The Thesis Committee for Lilith Joy Mercier
Certifies that this is the approved version of the following thesis:

Low pH waters in the vicinity of Oak Hill Mine: A statistical evaluation of water quality

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor:

John M. Sharp, Jr.

Meinhard Bayani R. Cardenas

Paola Passalacqua

Low pH waters in the vicinity of Oak Hill Mine: A statistical evaluation of water quality

by

Lilith Joy Mercier, B. Lib. Studies.; M.A.

Thesis

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Dedication

This thesis is dedicated to my close friends Danielle Madrid and Lauren Goldberg. I could not have completed this thesis without their understanding, patience, and unqualified support.

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Abstract

Low pH waters in the vicinity of Oak Hill Mine: A statistical evaluation of water quality

Lilith Joy Mercier, M.S. Geo. Sci.
The University of Texas at Austin, 2014

Supervisor: John M. Sharp, Jr.

Lignite (brown coal) mine-mouth power plants supply a significance portion of electricity generated annually in Texas. Most lignite is produced from the Wilcox Group at surface mines located near a power plant. At the Oak Hill Mine, a lignite mine in the Sabine Uplift area of northeast Texas, the presence of low pH seeps has delayed the release of some portions of the reclaimed land from bond of some until all surface water bodies achieves a stable pH between 6 and 9. But this federal requirement may require an artificial elevation of surface water pH above the natural range for low volume, groundwater-fed surface water bodies in that region. The primary objective of this thesis is to determine whether the distribution of groundwater pH at Oak Hill Mine has become more acidic as a result of mining activity. This study shows that low pH (<6.0) groundwater was common within the mine permit area prior to mining activities; the 95% confidence interval for the median pH of overburden pre-disturbance (OP) wells is 4.7 to 4.8. This naturally occurring, low pH groundwater is produced by the weathering (oxidative dissolution) of pyrite in the Carrizo Sand and overburden Wilcox Group. Although low pH groundwater occurs naturally within the Oak Hill Mine permit area, groundwater pH has also decreased (groundwater has become more acidic) as a result of mining activities. The 95% confidence interval for the median pH of overburden reclamation (OR) wells is 4.1 to 4.2, indicating that mining activities has changed the median groundwater pH by approximately -0.5 standard units. Underburden groundwater is less acidic than overburden groundwater, but also becomes more acidic after mining activities. Underburden pre-disturbance (UP) groundwater has a median pH of 6.2 to 6.3 at the 95% confidence interval, whereas underburden reclamation (UR) groundwater has a median pH of 5.6 to 5.8 at the 95% confidence interval.

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Chapter 1: Introduction

OVERVIEW OF THE EAST TEXAS (SABINE UPLIFT) SETTING

Approximately forty to fifty percent of energy produced in Texas in 2000 was produced by lignite (brown coal) mine-mouth power plants (Robert Gentry, personal communication, 2000). Coal is divided into four grades. In order from lowest to highest grade, these are: lignite, subbituminous, bituminous, and anthracite. Of the four grades of coal, lignite is youngest in age and least altered from its peat origins. It has the lowest carbon content (25-35% as-is basis) and heat value (4,000-8,300 BTUs-per-pound). In comparison, anthracite coal contains the highest carbon content (86-98%) and heat value (approximately 15,000 BTUs-per-pound).

Almost three-quarters of lignite resources in Texas occur in the Wilcox Group (Kaiser, 1978a). The remaining lignite is produced from mines in southeast Texas, which source lignite from the younger Jackson Group and Yegua Formation (Kaiser, 1978a and 1986). Wilcox lignite was originally deposited as peat blankets 40-60 million years ago (Palmquist, 1987) and is of better quality than Yegua Formation and Jackson Group lignite. Furthermore, Wilcox lignite in the Sabine Uplift is generally of better quality than central and east-central Wilcox lignite. Sabine Uplift lignite generally has the highest carbon content (~74%) and heat value and lowest sulfur and ash composition (Kaiser, 1986).

Only “near surface” lignite can be economically mined in Texas—by means of surface (strip) mining techniques. Kaiser (1986) defines “near surface” lignite as lignite located within 200 ft (61 m) of the land surface.[1] These near surface lignite deposits are overlain by unconsolidated soil and sediments that can be removed by draglines, excavators, and bucket-and-shovel equipment. Oak Hill Mine, the subject of this study, is

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[1] “Deep basin” lignite is more than 200 ft (61 m) from the surface (Kaiser, 1986).

one such surface mine. Located near the City of Henderson in Rusk County, east Texas, this mine has been supplying the nearby Martin Lake Power Plant with Wilcox lignite since 1985 (Figure 1.1).

In addition to being the principal host for economic lignite, the Wilcox Group also hosts the Carrizo-Wilcox aquifer, one of nine major aquifers in Texas (Figure 1.2). The Carrizo-Wilcox aquifer extends in a wide band from Mexico through Texas and

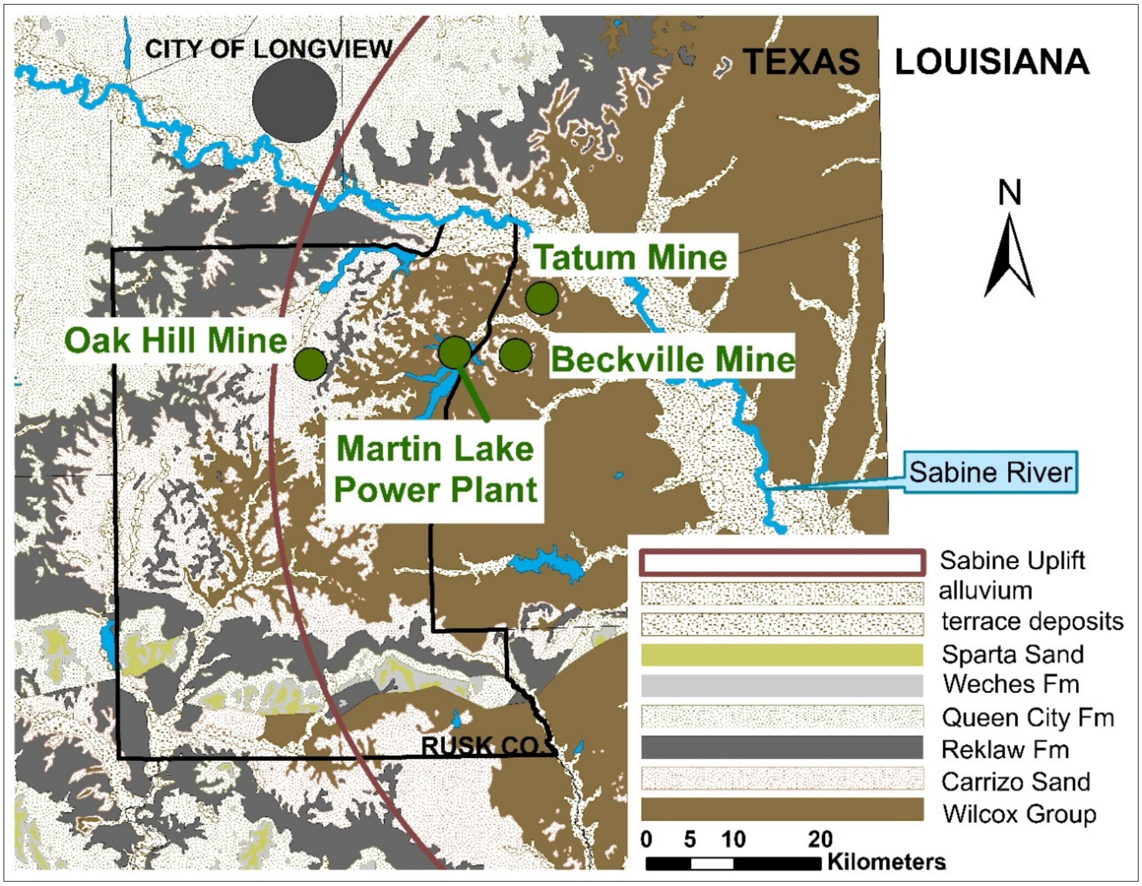

Figure 1.1: Location of the Martin Lake Power Plant in east Texas and the three surface lignite mines – Beckville, Oak Hill, and Tatum Mines – that supply lignite to the plant.

