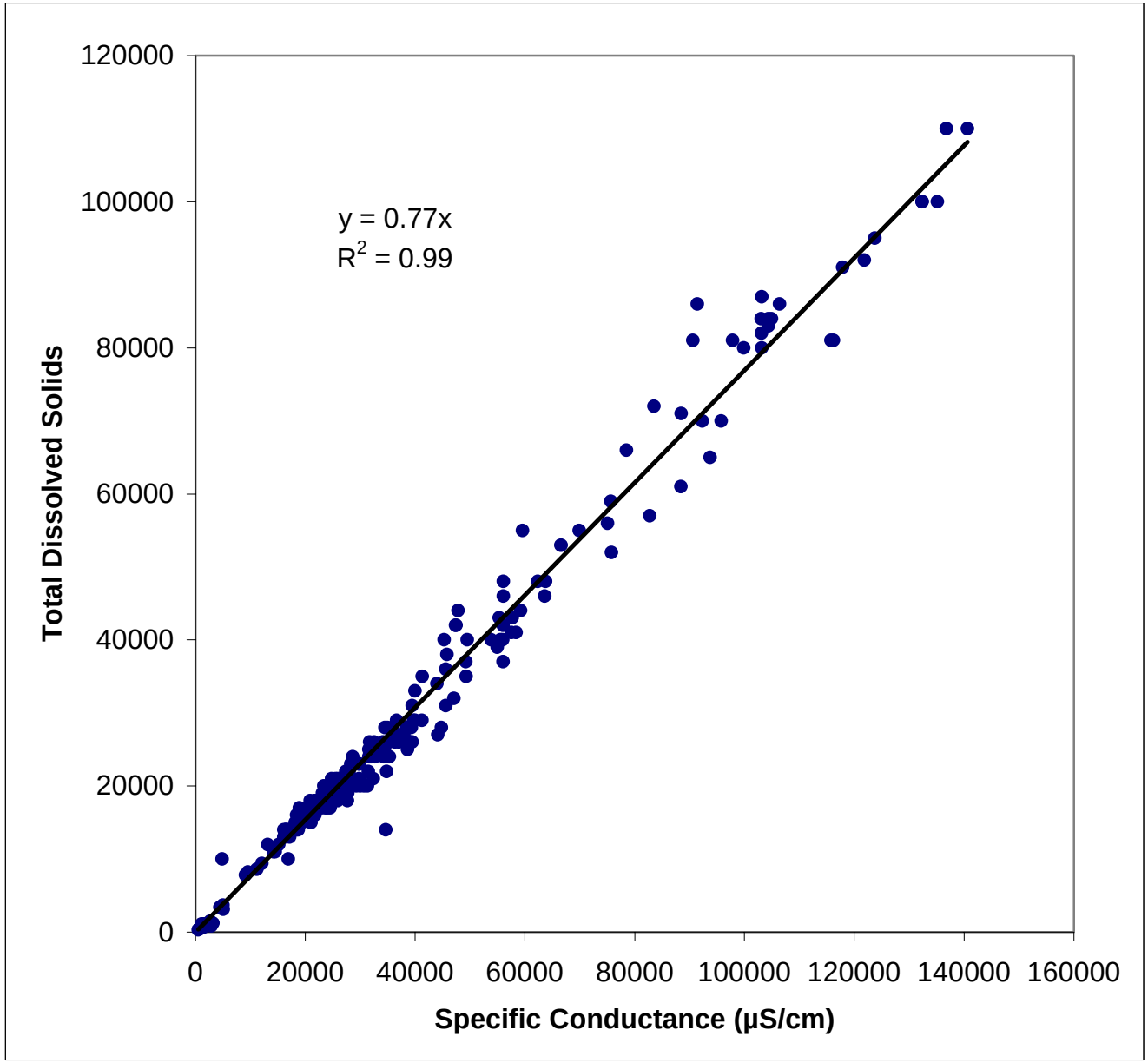


Figure 15. TDS vs Specific Conductance

Date	05/04/04
Mean Daily Flow (cfs)	4,150
Spec Cond (µS/cm)	4860
Paragon NH_3-N (mg/L)	320

Figure 16. Surface Location 0236—May 4, 2004
(formerly known as Surface Location 229)

Date	9/14/04
Mean Daily Flow at Cisco (cfs)	2,990
Spec Cond (µS/cm)	7,688
ESL NH_3-N (mg/L)	0.26

Figure 17. Surface Location 0236—September 14, 2004

Date	9/22/04
Mean Daily Flow at Cisco (cfs)	5,760
Spec Cond (µS/cm)	1,463
ESL NH_3-N (mg/L)	0.01

Note: Sample collected between PZs 591 and 592 (loc 240). See below.

Figure 18. Surface Location 0236—September 22, 2004

Date	10/15/04
Mean Daily Flow at Cisco (cfs)	3,450
Spec Cond (µS/cm)	16,476
ESL NH_3-N (mg/L)	125
Paragon NH_3-N (mg/L)	95

Figure 19. Surface Location 0236—October 15, 2004

Date	10/19/04
Mean Daily Flow at Cisco (cfs)	3,590
Spec Cond (µS/cm)	4,578
Paragon NH_3-N (mg/L)	79

Figure 20. Surface Location 0236—October 19, 2004

(Sample collected by D. Traub during routine sampling event)

Date	11/1/04
Mean Daily Flow at Cisco (cfs)	3,810
Spec Cond (µS/cm)	12,306
Paragon NH_3-N (mg/L)	170

Figure 21. Surface Location 0236—November 1, 2004

Date	11/3/04
Mean Daily Flow at Cisco (cfs)	3,600
Spec Cond (µS/cm)	19,325
Paragon NH_3-N (mg/L)	310

Figure 22. Surface Location 0236—November 3, 2004

Date	11/18/04
Mean Daily Flow at Cisco (cfs)	3,390
Spec Cond (µS/cm)	14,675
Paragon NH_3-N (mg/L)	290