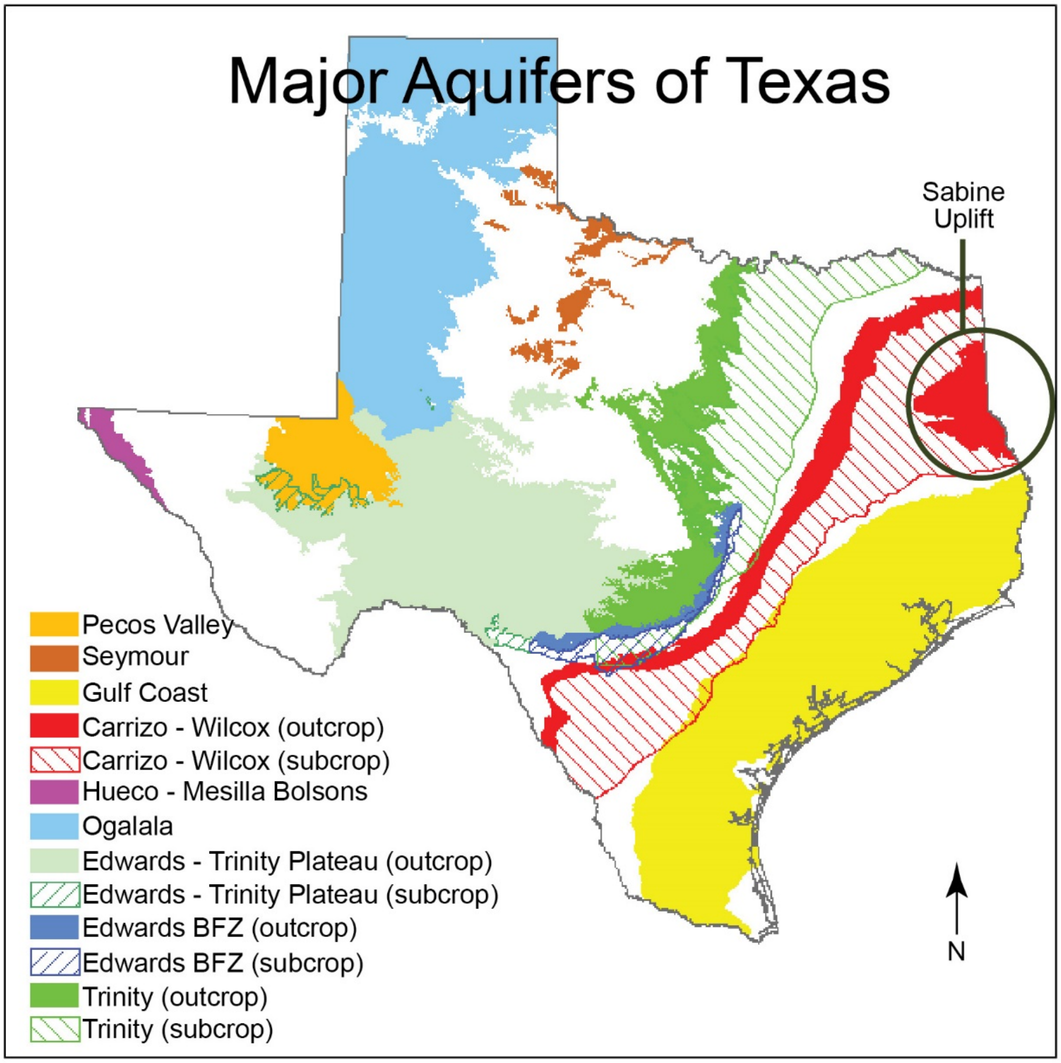

Figure 1.2: Major aquifers of Texas. Modified from (TWDB, 2011).

Louisiana and into Arkansas, approximately parallel to the Gulf Coast. It is a heterogeneous clastic sedimentary aquifer formed by the Wilcox Group and the disconformably overlying Carrizo Sand formation of the Claiborne Group. The hydrogeology of the Carrizo-Wilcox aquifer is discussed in Chapter 2. This major Texas aquifer is a primary source of drinking and irrigation water for many groundwater-dependent consumers in east and central Texas. In 1974, nearly 50% of water consumed in east Texas was groundwater pumped from the Carrizo-Wilcox aquifer system (Kaiser, 1986). By 2001-2003, the proportion of water supplied by the Carrizo-Wilcox aquifer was down to 11% of total water consumed in east Texas.[2] In 2006, groundwater (including the Carrizo-Wilcox aquifer) constituted 15% of the reliable fresh water supply in east Texas and remains an important resource for municipalities and rural consumers (Schaumburg & Polk, Inc., 2006).

PROBLEM STATEMENT

Near-surface lignite deposits in Texas are primarily associated with the Eocene Wilcox Group and lie within the recharge zone of the Carrizo-Wilcox aquifer. Surface mining can adversely affect groundwater quality by altering the redox conditions of the sediments, which can initiate or enhance the oxidative dissolution of reduced iron sulfide minerals, releasing acidity as well as dissolved iron and sulfate ions. The presence of low pH seeps has delayed the release from bond of some reclaimed lands in the Sabine Uplift area of northeast Texas. Federal regulations require that surface waters draining reclaimed mines have a stable pH between 6 and 9. Furthermore, reclaimed land cannot be released from bond until all surface water bodies achieves a stable pH between 6 and 9. Where seeps and low volume streams in mines are fed by naturally acidic groundwater, this regulation may require the artificial elevation of water pH by the addition of caustic, raising pH above the natural range for that region. Such a situation would contradict the purpose of the Surface Mining Control and Reclamation Act of 1977, which is to minimize damage to the environment caused by mining activities (United States, 2011). Thus, there is a need to identity naturally-occurring acidic groundwater in mine permit areas—including where

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[2] In 2001-2003, an average of 75,219 acre -ft/yr (92.781 GL/yr) of groundwater was pumped from the Carrizo-Wilcox aquifer. Total water consumed in east Texas (Region I) was 704,320 acre-ft/yr (868.776 GL/yr) in 2000 (Schaumburg & Polk, Inc., 2006; ETRWPG, 2010).

the water table "crops out" as seeps and low volume, groundwater-fed streams. This naturally occurring acidity should distinguished from mining-induced acidity so that the environmental impacts of mining can be accurately delineated. However, little work has been done to quantify the extent mining-related groundwater acidity in areas with naturally acidic groundwater.

EXAMPLES OF NATURALLY OCCURRING SOIL AND GROUNDWATER ACIDITY IN TEXAS AND ARKANSAS:

Several instances of naturally occurring, low pH waters have been documented in the east-central and east Texas. Horbaczewski (personal communication, 2007 and 2009) described in workshop presentations the presence of naturally occurring, low pH groundwater seeps and Peach Creek, a low volume gaining stream in an undisturbed watershed in Gibbons Creek Mine, a surface lignite mine in east-central Texas. He attributed acidity to natural weathering of pyrite, which is present in connection with the shallow lignite seam and proximal geologic strata of the Jackson Group. Shaw (2006) identifies multiple low-volume streams in unmined areas of the Sabine Uplift area of Texas with pH values as low as 3.9. For example, McNeil Creek is a short, low-discharge stream 13 miles southwest of Oak Hill Mine. The creek flows across the same surface geology as is present in the mine, and it has a pH <6.0 along its entire length—and as low as 4.2 at one sample location.

Similar conditions have been independently observed in two carbonate-poor groundwater systems in Arkansas. During a survey of wells near Hot Springs National Park in the ZigZag Mountains, Kresse and Hay (2009) encountered fresh (median TDS of 23 mg/L)[3], low pH (< 6.0) groundwaters in 10 out of 11 wells that were completed in near-

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[3] These quartz formation-sourced waters had a median TDS of 23 mg/L and a median specific conductance of 30 μS/cm, which is comparable to commercial bottled water (10-25 μS/cm) (Kresse and Hay, 2009). Water from shale formations had a median specific conductance of 290 μS/cm.

surface quartz[4] formation during a survey of groundwater quality. In these wells, pH ranged from 3.6 to 5.9 with a median value of 4.5. 8 of these wells had a pH below the typical pH of Arkansas rainwater (pH of 4.7). In contrast, wells completed in shale units had higher TDS (median 153 mg/L) and largely circumneutral pH, ranging from 5.8 to 7.7 with a median of 7.3. Kresse and Hay (2009) attribute the acidity of quartz formation groundwater to carbonic acid generated from the high pCO_2 typical of soils due to plant and microbe respiration (Chapter 2, "Carrizo-Wilcox Aquifer Water Quality in the Sabine Uplift Area of Texas") and a lack of calcium carbonate buffering capacity in the quartz formations. In contrast, carbonate dissolution, as well as dissolution and exchange reactions with clay minerals, buffers groundwater pH and increases TDS in shale formations.

Kresse et al. (2012) surveyed shallow groundwater in Van Buren and Faulkner Counties in north-central Arkansas to study the possible effects on shallow groundwater quality from gas production in the 1,500 to 1,600 ft (457 to 488 m) deep Fayetteville Shale.[5] Of 127 wells sampled, most were circumneutral (median pH of 6.5), but 25% were acidic (pH 4.2 to 5.9). Wells screened in quartz sandstone produced very fresh (< 30 mg/L), acidic to slightly acidic water whereas wells screened in shale produced water with a higher TDS and pH. The acidity of the sandstone-sourced groundwater quality is attributed to the nature product of mineral dissolution, limited cation exchange, and a lack of carbonates in the formation. Thus, in both east-central (Kresse and Hay, 2009) and north-central (Kresse et al., 2012) Arkansas, shallow groundwater pumped from a quartz-dominated formation is naturally fresh and acidic (pH <6 and often <5).

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[4] The quartz formations consist of novaculite, chert, and quartz sandstone formations.

[5] Kresse et al. (2012) conclude that there is no evidence of shallow groundwater contamination from gas production.

INDIRECT EVIDENCE FOR ACIDIC SOIL AND GROUNDWATER CONDITIONS:

Because jarosite precipitation requires acidic (pH 3 to 4) conditions (van Breemen, 1973), the presence of jarosite minerals in east Texas, and specifically in the immediate area surrounding Oak Hill Mine (Dixon et al., 1982; Carson et al., 1982), indicates a history of acid generation in the region that is unrelated to mining activities. Litter from coniferous vegetation—such as the litter generated by Loblolly pines in pine plantations in east Texas—contributes to soil acidity. Pine needles are broken down by fungi, releasing organic acids that are stronger than the weak carbonic acid (H_2CO_3) that is typically produced during break down of organic material (OSM, 1985).

RESEARCH OBJECTIVES AND HYPOTHESES

This thesis uses a combination of statistical tools, such as hypothesis tests, cumulative distribution plots, and multiple linear regression (MLR), to investigate groundwater acidity as measured by groundwater pH at Oak Hill Mine. The primary objective of this thesis is:

(1) To determine whether the distribution of groundwater pH at Oak Hill Mine has shifted towards a more acidic distribution as a result of mining activity.

Secondary objectives of this study are:

(2) To use descriptive statistics and regression modeling to describe how the pre-disturbance groundwater pH distribution at Oak Hill Mine corresponds both to local geology and to other groundwater quality parameters, and

(3) To use descriptive statistics and regression modeling to describe how the reclamation (post-disturbance) groundwater pH distribution at Oak Hill Mine corresponds both to local geology and to other groundwater quality parameters.

My hypotheses are that:

1. Low pH groundwater observed prior to mining disturbance is the result of natural weathering of the Reklaw Formation, a fine-grained marine unit,
2. Low pH (<6.0) groundwater was an isolated phenomenon in some pre-disturbance monitoring wells, and
3. The groundwater pH distribution did not change as result of mining.

Chapter 2: Rocks, Water, and Coal in East Texas

GEOLOGY OF EAST TEXAS

The Oak Hill Mine lies on the western flank of the Sabine Uplift in east Texas and western Louisiana (Figures 1.1 and 2.1). The Sabine Uplift is a flat topped, dome shaped structural high that has persisted since the Jurassic period (Murray, 1948 and 1961). The DeSoto- Red River (Bull Bayou) structure in western Louisiana is highest portion of the

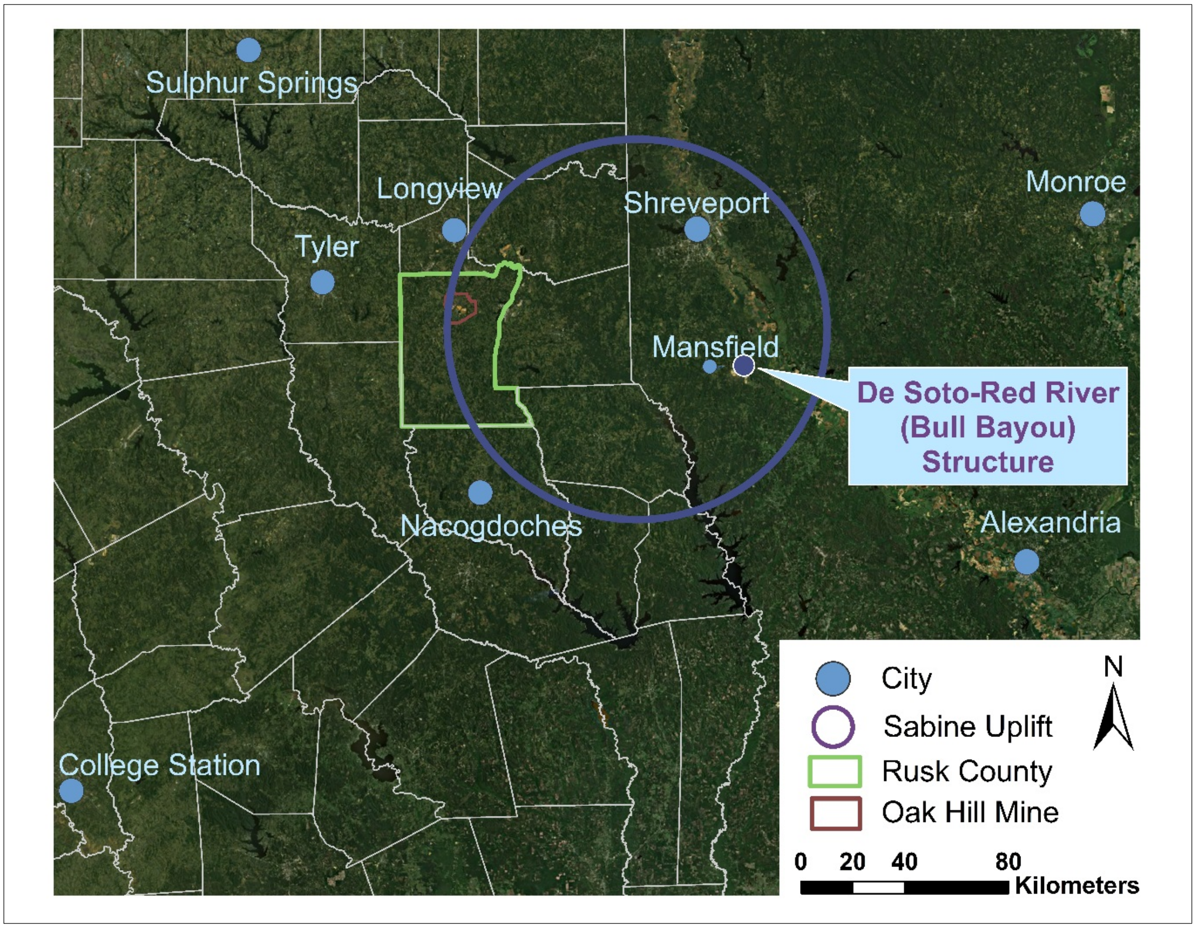

Figure 2.1: Locations of the Sabine Uplift in east Texas and West Louisiana, of Oak Hill Mine in Rusk County, and of the De Soto-Red River Structure, which is the highest point on the Sabine Uplift.

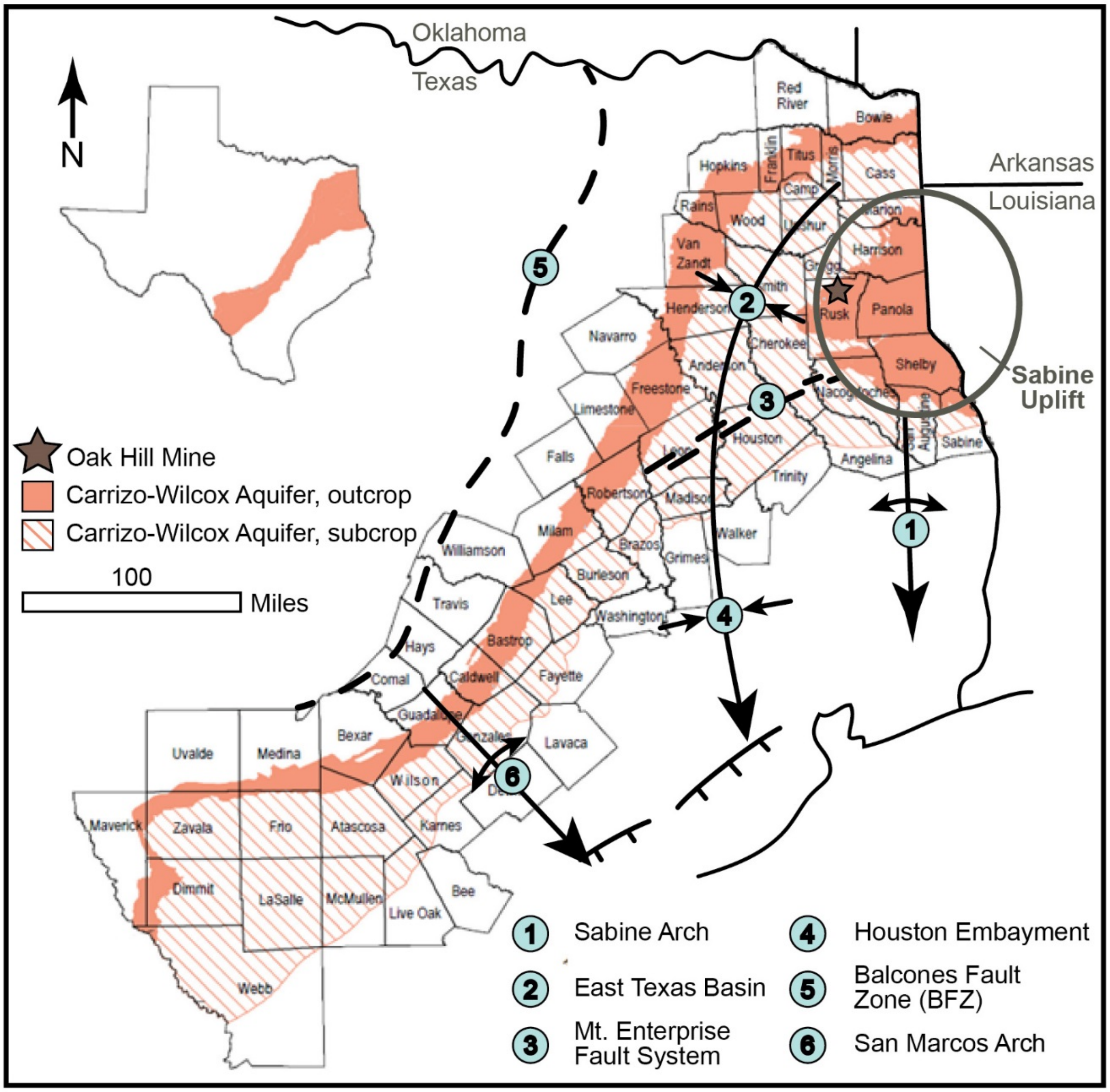

Figure 2.2: Structural Features in East Texas and their relation to Oak Hill Mine on the western flank of the Sabine Uplift. Modified from George et al. (2011) and Kaiser (1982).

Sabine Uplift region (Williamson, 1987). To the west of the Sabine Uplift is the East Texas Embayment, a regional syncline with axis dipping southeast toward the coast at about 1 degree, strike is roughly northeast-southwest (Palmquist, 1987) (Figure 2.2).

The persistence of the Sabine Uplift has exerted a strong control on the deposition of the lignite-bearing Wilcox Group and overlying formations. Strata dip radially away from the center of the Sabine Uplift. Wilcox Group sediments deposited on the flanks of the Sabine Uplift are shallow compared to those deposited in the East Texas Embayment (Figure 2.3)—enabling lignite-bearing layers in the upper Wilcox Group to be economically mined via surface (strip) methods.