Figure 23. Surface Location 0236—November 18, 2004

Date	12/15/04
Mean Daily Flow at Cisco (cfs)	2,830
Spec Cond (µS/cm)	9568
Paragon NH_3-N (mg/L)	190

Figure 24. Surface Location 0236—December 15, 2004

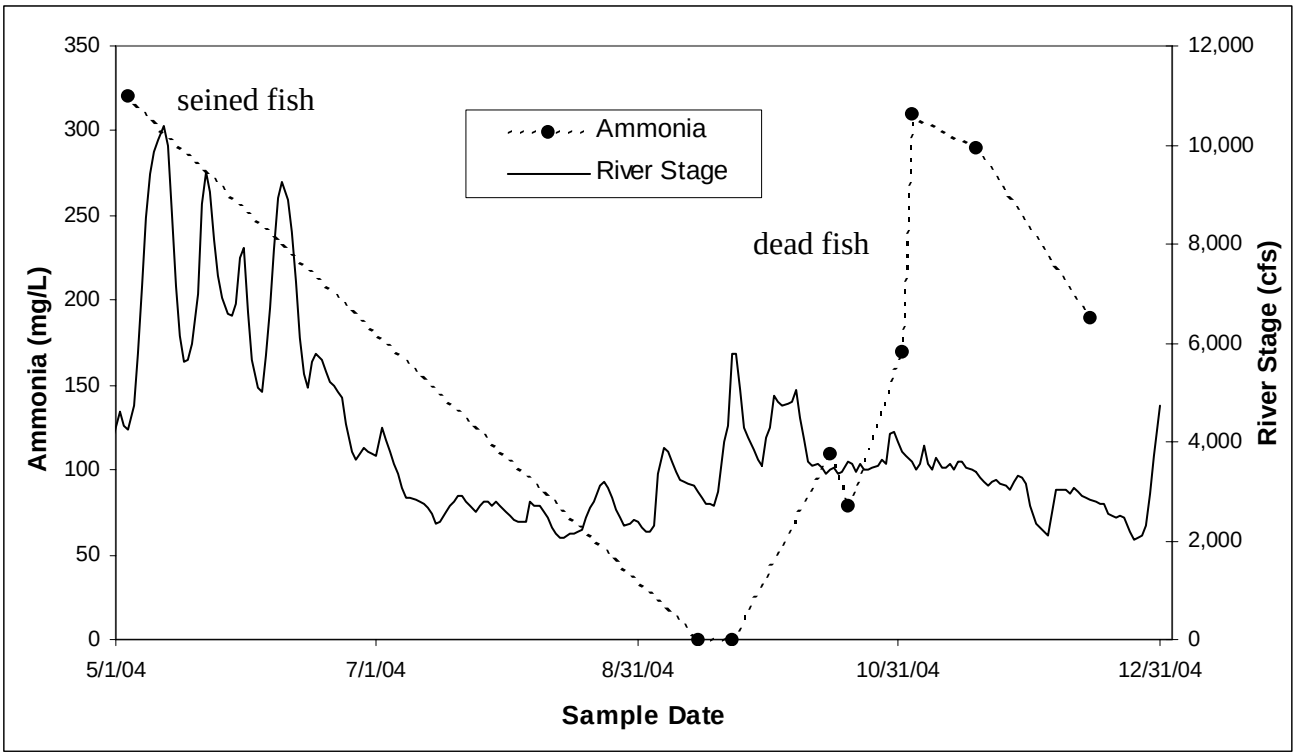


Figure 25. Ammonia and River Stage Data for Surface Location 0236

Tables

Table 1. Chronology for Monitoring Activities at the Moab Site

Date	Activity	Samples Collected
Configuration 1		
December 27, 2003	System shut down for winter.	NA
April 5–8, 2004	Completed profile baseline sampling.	All extraction wells sampled at 3 depths; observation wells at a single depth.
May 3–7, 2004	Developed extraction wells 0470–0479, completed small-scale injection test.	NA
Week of May 24, 2004	Started pumping from well field, flow rates set at ~ 1 gpm for each well.	NA
June 3, 2004	Completed monthly sampling.	Extraction wells 0470–0479, observation wells 0480–0485, pond inlet sample 0547, pond recirculation pump 0548, and surface water location 0216).
Week of June 7, 2004	Flows increased to maximum rates (varies for each well).	NA
July 6–7, 2004	Completed monthly sampling.	Same as June 3, 2004, sampling effort.
Late July 2004	Installed and developed 4 deep observation wells (0557, 0558, 0560, and 0561), 7 shallow observation wells (0551–0556, and 0559), and 6 floodplain piezometers (0562–0567).	NA
August 3–4, 2004	Completed monthly sampling.	Same as June 3, 2004, sampling effort.
August 18–19, 2004	Baseline profile sampling for selected new observation wells and piezometers.	Observation wells 0557–0561 (from two depths). Measured field parameters from piezometers 0562–0567 (samples collected for analysis only from 0563 and 0565, remaining never recharged after initial purge).
September 1–2, 2004	Completed monthly sampling.	Same as June 3, 2004, sampling effort plus added observation wells 0557–0561 (installed in August 2004).
October 13–14, 2004	Completed monthly sampling.	Same as September 1-2, 2004, sampling effort, water levels were measured in piezometers 0562–0565.
November 18–19, 2004	Completed monthly sampling.	The 10 extraction wells, 7 Observation wells (0403, 0407, 0483, 0484, 0557, 0559, and 0560), 3 piezometers (only 0563–0565, 0562 did not recharge after purge), 3 surface water locations (0216, 0547, and 0548). Also measured surface water field parameters off piezometer locations.
December 15–16, 2004	Completed monthly sampling.	The 10 extraction wells, 6 Observation wells (0403, 0407, 0483, 0557, 0559, and 0560), 4 piezometers (0562–0565), 3 surface water locations (0216, 0547, and 0548). Also measured surface water field parameters at surface water locations 0244 and 0245.
December 23, 2004	System shut down for winter.	NA
January 25, 26, and 27, 2005	Completed baseline sampling for 2005 pumping season.	The 10 extraction wells (sampled from one depth, measured field parameters from other depths), 13 observation wells (0403, 0407, 0480–0485, 0557 (2 depths), 0588 (2 depths), 0559, 0560 (2 depths), and 0561 (2 depths), 4 piezometers (0562–0565), 2 surface water locations (0216 and 0245).

Table 1. Chronology for Monitoring Activities at the Moab Site (continued)

Date	Activity	Samples Collected
Configuration 2		
Late July 2004	10 extraction wells, 7 shallow observation wells, 2 deep observation wells, and 6 floodplain piezometers (0590–0595) installed and developed in late July 2004.	NA
August 5–6, 17–20, 2004	Completed profile baseline sampling.	Collected profile baseline data from extraction wells 0570–0579 (sampled from 3 depths), deep observation wells 0588 and0589 (sampled from 2 depths), and piezometers 0590–0595.
September 2, 2004	Started pumping from extraction wells.	NA
September 3, 2004	Collected discharge baseline samples.	Extraction wells 0570–0579, shallow observation well 0580. System shut down for weekend.
September 8, 2004 10:00	Started extraction deep well test.	NA
September 13, 2004 17:00	Shut down extraction deep well test.	Extraction wells 0571, 0573, 0575, and 0579 (0577 pump not working), observation well 0580 at end of deep test.
September 14, 2004 10:00	Started extraction shallow well test.	Extraction wells 0570, 0572, 0574, 0576, and 0578 at the beginning of shallow test. Collected surface water sample from location 0236 for Environmental Sciences Laboratory NH_3 analysis.
September 22, 2004 16:00	Shut down extraction shallow well test.	Extraction wells 0570, 0572, 0574, 0576, and 0578 at the end shallow test. Collected surface water sample off piezometer 0592 (subsequently called location 0236) for Environmental Sciences Laboratory NH_3 analysis. Observation wells 0581–0587 and piezometers 0590–0593 were also sampled prior to full-scale test startup (data could be used for injection test background also).
September 23, 2004 12:00	Started extraction full-scale test.	NA
October 5, 2004 16:00	Shut down extraction full-scale test.	Extraction wells 0570–0579 and shallow observation well 0580 at end of test.
October 6, 2004	Pre-injection test sampling.	Measured field parameters (only) of all shallow observation wells prior to test startup.
October 6, 2004 13:00	Started injection test.	Injection water sample (location 0549) collected at beginning of test.
October 14–15, 2004	Injection test midpoint sampling.	Shallow observation wells 0401, 0402, 0580, 0582, 0583, and 0585–0587 submitted for analysis, measured field parameters in all other shallow observation wells, injection water sample (0549) collected. Also sampled surface water location 0236 (split analyzed by Environmental Sciences Laboratory).
October 19, 2004	Injection test midpoint sampling, continued.	Piezometers 0590, 0591, and 0593 (0592 was dry). Also sampled surface water location 0236.
November 2–3, 2004	Injection test sampling.	Observation wells 0401, 0402, and 0580–0589, piezometers 0590–0593, surface water locations 0236 and 0240, and 0549 (injection water sample) collected.
December 15, 16, and 17, 2004	Injection test sampling.	8 observation wells (0402, 0408, 0580–0584, and 0589), 4 piezometers (0590–0593), 2 surface waters (236 and 240), and injection water (0549). Also measured field parameters from 5 observation wells (0401, 0585–0588).
January 26 and 28, 2005	Injection test sampling.	7 observation wells (0408, 0580, 0582–0584, 0587, and 589, 4 piezometers (0590–0593), 1 surface water (00236), and injection water (0549). Also measured field parameters from 6 observation wells (0401, 0402, 0581, 0585, 0586, and 0588).

Table 1. Chronology for Monitoring Activities at the Moab Site (continued)

Date	Activity	Samples Collected
Baseline Area		
Late July 2004	Installed and developed 2 deep observation wells (0488 and 0493), and 6 floodplain piezometers (0494–0499).	NA
August 18–19, 2004	Baseline profile sampling for wells and piezometers.	Observation wells 0557–0561 (from two depths). Measured field parameters from piezometers 0562–0567 (samples collected for analysis only from 0563 and 0565, remaining never recharged).
October 15 and 19, 2004	Well and piezometer sampling.	Wells 0405 and 0488 (one depth) and well 0493 (two depths). Piezometer 0494 was dry and piezometer 0496 never recharged after purging. Samples were collected from piezometers 0495 and 0497.
Routine Sampling		
May 3–11, 2004	Sampling corresponded to Colorado River flows on the increasing side of the hydrograph. Flows ranged from 4,270 cfs (on May 3, 2004) to 9,790 cfs (on May 11, 2004).	**Millsite wells**: 0437, 0439, ATP-2-S, ATP-2-D, and TP-02 **Off-Site Wells**: 0401, 0402, 0403,0404, 0405, 0406, 0407, 0408, 0492, TP-17, TP-18, and TP-19 **Surface Water Locations**: CR1, CR3, CR5, 0201, 0204, 0217, 0219, 0220, 0221, 0222, 0223, 0224, 0225, 0226, 0227, 0228, 0229, 0230, 0231, 0232, 0233, and 0234
August 9–14, 2004	Sampling corresponded to Colorado River flows on the decreasing side of the hydrograph. Flows ranged from 2,050 cfs (on August 14, 2004) to 2,580 cfs (on August 9, 2004).	**Millsite wells**: 0437, 0439, ATP-2-S, ATP-2-D, and TP-02 **Off-Site Wells**: 0401, 0402, 0404, 0405, 0406, 0408, 0492, TP-17, TP-18, and TP-19 (note: 0403 and 0407 sampled previous week) **Surface Water Locations**: CR1, CR3, CR5, 0201, 0217, 0218, 0219, 0220, 0221, 0222, 0224, 0225, 0226, 0227, 0228, 0232, 0233, 0234 and 0235
October 26–29 and November 1 and 2, 2004	Sampling corresponded to Colorado River low flow conditions. Flows ranged from 3,510 cfs (on October 26, 2004) to 4,150 cfs (on October 29, 2004).	**Millsite wells**: 0437, 0438, 0439, ATP-2-S, ATP-2-D, and TP-02 **Off-Site Wells**: 0401, 0402, 0403, 0404, 0405, 0406, 0407, 0408, 0492, TP-17, TP-18, and TP-19 **Surface Water Locations**: CR1, CR3-003, CR5, 0201, 0204-003, 0217-003, 0218-003, 0219-003, 0220-003, 0222-003, 0223-003, 0224-003, 0225-003, 0226-003, 0227-003, 0228-003, 0232-003, 0233-003, 0234-003, 0235-003, and 0236