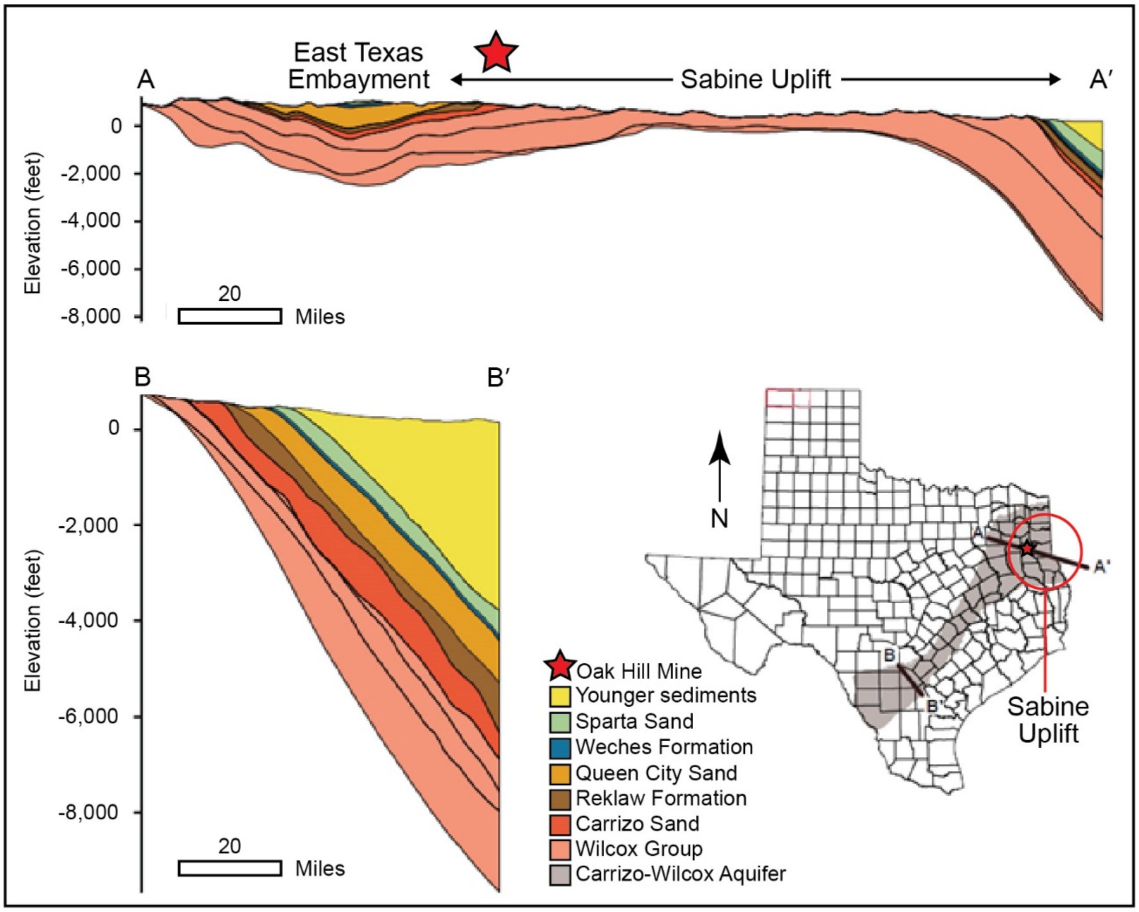

Figure 2.3: Cross sections in east and south Texas illustrating the relationship among major of sedimentary layers, the regional dip of the layers, and the location of the Oak Hill Mine on the western flank of the Sabine Uplift. Modified from George et al. (2011).

The Sabine Uplift also controls the recharge and confined zones of the Carrizo-Wilcox aquifer in east Texas. The recharge zone for the Carrizo-Wilcox aquifer occurs where these units crop out in a band parallel to the Gulf Coast and in a ring around the Sabine Uplift (Figure 1.2). Downdip of the recharge zone towards the East Texas Embayment and toward the Gulf Coast, the aquifer is overlain by the progressively younger sedimentary units of the Claiborne and Jackson Groups, all dipping towards the Gulf (Figure 2.3).

From oldest (deepest) to youngest (shallowest), the geologic units in the Sabine Uplift region of east Texas are the Eocene-age Wilcox Group, the Claiborne Group, and recent alluvium deposits (Figures 2.3 and 2.4).[6] In central and east-central Texas, the lignite-bearing Wilcox Group is composed of clastic sequences sub-divided into the Hooper, Simsboro, and Calvert Bluff formations. North of the Trinity River in east Texas (including the Sabine Uplift region), the Wilcox Group is undivided due to the disappearance of the Simsboro Sand as a mappable unit (Kaiser et al.. 1978). Lignite seams are located within the Wilcox Group. Seams economically amenable to surface mining techniques occur slightly downdip of where the Wilcox Group crops out (e.g., note location of Oak Hill Mine in Figure 2.2).

Where the Wilcox is formally divided into the Hooper, Simsboro, and Calvert Bluff formations, most of the produced lignite seams are located in the Calvert Bluff. The thickest seams occur in the Calvert Bluff Formation near the unconformable upper contact with the Carrizo Sand and near the conformable lower contact with the fluvial-origin Simsboro Sand (Kaiser, 1986). In east-central Texas south of the Trinity River (southwest of the Sabine Uplift), regular, thick lignite deposits averaging 5 to 10 ft (1.5 to 3 m) thick

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[6] The Jackson Group, which is younger than the Claiborne Group, is present in central and south Texas but is not present in the Sabine Uplift region.

are present in the lower Simsboro Sand (Kaiser, 1978a). The upper Simsboro Sand contains irregular lignite deposits of less commercial importance. Shallow lignite deposits exploitable by surface mining techniques or by *in situ* gasification are fluvial

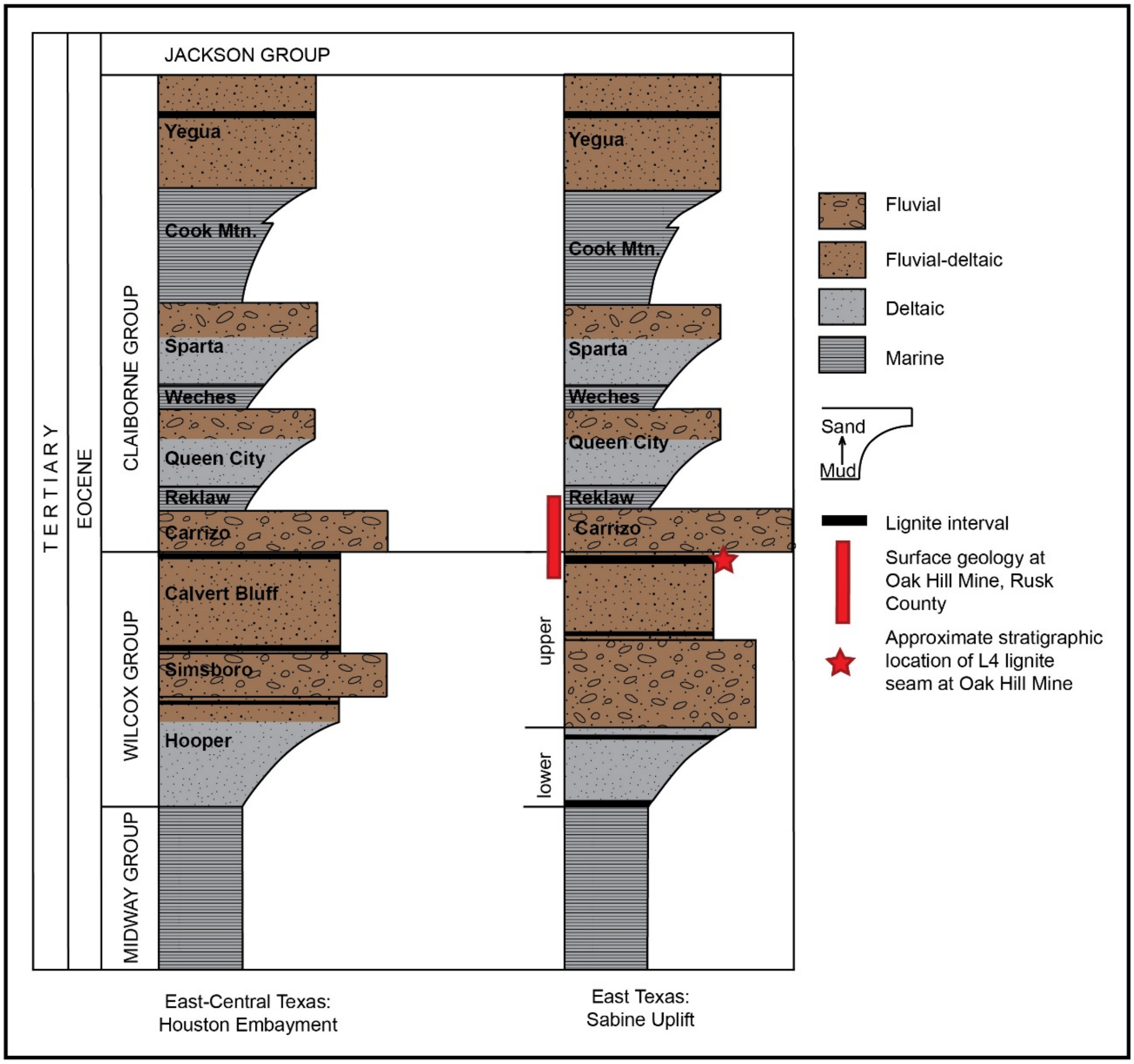

Figure 2.4: Stratigraphy of east-central Texas (Houston Embayment) and east Texas (Sabine Uplift) with approximate stratigraphic location of the Oak Hill Mine L4 lignite seams. Modified from (Kaiser 1986, Ayers and Kaiser 1987).

deposits from ancient hardwood swamps located in interchannel basins near the transition from lower alluvial plain to fluvial-dominated, highly constructive deltaic system (Kaiser, 1978a).[7,8]

In the Sabine Uplift region of east Texas, the Wilcox Group is a 400 to 1,400 ft (122 to 427 m) thick undivided sedimentary unit containing layers of sand, mud, and lignite. Fisher et al. (1969) and Kaiser (1978b, 1986) informally divide the Wilcox group into a lower progradational and an upper aggradational unit. Both units are operationally defined for logging purposes: the former by an inverted Christmas-tree log pattern and the latter by blocky, Christmas-tree, and saw tooth log patterns. Lignite seams occur in the both units, though the thickest and most laterally extensive lignite seams occur in the lower progradational unit (Kaiser 1986). Lignite deposits producible by surface mining techniques occur in the upper unit. Seams average 2 to 13 ft (0.6 to 4 m) thick and 25 to 400 million tons in size (Kaiser et al., 1978). At the Oak Hill Mine, economic lignite seams occur in the upper Wilcox Group (Luminant, private communication).