Table 2. 2004 Monitoring Locations

Locations	Sample Type	Sampling Objective	Colocated Samples (if applicable)
Surface Water			
0201	River	Downstream compliance	
0204	River	Colocated	TP02/0218
0216	River	Monitor IA	Config 1
0217	River	Background Habitat	
0218	River	Colocated	TP02/0204
0219	River	Colocated	0406
0220	River	Colocated	0405
0221	River	Colocated	0404
0222	River	Colocated	0401/0408
0223	River	Colocated-near shore	0402/0234
0224	River	Colocated	0403
0225	River	Colocated[a]	0407/0235
0226	River	Colocated	TP17
0227	River	Colocated-Near shore	TP18/232
0228	River	Colocated	TP19
0229/0236	River	Opportunistic Habitat	
0230	River	Opportunistic Habitat	
0231	River	Opportunistic Habitat	
0232	River	Colocated-in stream	TP18/0227
0233	River	Colocated-in stream	CR3/0492
0234	River	Colocated-in stream	0402/0223
0235	River	Colocated[a]	0407/225
0236	River	Opportunistic Habitat	
0240	River	Opportunistic Habitat	
CR-1	River	Background	
CR-3	River	Colocated-near shore	0492/0233
CR-5	River	In stream compliance	
Ground Water			
0401	Monitor well	Colocated	0408/0222
0402	Monitor well	Colocated	0223/0234
0403	Monitor well	Colocated	0224
0404	Monitor well	Colocated	0221
0405	Monitor well	Colocated	0220
0406	Monitor well	Colocated	0219
0407	Monitor well	Colocated	0225
0408	Monitor well	Colocated	0401/0222
0437	Monitor well	Deep ammonia plume	
0438	Monitor well	Samples below pile	
0439	Monitor well	Shallow ammonia plume	
0470	Extraction well	Config 1	
0471	Extraction well	Config 1	
0472	Extraction well	Config 1	
0473	Extraction well	Config 1	
0474	Extraction well	Config 1	
0475	Extraction well	Config 1	
0476	Extraction well	Config 1	
0477	Extraction well	Config 1	
0478	Extraction well	Config 1	
0479	Extraction well	Config 1	
0480	Observation well	Config 1	
0481	Observation well	Config 1	
0482	Observation well	Config 1	
0483	Observation well	Config 1	
0484	Observation well	Config 1	

Table 2. 2004 Monitoring Locations (continued)

Locations	Sample Type	Sampling Objective	Colocated Samples (if applicable)
Ground Water (continued)			
0485	Observation well	Config 1	
0488	Monitor well	Baseline	
0492	Monitor well	Colocated	CR3/0233
0493	Monitor well	Baseline	
0495	Piezometer	Baseline	
0497	Piezometer	Baseline	
0498	Piezometer	Baseline	
0499	Piezometer	Baseline	
0547	TS Influent	Config 1	
0548	Evaporation Pond		
0557	Monitor Well	Config 1	
0558	Monitor Well	Config 1	
0559	Monitor Well	Config 1	
0560	Monitor Well	Config 1	
0561	Monitor Well	Config 1	
0563	Piezometer	Config 1	
0565	Piezometer	Config 1	
0570	Injection/Extraction	Config 2	
0571	Injection/Extraction	Config 2	
0572	Injection/Extraction	Config 2	
0573	Injection/Extraction	Config 2	
0574	Injection/Extraction	Config 2	
0575	Injection/Extraction	Config 2	
0576	Injection/Extraction	Config 2	
0577	Injection/Extraction	Config 2	
0578	Injection/Extraction	Config 2	
0579	Injection/Extraction	Config 2	
0580	Monitor well	Config 2-WL[b]	
0581	Monitor well	Config 2-WL	
0582	Monitor well	Config 2-WL	
0583	Monitor well	Config 2-WL	
0584	Monitor well	Config 2-WL	
0585	Monitor well	Config 2-WL	
0586	Monitor well	Config 2-WL	
0587	Monitor well	Config 2-WL	
0588	Monitor well	Config 2	
0589	Monitor well	Config 2	
0590	Piezometer	Config 2	
0591	Piezometer	Config 2	
0592	Piezometer	Config 2	
0593	Piezometer	Config 2	
0594	Piezometer	Config 2	
0595	Piezometer	Config 2-WL	
ATP-2-D	Piezometer	Historic trends	
ATP-2-S	Piezometer	Historic trends	
TP-02	Monitor well	Colocated	
TP-17	Monitor well	Colocated	
TP-18	Monitor well	Colocated	
TP-19	Monitor well	Colocated	

Table 3. Results for May 2004 Colocated Sampling Event

Location Code	Date Sampled	Ammonia, total as N (mg/L)	Chloride (mg/L)	Specific Conductivity (µmhos/cm)	Sulfate (mg/L)	TDS (mg/L)	Uranium (mg/L)
0204-001	5/11/2004	0.1	32	497	99	320	0.0017
TP-02	5/11/2004	1.1	460	4,467	1,400	3,400	12
DF[a]		11.00	14.38	8.99	14.14	10.63	7058.82
0219-001	5/6/2004	0.1	67	888	200	550	0.012
0406	5/6/2004	400	810	14,210	6,400	11,000	1.3
DF		4,000.00	12.09	16.00	32.00	20.00	108.33
0220-001	5/6/2004	0.1	67	892	200	550	0.0057
0405	5/6/2004	390	1,300	15,220	7,000	12,000	1.3
DF		3,900.00	19.40	17.06	35.00	21.82	228.07
0221-001	5/6/2004	0.38	66	980	210	570	0.0065
0404	5/6/2004	340	2,000	18,180	7,800	15,000	2.1
DF		894.74	30.30	18.55	37.14	26.32	323.08
0222-001	5/6/2004	0.34	68	917	210	560	0.0065
0401	5/6/2004	480	1900	17,670	7700	14,000	2.1
0408	5/6/2004	930	2,700	24,570	12,000	20,000	2.8
DF	401/222	1,411.76	27.94	19.27	36.67	25.00	323.08
0223-001	5/5/2004	22	160	1875	540	1,100	0.094
0234-001	5/5/2004	0.22	68	908	200	550	0.0064
0402	5/5/2004	420	2,100	18,090	7,800	14,000	2.6
DF		1,909.09	30.88	19.92	39.00	25.45	406.25
0224-001	5/5/2004	30	220	2,684	740	1,500	0.16
0403	5/5/2004	370	3,000	19,460	7,300	15,000	2.6
DF		12.33	13.64	7.25	9.86	10.00	16.25
0225-001	5/5/2004	4.3	92	1,239	280	670	0.028
0407	5/5/2004	690	4,900	26,930	9,400	19,000	3.1
DF		160.47	53.26	21.74	33.57	28.36	110.71
0226-001	5/4/2004	0.21	75	916	200	570	0.0054
TP-17	5/4/2004	2.8	58,000	123,800	4,500	95,000	0.0071
DF		13.33	773.33	135.15	22.50	166.67	1.31
0227-001	5/4/2004	0.18	73	903	200	570	0.005
TP-18	5/4/2004	3.1	63,000	132,400	4,800	100,000	0.018
0232-001	5/5/2004	0.1	68	889	190	550	0.0044
DF	TP18/227	17.22	863.01	146.62	24.00	175.44	3.60
0228-001	5/4/2004	0.1	71	883	190	550	0.004
TP-19	5/4/2004	3.2	62,000	132,400	4,500	100,000	0.00015
DF		32.00	873.24	149.94	23.68	181.82	0.04
0233-001	5/5/2004	0.32	69	893	200	560	0.0055
0492	5/5/2004	70	11,000	45,330	15,000	40,000	5.5
CR3	5/5/2004	0.33	69	891	200	570	0.0065
DF	492/233	218.75	159.42	50.76	75.00	71.43	1,000.00

[a] Dilution factor

Table 4. Results for August 2004 Colocated Sampling Event

Location Code	Date Sampled	Ammonia-N (mg/L)	Chloride (mg/L)	Specific Conductivity (µmhos/cm)	Sulfate (mg/L)	TDS (mg/L)	Uranium (mg/L)
0218	8/10/2004	0.1	96	1,280	350	920	0.0094
TP-02	8/10/2004	1.5	460	5,038	1,500	3,700	12
DF[a]		15.00	4.79	3.94	4.29	4.02	1,276.60
0219-002	8/11/2004	0.1	97	1,375	350	900	0.013
0406	8/11/2004	420	790	14,517	6,300	11,000	1.3
DF		4,200.0	8.1	10.6	18.0	12.2	100.0
0220-002	8/11/2004	0.72	95	1,365	360	940	0.014
0405	8/11/2004	470	1,300	16,083	7,100	13,000	1.3
DF		652.78	13.68	11.78	19.72	13.83	92.86
0221-002	8/11/2004	0.4	93	1,342	350	900	0.012
0404	8/11/2004	300	1,100	19,264	4,500	16,000	2.2
DF		750.00	11.83	14.35	12.86	17.78	183.33
0222-002	8/11/2004	0.39	92	1,456	350	870	0.011
0401	8/11/2004	520	1,700	18,241	7,300	14,000	2.2
0408	8/11/2004	770	2,200	25,388	9,300	20,000	2.8
DF	401/222	1,333.33	18.48	12.53	20.86	16.09	200.00
0224-002	8/11/2004	0.17	91	1,303	340	900	0.0093
403	8/4/2004	780	3,900	25,921	8,900	18,000	2.8
DF		4,588.24	42.86	19.89	26.18	20.00	301.08
0225-002	8/11/2004	0.11	93	1,302	350	920	0.0087
407	8/4/2004	81	290	2,528	440	1,100	0.26
0235	8/11/2004	1.5	120	1,424	380	960	0.013
DF	407/235	54.00	2.42	1.78	1.16	1.15	20.00
0226-002	8/12/2004	1.3	240	3,177	380	1,200	0.015
TP-17	8/12/2004	3.4	56,000	135,198	4,500	100,000	0.012
DF		2.62	233.33	42.56	11.84	83.33	0.80
0227-002	8/12/2004	0.49	160	2,896	360	1,100	0.0099
TP-18	8/12/2004	3.5	58,000	140,602	4,600	110,000	0.015
0232	8/12/2004	0.33	150	1,606	380	1,100	0.01
DF	TP18/227	7.14	362.50	48.55	12.78	100.00	1.52
0228-002	8/12/2004	0.23	140	1,885	360	1,000	0.0083
TP-19	8/12/2004	3.4	58,000	136,822	4,400	110,000	0.000064
DF		14.78	414.29	72.58	12.22	110.00	0.01
0233-002	8/11/2004	1.1	150	1,630	370	1,100	0.012
0492	8/11/2004	82	11,000	47,521	15,000	42,000	5.7
CR3-002	8/11/2004	1.3	170	1,577	360	1,100	0.014
DF	492/233	74.55	73.33	29.15	40.54	38.18	475.00
0234-002	8/12/2004	0.39	95	1,397	370	940	0.013
0402	8/12/2004	630	1,700	18,023	7,600	14,000	2.4
DF		1,615.38	17.89	12.90	20.54	14.89	184.62