The Eocene-age Claiborne Group disconformably overlies the Wilcox Group. It consists of the Carrizo Sand conformably overlain by two progradational series. The

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[7] "Shallow" lignite deposits are defined lignite seams less than 200 ft (61 m) below ground surface (Kaiser, 1986). Lignite deposits amenable to *in situ* gasification are deeper than 200 ft below ground surface and no more than 1,500 ft (457 m) below sea level (Kaiser, 1978a).

[8] Early workers interpreted the undivided Wilcox Group as an ancient high alluvial plain river system, named the Mt. Pleasant system (Fisher and McGowen, 1967; Kaiser et al., 1978c) and lignite deposits were believed to be the result of hardwood swamps established in interchannel basins between alluvial ridges (Nichols and Traverse, 1971; Kaiser et al., 1978c; Kaiser et al. 1980). Subsequent interpretations distinguished between a lower and upper portion for the undivided Wilcox Group, with different depositional systems for the two portions. Specifically, Kaiser et al. (1986) interpret the Sabine Uplift Wilcox Group as a fluvial-deltaic sequence with sediment sources in the north and northeast. They argue that the progradational (lower) Wilcox Group lignite is deltaic in origin whereas the aggradational (upper) Wilcox Group lignite is fluvial. This interpretation agrees with earlier workers that both major lignite deposits in the Wilcox accumulated in hardwood swamps located between and bounded by alluvial ridges. However, Breyer (1987) argues on the basis of sedimentary texture and structures as well as palynomorphs (pollen) that the upper Wilcox Group in the East Texas Embayment and Sabine Uplift regions was deposited in an riverine estuary (embayed coastline system) susceptible to tidal influences but with fresh to slightly brackish water.

Carrizo Sand formation is composed of sometimes silty, medium- to very fine-grained, massive, locally cross-bedded, quartz channel sand deposits ranging from 20 to 150 ft (to 45 m) thick (Barnes et al., 1965; Ayers and Lewis, 1985). Locally, the Carrizo may contain a thin interbedded sandstone and claystone (Kersey, 1980) and ironstone ledges (Barnes et al., 1965).

The first progradational series overlying the Carrizo Sand consists of the Reklaw Formation and the Queen City Sand (Figure 6).[9] The contact between the Carrizo and Reklaw is gradational and marked by significant bioturbation (Kersey, 1980). The Reklaw Formation consists of a sandy basal sand layer called the Newby Sand Member, which is an average of 15 ft (Barnes et al., 1965; Kersey, 1980). Overlying the Newby Sand is the fine-grained Marquez Shale Member, which averages 100 ft (30.5 m). The Newby Sand consists of glauconitic, fine-to very fine-grained sand with interbedded clay ironstone. The Marquez Shale Member is a silty clay with carbonate and iron cement and ironstone concretions (Barnes et al., 1965). The Reklaw Formation acts as a leaky aquitards on a regional scale (Fogg et al., 1991). An unconformable contact separates the Reklaw from the overlying Queen City Sand, a mostly fine-grained, glauconitic quartz sand with local ironstone concretions and ledges. Where it has not been removed or thinned by erosion, the Queen City Sand is 100 to 400 ft (30.5 to 122 m) thick and forms a minor aquifer in the Sabine Uplift area (Barnes et al., 1965).

In the vicinity of the Oak Hill Mine on the western flank of the Sabine Uplift, the uppermost geologic units are the Wilcox Group, Carrizo Sand, Reklaw Formation, and quaternary fluviatile terrace and alluvium deposits (Barnes et al., 1965; PBW, 2008a).

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[9] A second progradational series in central Texas consists of (from oldest to youngest): the muddy Weches Formation, the fine-to-course-grained Sparta Sand, the thick, muddy Cook Mountain Formation, and the sandy, lignitic-bearing .Yegua Formation (Figure 2.4). Most of this series is not present in the Sabine Uplift region.

THE CARRIZO-WILCOX AQUIFER IN THE SABINE UPLIFT AREA OF TEXAS

The Wilcox Group hosts both produceable lignite seams and the Carrizo-Wilcox aquifer, one of nine major aquifers in Texas. The Carrizo-Wilcox aquifer extends in a wide band from Mexico through Texas and Louisiana and into Arkansas, approximately parallel to the Gulf Coast. The aquifer widens from central Texas to Louisiana to encompass the Sabine Uplift area as well as a portion of northeast Texas (Figures 2.2 and 2.2).

The aquifer consists of the Wilcox Group and the disconformably overlying Carrizo Sand formation of the Claiborne Group (Figures 2.3 and 2.4). The Carrizo-Wilcox is a heterogeneous clastic sedimentary aquifer. It is 400 to 3,600 ft (122 to 1,098 m) thick—thinnest in the outcropping areas and thickening basinward to 1,000 to 3,600 ft (305 to 1,098 m) (Kaiser et al., 1986). Within the aquifer, thick sandy layers have hydraulic conductivities as high as 66 ft/day (20 m/day). Other layers (mudstones and shales) act as aquitards with very low hydraulic conductivities (Kaiser, 1986). Most springs in the Sabin Uplift area of Texas are small (< 10 gpm or < 6.3×10^{-4} m^3/s) (ETRWPG, 2010).

In areas where laterally extensive, low permeability clay layers and/or lignite separate the Carrizo and Wilcox sands, these units may be treated as hydrogeologically distinct at the county scale. For example, the Carrizo Sand and Wilcox Group have been treated as hosts to two distinct aquifers in Nacogdoches County and parts of Rusk and Cherokee Counties (Kaiser, 1986; Sandeen, 1987). But these units host a single aquifer in parts of Leon, Anderson, Smith, and Cherokee Counties) where the finer-grained layers capping the Wilcox Group are absent--putting high permeability sand bodies of both units in direct hydraulic communication and thereby causing them to respond as one hydraulic unit (Kaiser, 1986). Where the Wilcox-Carrizo units outcrop, the potentiometric surface of the Aquifer (or of the Carrizo Aquifer where the Carrizo and Wilcox Group are hydraulically separated by one or more layers of low permeability clays and lignite seams) tend to reflect local topography (Kaiser, 1986). Topographic highs generally are significant recharge areas, especially where the surface geology is dominated by sandy textures. Topographic lows correspond to stream valleys such as the Brazos, Little Brazos, and Little Rivers, which are major discharge areas for local and intermediate flow systems.

The Carrizo-Wilcox aquifer is a primary source of drinking and irrigation water for many groundwater dependent consumers in east and central Texas.[10] In 1974, nearly 50% of the water consumed in east Texas was groundwater pumped from the Carrizo-Wilcox aquifer system (Kaiser, 1986). By 2001-2003, the proportion of water supplied by the Carrizo-Wilcox aquifer was down to 11% of total water consumed in east Texas.[11] In 2006, groundwater (including the Carrizo-Wilcox aquifer) constituted 15% of the reliable fresh water supply in east Texas and remains an important resource for municipalities and rural consumers (Schaumburg & Polk, Inc., 2006).

Oak Hill Mine, situated on the western flank of the Sabine Uplift, is within the outcrop zone of the Carrizo-Wilcox aquifer (Figures 1.2 and 2.2). Throughout most of the Mine, the Carrizo-Wilcox aquifer behaves as two distinct aquifers: a local groundwater system that recharges on topographic highs and discharges at the topographic lows of nearby steam valleys: Mill Creek, Boggy Branch, and sometimes Dry Creek (Figure 2.5) (United States, 1983; PBW, 2008b). This local flow system occurs in the Reklaw Formation, Carrizo Sand, and the uppermost portion of the Wilcox Group (Figure 2.4). Where channels sands in the Wilcox Group are in direct contact in portions of the Mine

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10 Groundwater in the Sabine Uplift region of Texas is produced primarily from the Carrizo-Wilcox Aquifer. Some wells produce from the Queen City, Sparta, and Yegua-Jackson Aquifers, but as these minor aquifers that are not present at the Oak Hill Mine, they are not discussed here. The reader is referred to George et al. (2011) for an overview to these minor aquifers.

[11] In 2001-2003, an average of 75,219 acre -ft/yr (92.781 GL/yr) of groundwater was pumped from the Carrizo-Wilcox aquifer. Total water consumed in east Texas (Region I) was 704,320 acre-ft/yr (868.776 GL/yr) in 2000 (Schaumburg & Polk, Inc., 2006; ETRWPG, 2010).

area, these sands are treated as one hydrogeologic unit (SD2), though Wilcox Group channel sands are generally less permeable than those of the Carrizo Sand (PBW, 2008b). The local flow system occurs primarily under water table (unconfined) conditions, but some flow paths experience confined or semi-confined conditions prior to discharge in areas where they are overlain by low permeability mixed (sandy clays, silty clays, etc.) layers and “dirty” sands (silty sands, clayey sands) (United States, 1983; PBW, 2008b).