[a] Dilution factor

Table 5. Results for November 2004 Colocated Sampling Event

Location Code	Date Sampled	Ammonia-N (mg/L)	Chloride (mg/L)	Specific Conductivity (µmhos/cm)	Sulfate (mg/L)	TDS (mg/L)	Uranium (mg/L)
0204-003	10/26/2004	0.1	90	1,206	330	830	0.011
TP-02	10/26/2004	1.5	420	4,371	1,300	3,100	12
DF[a]		15.00	4.67	3.62	3.94	3.73	1,090.91
0219-003	11/2/2004	0.1	84	1,241	310	770	0.009
0406	11/2/2004	400	820	13,792	6,300	10,000	1.5
DF		4,000	9.76	11.11	20.32	12.99	166.67
0220-003	11/2/2004	0.1	86	1,206	320	790	0.0083
0405	11/2/2004	400	1,300	15,879	7,100	12,000	1.4
DF		380.00	2,000	18,863	8,400	15,000	2.1
0222-003	11/1/2004	0.1	86	1,205	320	790	0.0089
0401	11/1/2004	82	110	1,901	460	840	0.14
0408	10/28/2004	530	1,200	15,019	6,800	11,000	1.3
DF	401/222	820.00	1.28	1.58	1.44	1.06	15.73
0223-003	11/2/2004	0.1	86	1,205	310	780	0.0085
0234-003	11/2/2004	0.1	89	1,205	320	770	0.008
0402	11/2/2004	90	410	4,812	1,600	3,500	0.38
DF		900.00	4.61	3.99	5.00	4.55	47.50
0224-003	11/1/2004	0.1	86	1,202	310	780	0.0085
0403	11/1/2004	170	1,000	7,013	1,600	4,000	0.52
DF		1,700.00	11.63	5.83	5.16	5.13	61.18
0225-003	11/2/2004	0.72	93	1,236	330	750	0.015
0407	10/28/2004	53	280	2,599	670	1,200	0.28
DF		73.61	3.01	2.10	2.03	1.60	18.67
0226-003	10/27/2004	0.1	99	1,240	330	820	0.0073
TP-17	10/27/2004	3.6	60,000	134,758	4,900	110,000	0.014
DF		36.00	606.06	108.68	14.85	134.15	1.92
0227-003	10/27/2004	0.1	100	1,252	330	820	0.0068
TP-18	10/27/2004	3.5	60,000	132,709	4,900	110,000	0.012
DF		35.00	600.00	106.00	14.85	134.15	1.76
228-003	10/27/2004	0.1	95	1,248	320	830	0.007
TP-19	10/27/2004	3.7	62,000	134,590	5,100	110,000	0.00008
233-003	10/28/2004	0.32	100	1,257	340	780	0.0078
492	10/28/2004	95	14,000	47,944	15,000	43,000	4.8
CR3-003	10/28/2004	0.1	100	1,230	320	800	0.0079
DF	492/233	296.88	140.00	38.14	44.12	55.13	615.38

[a] Dilution factor

Table 6. 2004 Ammonia Sampling Results for Surface Water

Surface Locations	Date	PH	Temp (°C)	Tot NH_3-N (mg/L)	Federal Acute[1]	Federal Chronic[1]	Obs/std Acute	Obs/std Chronic	River Stage (cfs)
0216	4/8/2004	8.2	14.9	0.24	5.7	1.7	0.04	0.14	5,990
0201	5/3/2004	8.32	19.04	0.1	4.5	1.0	0.02	0.10	4,270
CR1	5/3/2004	8.32	18.63	0.1	4.5	1.1	0.02	0.09	4,270
CR5	5/3/2004	8.32	19.15	0.1	4.5	1.0	0.02	0.10	4,270
0226-001	5/4/2004	8.36	19.4	0.21	4.2	1.0	0.05	0.22	4,190
0227-001	5/4/2004	8.37	20.26	0.18	4.1	0.9	0.04	0.20	4,190
0228-001	5/4/2004	8.45	17.67	0.1	3.5	0.9	0.03	0.11	4,190
0229/0236	5/4/2004	7.59	27.53	320	17.3	1.7	18.49	185.04	4,190
0230	5/4/2004	8.31	22.5	2.8	4.6	0.9	0.61	3.24	4,190
0231-001	5/4/2004	8.34	20.8	0.47	4.4	0.9	0.11	0.52	4,190
0223-001	5/5/2004	8.24	20.5	22	5.3	1.1	4.15	19.98	4,660
0224-001	5/5/2004	8.18	25.23	30	6.0	0.9	5.04	32.99	4,660
0225-001	5/5/2004	8.31	21.97	4.3	4.6	0.9	0.93	4.82	4,660
0232-001	5/5/2004	8.43	20.39	0.1	3.7	0.8	0.03	0.13	4,660
0233	5/5/2004	8.41	20.16	0.32	3.8	0.8	0.08	0.38	4,660
0234-001	5/5/2004	8.51	19.76	0.22	3.1	0.7	0.07	0.31	4,660
CR3	5/5/2004	8.41	18.91	0.33	3.8	0.9	0.09	0.37	4,660
0219-001	5/6/2004	8.42	19.59	0.1	3.7	0.8	0.03	0.12	5,650
0220-001	5/6/2004	8.41	20.67	0.1	3.8	0.8	0.03	0.12	5,650
0221-001	5/6/2004	8.47	20.14	0.38	3.4	0.7	0.11	0.51	5,650
0222-001	5/6/2004	8.45	19.76	0.34	3.5	0.8	0.10	0.43	5,650
0217	5/7/2004	8.33	19.04	0.1	4.4	1.0	0.02	0.10	6,940
0204-001	5/11/2004	7.85	16.34	0.1	11.1	2.6	0.01	0.04	9,790
0216	6/3/2004	7.99	28	4.2	8.6	1.0	0.49	4.09	5,160
0216	7/6/2004	8.26	30.4	13	5.1	0.6	2.55	22.28	3,330
0201	8/9/2004	8.16	26.7	0.1	6.2	0.9	0.02	0.12	2,580
CR1	8/9/2004	8.19	27.9	0.1	5.8	0.8	0.02	0.13	2,580
CR5	8/9/2004	8.19	26.6	0.1	5.8	0.8	0.02	0.12	2,580
0218	8/10/2004	8.28	27.4	0.1	4.9	0.7	0.02	0.15	2,430
0219-002	8/11/2004	8.26	24.87	0.1	5.1	0.8	0.02	0.12	2,270
0220-002	8/11/2004	8.35	26.49	0.72	4.3	0.6	0.17	1.14	2,270
0221-002	8/11/2004	8.36	26.79	0.4	4.2	0.6	0.10	0.65	2,270
0222-002	8/11/2004	8.23	28.64	0.39	5.4	0.7	0.07	0.57	2,270
0224-002	8/11/2004	8.36	28.68	0.17	4.2	0.5	0.04	0.31	2,270
0225-002	8/11/2004	8.45	30.31	0.11	3.5	0.4	0.03	0.26	2,270
0233	8/11/2004	8.55	27.5	1.1	2.9	0.4	0.38	2.61	2,270
0235	8/11/2004	8.49	36.23	1.5	3.3	0.3	0.46	5.21	2,270
CR3-002	8/11/2004	8.59	27.9	1.3	2.7	0.4	0.48	3.38	2,270
0217	8/12/2004	8.31	27.45	0.1	4.6	0.6	0.02	0.16	2,110
0226-002	8/12/2004	8.47	26.89	1.3	3.4	0.5	0.38	2.59	2,110

Table 6. 2004 Ammonia Sampling Results for Surface Water (continued)

Well	Date	pH	Temp (°C)	Tot NH_3-N (mg/L)	Federal Acute[1]	Federal Chronic[1]	Obs/std Acute	Obs/std Chronic	River Stage (cfs)
0227-002	8/12/2004	8.49	28.97	0.49	3.3	0.4	0.15	1.14	2,110
0228-002	8/12/2004	8.45	28.1	0.23	3.5	0.5	0.07	0.47	2,110
0232-002	8/12/2004	8.4	28.32	0.33	3.9	0.5	0.08	0.63	2,110
0234-002	8/12/2004	8.29	25.43	0.39	4.8	0.7	0.08	0.52	2,110
0236	9/14/2004	9.15	23.48	0.26	1.1	0.2	0.25	1.38	2,990
0236	9/22/2004	8.22	16.67	0.01	5.5	1.4	0.00	0.01	5,760
0201	10/26/2004	8.46	10.07	0.1	3.5	1.1	0.03	0.09	3530
0204-003	10/26/2004	8.43	10.5	0.1	3.7	1.1	0.03	0.09	3530
0217	11/2/2004	8.46	7.76	0.1	3.5	1.1	0.03	0.09	3700
0218-003	10/26/2004	8.39	11.1	0.1	4.0	1.2	0.03	0.08	3530
0219-003	11/2/2004	8.39	6.47	0.1	4.0	1.2	0.03	0.08	3700
0220-003	11/2/2004	8.48	7.16	0.1	3.3	1.0	0.03	0.10	3700
0222-003	11/1/2004	8.38	7.74	0.1	4.0	1.2	0.02	0.08	3810
0223-003	11/2/2004	8.51	8.51	0.1	3.1	1.0	0.03	0.10	3700
0224-003	11/1/2004	8.41	8.71	0.1	3.8	1.2	0.03	0.08	3810
0225-003	11/2/2004	8.51	8.84	0.72	3.1	1.0	0.23	0.74	3700
0226-003	10/27/2004	8.56	10.8	0.1	2.9	0.9	0.03	0.11	3620
0227-003	10/27/2004	8.54	10.69	0.1	3.0	0.9	0.03	0.11	3620
0228-003	10/27/2004	8.45	10.66	0.1	3.5	1.1	0.03	0.09	3620
0232-003	10/27/2004	8.51	11.04	0.1	3.1	1.0	0.03	0.10	3620
0233-003	10/28/2004	8.35	9.71	0.1	4.3	1.3	0.02	0.08	3540
0234-003	11/2/2004	8.5	7.62	0.1	3.2	1.0	0.03	0.10	3700
0235-003	11/2/2004	8.49	8.15	0.1	3.3	1.0	0.03	0.10	3700
0236	11/1/2004	8.05	14.74	170	7.6	2.2	22.23	78.82	3810
0236	11/3/2004	7.87	12.63	310	10.7	2.8	28.96	108.89	3600
0240	11/3/2004	7.73	9.99	320	13.7	3.4	23.32	94.04	3600
CR1	10/26/2004	8.44	9.79	0.1	3.6	1.1	0.03	0.09	3530
CR3-003	10/28/2004	8.38	9.8	0.1	4.0	1.2	0.02	0.08	3540
CR5	10/27/2004	8.57	10.57	0.1	2.8	0.9	0.04	0.11	3620

[1]Criteria for salmonids absent; early life stages present
[2]USGS data for Cisco gauging station—http://waterdata.usgs.gov/nwis