Below a confining layer consisting of the target lignite seam (L4) and proximal clay layers is an intermediate-to-regional flow system. This system is confined; hydraulic heads are elevated above the confining lignite-clay aquitards. Communication with the overlying local system appears to be limited to isolated areas where the lignite seam is absent. Mill Creek and Boggy Branch, both perennial streams within the permit area (Figure 2.5), receive discharge from these longer flowpaths.

CARRIZO-WILCOX AQUIFER WATER QUALITY IN THE SABINE UPLIFT AREA OF TEXAS

The Carrizo-Wilcox aquifer as well as the Queen City and Sparta aquifers supply the Sabine Uplift area of east Texas with fresh (<1,000 mg/l total dissolved solids, or TDS) to slightly saline (1,000 – 3,000 mg/l TDS) groundwater resources. In 1980, 5.40 million gal/d (20.4 ML/d) of fresh to slightly saline water were produced from these aquifers in Rusk County, where the Oak Hill Mine is located. Of this amount, 78% was produced for public supply, 18% for mining and industrial purposes, and 4% for rural domestic uses (Sandeen, 1987).

Groundwater chemistry in the aquifer evolves from calcium-bicarbonate in recharge areas to sodium-bicarbonate along intermediate and regional flow paths (Kaiser 1986), and is consistent with overall freshening of the aquifer as old ocean water (either connate water or water that intruded during marine transgressions) is progressively

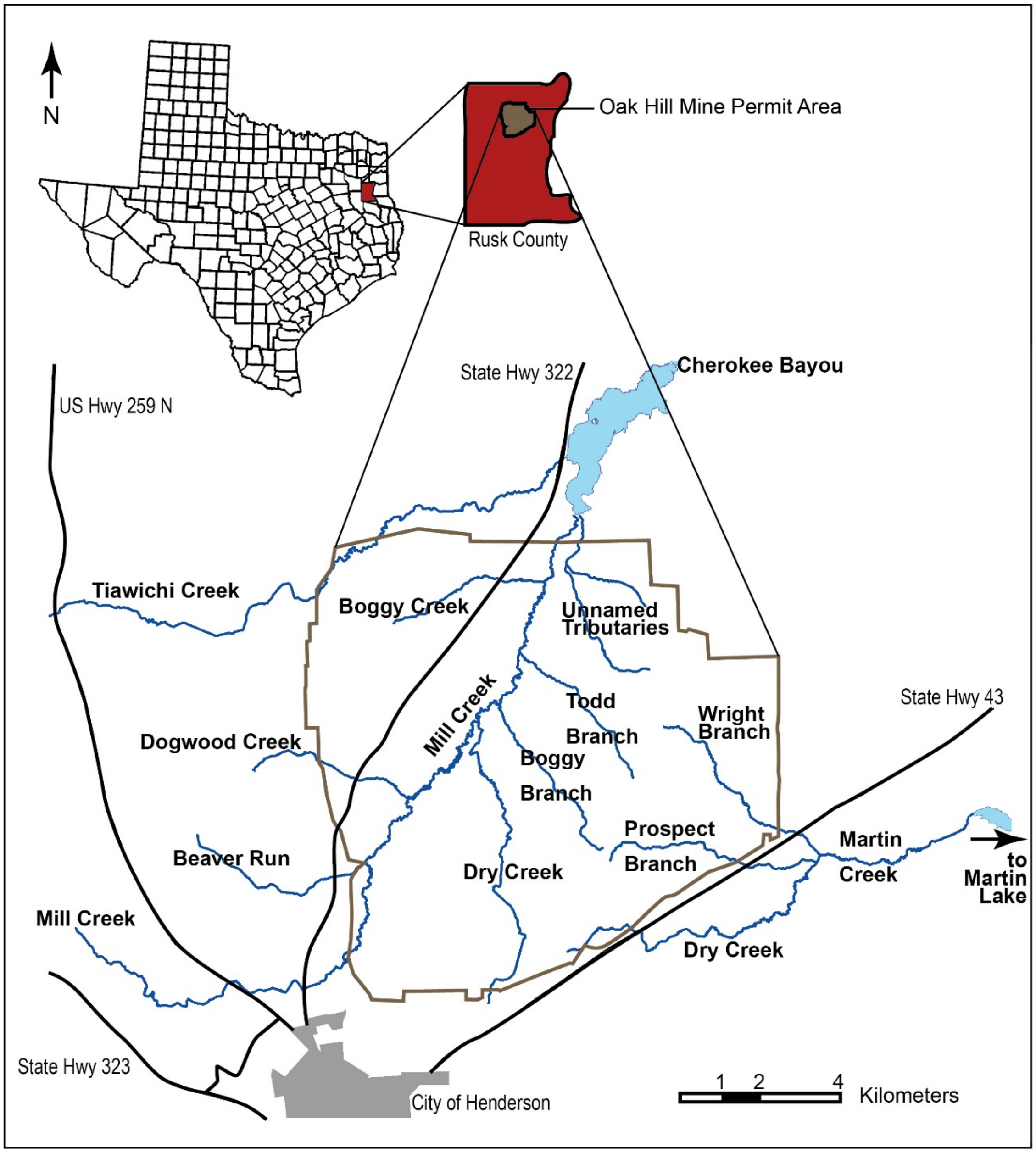

Figure 2.5: Location of pre-disturbance streams in Oak Hill Mine, Rusk County, Texas.

displaced by fresh water (Appelo and Postma, 2005). In a 1987 report, the two most common water types observed in active wells in Rusk County were Na-HCO_3 to Ca-Mg-Cl-SO_4; the former type was more common in Wilcox wells while the latter type was more common in Carrizo wells (Sandeen, 1987).

Throughout the Sabine Uplift region of Texas, groundwater quality—especially from the Carrizo-Wilcox aquifer—is good. Salinization is not a significant concern overall though concentrations of iron and manganese above secondary (aesthetic) drinking water standards are common, and sulfate and chloride contamination occur in isolated areas (ETRWPG, 2010). Also common are pH values below the 6.5 lower limit drinking water standard (ETRWPG, 2010). Indeed, previous studies have described the presence of naturally occurring low discharge, low pH surface waters where the Carrizo Sand and Wilcox Group crop out (Carson et al., 1982; Dixon et al., 1982; Shaw, 2006). A report issued by the Office of Surface Mining (OSM, 1985) noted naturally occurring soil acidifications have created soils with a pH range of 4.0 to 7.8 in east Texas.

Groundwater quality in the Sabine Uplift area of Texas is the product of a few plant-water and water-rock chemical reactions, which are briefly reviewed here.[12] For a robust discussion of these reactions, the reader is referred to Appelo and Postma (2005) and Stumm and Morgan (1995). For a practical introduction to chemistry for geologists, see Keller (1969). For a practical discussion of low pressure and temperature (low P/T) aqueous geochemistry with an emphasis on statistical analyses of water quality data, see Edmunds and Shand (2008). For a practical discussion of groundwater quality with a mining emphasis, see Chapter 3 of Clarke (1995).

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[12] The effects of anthropogenic contamination, such as nitrate pollution from fertilizer, are discussed here as they are not relevant to the Oak Hill Mine study site.

Root respiration (release of CO_2 gas) and decay of organic materials (Equation 1) increases the partial pressure of carbon dioxide in soils. As a result, additional carbon dioxide is dissolved in the soil water. Carbon dioxide then reacts with water to create carbonic acid[13] (Equation 2):

$$CH_2O_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O \qquad (1)$$

$$CO_{2(g)} + H_2O \rightarrow CO_{2(aq)} + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^- \qquad (2)$$

When limestone or calcite-bearing sediments are present, carbonate anions are produced by the congruent dissolution of calcite (Equation 3). These carbonate anions can then buffer acidic waters ($pH<7$) by bonding with 1 or 2 hydrogen protons (Equation 4):

$$CaCO_{3(s)} \rightarrow Ca^{2+}{}_{(aq)} + CO_3^{=}{}_{(aq)} \qquad (3)$$

$$CO_3^{=}{}_{(aq)} + 2H^+{}_{(aq)} \rightarrow HCO_3^-{}_{(aq)} + H^+{}_{(aq)} \rightarrow H_2CO_{3(aq)} \qquad (4)$$

However, east-central and east Texas lack the limestone formations that are present in central Texas. While calcite is present in the Wilcox Group, Carrizo Sand, and Reklaw Formation, its quantity is so limited that the role of calcite as a buffer is eclipsed by the role of silicic acid (discussed below) and CO_2-derived carbonic acid (Dutton, 1990; Holzmer, 1992).

When water pH lies within the range of 6.3 to 10.3, the dominant inorganic carbon species is bicarbonate (HCO_3^-). At $pH > 10.33$, the concentration of carbonate ($CO3^=$) is greater than that of bicarbonate (HCO_3^-), and at a $pH > 12.3$, essentially all bicarbonate has reacted to become carbonate. At pH values < 6.3, the concentration of carbonic acid (H_2CO_3) is greater than that of bicarbonate, and at a $pH < 4.3$, essentially all inorganic carbon is present as H_2CO_3. When groundwater pH is at 4.3 and below, an increase in the partial pressure of CO_2 (P_{CO2}) can cause additional CO_2 gas to dissolve into the water, and

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[13] Technically, the concentration of dissolved carbon dioxide in aqueous solution is many times great than the concentration of carbonic acid in aqueous solution (Appelo and Postma, 2005). For simplicity, however, only the small percent carbon dioxide that reacts to form carbonic acid is discussed.

this dissolved CO_2 can react with water to form carbonic acid. However, groundwater pH will not decrease as the carbonic acid will not dissociate to form (i.e. will remain as $H_2CO_{3(aq)}$ and will not dissociate into HCO_3^- and H^+). This explains why the lower pH limit of natural groundwater due to carbon production from root respiration and organic matter decay is 4.6 (Appelo and Postma, 2005).

Weathering of primary silicate rock minerals to clay minerals[14] releases metal cations and silicic acid. Examples of these reactions are albite (Na-plagioclase) weathering to kaolinite clay (Equation 5) and biotite weathering to kaolinite clay (Equation 6). These reactions play a role in counteracting groundwater acidity by consuming hydrogen protons and thereby raising pH:

$$2Na(AlSi_3)O_{8(s,\ albite)} + 2H^+_{(aq)} + 9H_2O \rightarrow Al_2Si_2O_5(OH)_{4(s,\ kaolinite)} + 2Na^+_{(aq)} + 4Si(OH)_{4(silicic\ acid,\ aq)} \tag{5}$$

$$2KMg_3(AlSi_3)O_{10}(OH)_{2(s,\ biotite)} + 14H^+_{(aq)} + H_2O \rightarrow Al_2Si_2O_5(OH)_{4(s,\ kaolinite)} + 2K^+_{(aq)} + 6Mg^{2+}_{(aq)} + 4Si(OH)_{4(silicic\ acid,\ aq)} \tag{6}$$

Clay minerals and organic material influence groundwater pH not only through the above reactions, but also as ion exchange sites. Both materials have a large specific surface area and therefore a disproportionately large number of ion exchange sites for their size (Appelo and Postma, 2005). Soil acidification occurs when hydrogen protons displace other cations on exchange sites. The number of hydrogen protons sorbed for each metal cation released depends upon the charge of the metal cation (Equations 7 – 8). This process buffers groundwater pH by reducing the concentration of hydrogen protons (increasing pH), but it also increases the salinity (TDS) of the water:

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[14] Weathering rates in warm, humid climates like Texas are largely controlled by rate of groundwater flow rates, which in turn are controlled by rainfall, irrigation, infiltration, soil permeability, and the groundwater gradient. As weathering rates increase, minerals are leached of silica and soluble cations (Appelo and Postma, 2005). For example, gibbsite ($Al(OH)_3$) is more weathered than kaolinite ($AlSi_2O_5(OH)_4$), which is more weathered than montmorillonite ($Na_{0.5}(Al_{1.5}M_{g0.5})Si_4O_{10}(OH)_2$).

$H^+ + Na\text{-}X \rightarrow Na^+ + H\text{-}X$ (7)

$2H^+ + Ca\text{-}X_2 \rightarrow Ca^{2+} + 2H\text{-}X$ (8)

Metal cations can contribute to groundwater acidity by splitting a water molecule (hydrolysis) and bonding with the hydroxide base (OH^-). The liberated hydrogen proton contributes to a decrease in water pH (Equations 9 and 10):

$Al^{3+}_{(aq)} + 3H_2O \rightarrow Al(OH)_3 + 3H^+_{(aq)}$ (9)

$Mn^{2+}_{(aq)} + 1/4O_2 + 3/2H_2O \rightarrow MnOOH + 2H^+_{(aq)}$ (10)

Finally, groundwater pH is strongly influenced by the oxidative dissolution of pyrite (FeS_2), a mineral commonly found in lignite seams and in associated sediments. The dissolution of pyrite produces higher dissolved iron and sulfate concentrations, insoluble ferrous iron minerals such as goethite (FeOOH) and jarosite ($KFe_3(SO_4)_2(OH)_6$), and lower pH. This reaction is discussed in more detail below in section "Chemical Effects of Surface Lignite Mining on Groundwater Quality in Texas." Previous research has explored the acid-producing potential of the lignite seams in the Wilcox Group and associated overburden due to the presence of pyrite (Dixon et al., 1982; Arora et al., 1984).

CHARACTERISTICS OF TEXAS LIGNITE

Lignite is defined by Wielchowsky et al. (1977) as "a soft, porous, friable, low-rank, brownish-black coal that is intermediate in coalification between peat and subbituminous coal and has a heating value of less than 8300 Btu/lb on a moist, mineral-matter-free basis." Coal grade, or rank, is primarily a function of fixed carbon content (as a weight percent) and calorific value (Schweinfurth, 2009). In order of lowest to highest values, the coal grades are: lignite, subbitumunious coal, bituminous coal, and anthracite.[15]

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[15] By definition, coal must have less than a 50% ash content by weight. Peat is not a type of coal because the ash content of peat is too high. Peat has a lower fixed carbon content and calorific value than lignite, which is the lowest grade coal.

Lignite, or “brown coal”, has undergone the least amount of coalification; it has been subjected to lower pressures and temperatures during burial and diagensis compared to higher grades of coal. As a result, lignite has the highest amount of moisture and oxygen and least amount of fixed carbon of the four grades of coal. It can ignite at lower temperatures than the other grades of coal. In fact, whereas anthracite must be heated to 925 ^{o}F (496 ^{o}C) before it can ignite, mined lignite can spontaneously combust under certain conditions. The unstable nature of lignite and its low calorific value make long distance transport both difficult and uneconomic. Freight costs are reduced by transporting lignite from multiple mines to a nearby, centrally-located “mine-mouth” power plant (Fisher, 1963; Schweinfurth, 2009). Martin Lake Power Plant is one such plant (Figure 1).

Within a given grade of coal, quality is variable and is inversely related to percent moisture, ash (noncombustible material), and percent sulfur. These characteristics are determined by the depositional environment during accumulation of the original organic materials (peat), early coalification (diagenetic) processes, and sometimes during post-coalification (epigenetic) alteration (Tewalt, 1987). Across coal grades, ash content varies from 3 to 49% by weight. Percent ash content is positively correlated with proximity to an active sedimentation source during deposition (Tewalt, 1987). A high ash content is undesirable in lignite as ash disposal is costly, and ash content is inversely related to heat values (Tewalt, 1986).

In addition to percent moisture and ash content, coal grade quality is also a function of sulfur content. Across coal grades, sulfur content can vary from less than 1% to greater than 3% by weight. High sulfur content in coal is undesirable because sulfides will react to form environmentally harmful compounds that must be filtered out of power plant emissions (Schweinfurth, 2009) Sulfur content in coal is related to the presence of brackish water during deposition or early-diagenesis (Tewalt, 1987). Specifically, sulfur is incorporated into coal deposits when it interacts with ocean water, which has a much higher sulfate ($SO_4^=$) concentration than fresh water.[16] When diluted ocean water (brackish water) enters an oxygen-poor environment such as a peat bogs or swamps, sulfur-fixing microbes and sulfate-reducing microbes reduce the sulfate to organic sulfur and sulfide compounds, respectively. These reduced forms of sulfur are then incorporated into the accumulating organic materials (peat) in the form of pyrite (FeS_2) and other sulfide minerals such as marcasite (FeS_2), chalcopyrite ($CuFeS_2$), galena (PbS), and sphalerite (ZnS). Within this general setting, the type of local depositional environment (e.g., poorly drained freshwater swamp, swamp crevasse splay, lacustrine) can affect the deposition rate and the distribution of sulfur species (Lentz, 1975).

At a Luminant mine[17] near Oak Hill Mine in the Sabine Uplift area, the major inorganic coal minerals are quartz, kaolinite, and pyrite. Minor minerals consist of mixed clays and trace minerals consist of gypsum, rutile, and calcite (Benson, 1987). See Table 2.1 for the chemical formulas for these minerals.

Wilcox lignite north of the Colorado River (central and east-central Texas) is of better quality than lignite to the south (Kaiser, 1978a). And lignite in the Sabine Uplift is generally of even better quality with the highest carbon content (74.3% versus 71.3% on a dry, ash-free basis) and heat values (Kaiser, 1986). They also tend to have the lowest sulfur and ash composition (Fisher, 1963; Kaiser, 1986). Concentrations of selenium, arsenic, and uranium (all toxic metals) are present in trace metal concentrations in Sabine Uplift lignite, with an average of 10.2, 3.4, and <1 ppm, respectively (Kaiser, 1986). Total sulfur

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[16] Ocean water has an average of 885 mg/L of sulfate ($S0_4^=$) (Field, 1972), whereas fresh water sulfate concentrations above 250 mg/L are notable for their foul smell and distinctive taste.

[17] Benson (1987) refers to the study site as the “Mine Lake Mine,” which could actually refer to any one of three mines (Oak Hill, Beckville, and Tatum Mines) that currently supply lignite to Martin Lake Power Plant. All three mines are on the western flank of the Sabine Uplift and are in similar geologic settings.

in Texas lignite ranges from 1.3-1.5%, with most (75%) present as organic sulfur (Kaiser, 1986).

Major Minerals	Minor Minerals	Trace Minerals
Quartz, SiO_2	Mixed clays, e.g. montmorillonite, illite, chlorite, respectively: $(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot nH_2O$ $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ $(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2 \cdot (Mg,Fe)_3(OH)_6$	Gypsum, $CaSO_4 \cdot 2H_2O$
Kaolinite, $Al_2Si_2O_5(OH)_4$		Rutile, TiO_2
Pyrite, FeS_2		Calcite, $CaCO_3$

Table 2.1: Major, minor, and trace inorganic minerals in coal at a Luminant mine near Oak Hill Mine.