*Table 7. Ammonia Exceedance Table—Surface Water**

Location	Date	Conc. (as N) (mg/L)	Obs/Std	Description	River stage (cfs)	Closest GW Conc.	Dilution Factor GW/SW
0229/0236	5/4/04	320	18.49-A 185-C	6-7” depth; v. slight flow to river; almost stagnant; seine location (habitat)	4,190	0402–420 mg/L	1.3
0230	5/4/04	2.8	3.24-C	4” depth; v. slight flow in channel; seine location (habitat)	4,190	0404–340 mg/L	121
0223-001	5/5/04	22	4.15-A 19.98-C	6” depth; 20’ from bank; low flow; side channel 40-50’ across; seine location (habitat)	4,660	0402–420 mg/L	19
0224-001	5/5/04	30	5.04-A 32.99-C	6” depth; 9’ from bank; low flow; side channel	4,660	0403–370 mg/L	12
0225-001	5/5/04	4.3	4.82-C	5-6”; 5’ from bank; medium flow; side channel with several shallow gravel bars in area	4,660	0407–690 mg/L	160
0216	6/3/04	4.2	4.09-C	N/A	5,160	0483–0485; 500–1,100 mg/L; these wells span the “interface”	119-262
0216	7/6/04	13	2.55-A 22.28-C	N/A	3,330	0483–0485; 460–1200 mg/L	35-92
0220-002	8/11/04	0.72	1.14-C	Off base of bank in main channel; 6-12” depth; 5-10’ from shore; med. Flow	2,270	0405–470 mg/L	652
0233-002	8/11/04	1.1	2.61-C	6-18” depth; side channel 10’ from shoreline; med. Flow	2,270	0492–82 mg/L	74
0235	8/11/04	1.5	5.21-C	12” depth; 120’ from base of bank; backwater open to main channel downstream, closed upstream (habitat); low flow	2,270	0407–81 mg/L	54
CR3-002	8/11/04	1.3	3.38-C	Main channel 1’ from shoreline; 6” depth; med. Flow	2,270	0407–81 mg/L	62
0226-002	8/12/04	1.3	2.59-C	8-12” depth; side channel 5-10’ from shoreline; low flow	2,110	TP-17–3.4 mg/L	2.6
0227-002	8/12/04	0.49	1.14-C	Main channel, 5’ from shore; low flow; unknown depth	2,110	TP-18–3.6 mg/L	7.3
0236	9/14/04	0.26	1.38-C	Stagnant pool 18’ off bank; 4” depth; no flow	2,990	0588–1,200 mg/L	4,615
0236	11/1/04	170	22.23-A 78.82-C	Backwater 8-10” deep; calm flow, fairly clear; dead minnows observed	3,810	0591–na	–
0236	11/3/04	310	28.96-A 108.89-C	6” deep; backwater; low flow	3,600	0591–330 mg/L	1.06
0240	11/3/04	320	23.32-A 94.04-C	4” deep; backwater; little or no flow	3,600	0591–1,000 mg/L	3.1

Table 8. Results of Habitat and In-Stream Compliance Sampling

Location	Date Sampled	Ammonia-N (mg/L)	Chloride (mg/L)	Specific Conductivity (µmhos/cm)	Sulfate (mg/L)	TDS (mg/L)	Uranium (mg/L)
Habitat Samples							
0217	5/7/2004	0.1U	62	818	180	500	0.0031
0217	8/12/2004	0.1U	95	1,467	360	940	0.0061
0229	5/4/2004	320[a]	1,400	4,860	5,800	10,000	1.8
0230	5/4/2004	2.8[a]	84	1,059	250	670	0.023
0231-001	5/4/2004	0.47	70	925	200	580	0.015
0236	11/1/2004	170[a]	2000	12,306	6300	10,000	1.7
0236	11/3/2004	310[a]	2300	19,325	8100	17,000	2.6
0240	11/3/2004	320[a]	2500	19,951	8500	17,000	2.7
Compliance Samples							
0201	5/3/2004	0.1U	74	1,000	190	550	0.0034
0201	8/9/2004	0.1U	99	1,322	360	930	0.0064
0225-002	8/11/2004	0.11	93	1,302	350	920	0.0087
0232-001	5/5/2004	0.1	68	889	190	550	0.0044
0232-002	8/12/2004	0.33	150	1,606	380	1,100	0.01
0232-003	10/27/2004	0.1U	100	1264	320	820	0.0072
0233-001	5/5/2004	0.32	69	893	200	560	0.0055
0233-002	8/11/2004	1.1[a]	150	1,630	370	1,100	0.012
0233-003	10/28/2004	0.1U	100	1257	340	780	0.0078
0234-001	5/5/2004	0.22	68	908	200	550	0.0064
0234-002	8/12/2004	0.39	95	1,397	370	940	0.013
0234-003	11/2/2004	0.1	89	1205	320	770	0.008
CR5	5/3/2004	0.1U	80	873	180	550	0.0038
CR5	8/9/2004	0.1	100	1,323	350	920	0.007
CR5	10/27/2004	0.1U	100	1245	320	810	0.0067

[a]Exceeds ambient water quality for ammonia (see Table 6)

Table 9. Results of Surface Water Sampling in Interim Action Area—2004

Location	Date Sampled	Ammonia Total as N (mg/L)	Chloride (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	TDS (mg/L)	Uranium (mg/L)	Cfs at Cisco gaging station
0216	04/08/2004	0.24	54	811	170	470	0.0051	5,990
0216	06/03/2004	4.2	79	1,479	260	660	0.034	5,160
0216	07/06/2004	13	140	1,117	470	1,100	0.080	3,330
0216	10/14/2004	0.14	100	1,438	370	830	0.019	3,340
0216	11/18/2004	6.4	130	1,609	400	1,000	0.050	3,390
0216	12/15/2004	140	610	7,437	2,700	5,100	0.840	2,830
0229/0236	05/04/2004	320	1,400	4,860	5,800	10,000	1.8	4,190
0236[a]	09/14/2004	0.26	–	7,688	–	–	–	2,990
0236[a]	09/22/04	0.01	–	5,760	–	–	–	5,760
0236	10/15/2004	95	2,000	16,476	7,000	15,000	2.200	3,450
0236	10/19/2004	79	1,100	4,578	3,800	9,200	1.400	3,590
0236	11/01/2004	170	2,000	12,306	6,300	10,000	1.700	3,810
0236	11/03/2004	310	2,300	19,325	8,100	17,000	2.600	3,600
0236	11/18/2004	280	1,500	14,675	5,700	11,000	1.900	3,390
0236	12/15/2004	190	820	9,568	3,400	6,800	0.970	2,830
0240	11/03/2004	320	2,500	19,951	8,500	17,000	2.700	3,600
0240	12/15/2004	160	650	8,218	3,000	5,800	0.880	2,830

[a] Field measurements only

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