Most near-surface lignite – including lignite from Oak Hill Mine – is produced from the Wilcox Group due to its greater abundance and quality than lignite from the Jackson Group (Kaiser, 1986). In 1985, 88% of lignite was produced from this Group, and the remaining fraction was produced for the younger Jackson Group (Ayers and Kaiser, 1987). Producable shallow lignite seams in the Texas Wilcox Group are usually 3-10 ft (0.9- 3 m) thick (Espey, Huston and Associates, 1983; Kaiser, 1976b), though Wilcox Group lignite seams can be as thick as 22 ft (6.7 m). In order for surface mining to be economic in Texas, minimum lignite seam thickness is 3 ft (0.9 m) and overburden cover cannot be more than 150 ft (46 m) thick in general (Kaiser, 1978a). However, in east Texas, lignite less than 15 ft (4.5 m) below ground surface is usually of very poor quality due to chemical weathering processes (viz. oxidation) (Kaiser, 1978a).[18]

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[18] In south Texas, , lignite less than 25 ft (7.6 m) below ground surface is usually of too weathered to be suitable for energy production (Kaiser 1978a).

LIGNITE PRODUCTION IN TEXAS

Some of the earliest documented lignite production in Texas occurred in the form of first generation underground mines ("shaft and slope" mines) around 1850. Early lignite production peaked in the mid-1920's at 1.3 million metric tons of lignite per year (Fisher, 1963; Kaiser, 1978a; Ayers and Kaiser, 1987). For example, the underground Evansville Mine in Leon County, east Texas opened in 1907 operated sporadically with demand-driven production rates (Palmquist, 1987). Early lignite production supplied fuel for steam generation in stationary boilers (e.g., at cotton gins) and steam-driven power plants (Ayers and Kaiser, 1987). After this production peak, the start of the Great Depression, the rise of oil and gas production, and the development of the internal combustion engine all combined to subsequently depress the demand for lignite. By 1950, lignite production in Texas had fallen to 18.1 thousand metric tons (Table 2.2). In order to take advantage of economies of scale and keep lignite production profitable, lignite mining techniques shifted from underground to surface (strip) mining methods (Fisher, 1963; Kaiser, 1978a).

Year	**Annual lignite production in Texas (million short tons)**	**Source**
1913 & 1918	1.1 (early production peak)	Kaiser 1978a
1915-1930	0.9 (annual average)	Kaiser 1978a
1940	0.5	Kaiser 1978a
1950	0.16 (production low)	Kaiser 1978a
1976	12.7	Kaiser 1978a
2003	43.7	RRC 2013
2011	41.4	RRC 2013

Table 2.2: Annual lignite production (in million metric tons) in Texas.

Surface mining of shallow lignite deposits allows companies to exploit economies of scale and also enables greater total lignite recovery.[19] The application of surface mining technology to lignite mining in Texas beginning in the mid-twentieth century resulted in a resurgence of lignite production in the state. The Aluminum Company of America (ALCOA) opened the first major "mine-mouth" surface lignite mine in Texas, the Sandow Mine in Milam County in central Texas, which began surface mining operations in 1954 (Ayers, 1987; Ayers and Kaiser, 1987). Additional large scale surface mines began production two decades later and continued to grow in the 1980's as a result of increasing demand for electricity coupled with increasing prices of oil and gas fuels (Ayers, 1987). With the exception of Darco Mine (which produces lignite for activated charcoal), all modern surface mines in Texas produce lignite for electricity generation at mine-mouth electric power plants (Ayers and Kaiser, 1987). In 1985, mines produced 40.8 million metric tons of lignite that was burned in nine power plants to generate 20% of the state's electricity (Palmquist, 1987) (Tables 2.2 and 2.3).

Year	**% Annual Electrical Generating Capacity from Lignite**	**Source**
1971	1%	Kaiser, 1978a
1978	8%	Kaiser, 1978a
1981	About 20%*	Espey, Huston and Associates, 1983
1985	20%	Palmquist, 1987
2000	About 45%	Gentry, personal communication, 2000

*****includes energy produced from subbituminous coal transported to Texas power plants

Table 2.3: Percent of total annual electrical generating capacity in Texas contributed by lignite production.

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[19] Total lignite recovery is 75% or more for surface mining versus 50% recovery for underground mining Fisher 1963).

Mining production began at Oak Hill Mine in 1985, though initial geologic exploration, test pit studies, and groundwater baseline studies were completed in the preceding years. Lignite mined to a depth of 150 feet (46 m) and transported 11.5 miles (18.5 km) from the mine by rail to the Martin Lake Power Plant, where it is burned for generation of electricity (United States, 1983). Mining occurs by electric dragline. Reclamation activities begin almost immediately (within a few months) after lignite has been removed spoil emplaced. . Initial reclamation activities include smoothing, grading, and re-contouring the spoil piles. Oxidized overburden sediments are then placed on the spoil. The initial method for overburden handling was top soil replacement, which consisted of removal and haul back of the top 4 ft (1.2 m) of soil and a mixing of the rest of the overburden. This method was later replaced by oxidized material (red dirt) haul back, which consists of removal of the top 8 to 16 ft (2.4 to 4.9 m) of oxidized material. After lignite is mined and spoil is graded, the “red dirt” is hauled back to create an 8 ft (2.4 m) layer at the surface. The goal of both methods is two-fold: (1) to sufficiently bury acid-forming materials (pyrite-bearing, reduced sediments) so as to control of rate of acid-formation in post-disturbance areas, and (2) to place sediments on the surface with characteristics that are at least as favorable to plant growth as the pre-disturbance soil. To further the attainment of this latter goal, lime is incorporated into the uppermost several inches of reclaimed sediments. Sediments are treated with fertilizer, and fast-growing seasonal grasses are planted to control erosion. Trees are subsequently planted in accordance with the specific reclamation designed by Luminant and the RRC for that region.

Due to the presence of acidic (pH <6.0) groundwater in baseline studies and concerns about the potential for low pH and high iron and manganese concentrations in surface water discharge, the United States Environmental Protection Agency (EPA) classifies the Oak Hill Mine as an “acid ferruginous” mine and surface water discharge as is regulated as to acid mine drainage (Unites States, 1983). Acid mine drainage (AMD) discharge regulations require mine effluent to have a pH between 6.0 and 9.0 standard units.

For information about mining operations, power plant designs, and emission standards, the reader is referred to Fisher (1963), Kaiser (1978a), and Espey, Huston and Associates (1983). Information about reclamation practices at Texas mines can be found in Espey, Huston and Associates (1983), Office of Surface Mining (1985), Clarke (1995). Additional information about regulating bodies and relevant legislation is available in Hirsch (1977) and Espey, Huston and Associates (1983).

PHYSICAL EFFECTS OF SURFACE LIGNITE MINING ON GROUNDWATER QUANTITY IN TEXAS

Surface mining of lignite changes the stratigraphy and the hydrogeologic properties of the sediments within the mine and has the potential to affect a larger region where mining disturbance creates a significant effect on groundwater quality or quantity discharge. In the short-term, aquifer dewatering can change hydraulic gradient and groundwater flow paths (Holzmer, 1992; Sukhija et al., 1996). In the long-term, reclaimed land acquires a new infiltration capacity distribution (HSW, 1990; HSW, 1991; PBW, 2008c). Jarocki (1994) found that mean infiltration rates were lower than unmined soils by 38-58%, with variability in infiltration rates explained as a function of soil moisture content rather than soil texture. Spoil has different horizontal and vertical hydraulic conductivities (permeabilities) compared to the pre-disturbance overburden (HSW, 1990; HSW, 1991; PBW, 2008c). Saturated hydraulic conductivity of spoil tends to decrease with depth due to compaction (Hewitt, 1990; Holzmer, 1992) except in areas where spoil has a high (>75%) sand content 9 (Kennedy and Pepper, 1980; Hewitt, 1990). Spoil mounds retain new preferential flow paths even after re-grading (Hangen et al., 2005). Hewitt (1990) observed that actual spoil mound resaturation rates greatly exceeded previously estimated infiltration rates (Dutton, 1986; French, 1979) at a lignite mine in central Texas. French (1979) and Hewitt (1990) assert that initial spoil mound resaturation at Big Brown Mine in central Texas occurs as a combination of lateral recharge from adjacent, saturated materials and vertical recharge from rainfall. Hewitt (1990) found that 9 year old spoil mound appeared to have established a water table equilibrium that would approximately re-establish premine flow directions, and Jarocki (1994) was subsequently unable to detect evidence of lateral recharge of saturated spoil by adjacent material.

CHEMICAL EFFECTS OF SURFACE LIGNITE MINING ON GROUNDWATER QUALITY IN TEXAS

The process of removing the overburden to mine economic lignite seams can negatively impact water quality. The presence of bare or sparsely vegetated soils increases erosion rates in the immediate vicinity of the active mine pit, which can result in an increase in total suspended solids (TSS). Due to the heterogeneous and semi-inverted nature of spoil, some poorly weathered sediments—which are more reactive than the well-weathered soils at the surface prior to mining—are placed near the ground surface and react with infiltrating fresh rainwater. The result is an initial increase mineral dissolution and total dissolved solids (TDS) (e.g., Woessner et al., 1979; Holzmer, 1992), and advection from spoil to downgradient overburden sediments results in initial increases in sulfate and TDS undisturbed material (Cagle, 2007). But where mining significantly increases the permeability and rate of flushing in spoil as at the Big Brown Mine in east-central Texas, groundwater TDS may decrease with time after mining (Dutton, 1982).

Furthermore, if these poorly weathered sediments were in an oxygen-poor, reducing environment prior to disturbance, then the exposure to oxygenated rainwater induces a rapid change in the reducing-oxidizing (redox) environment. Materials that were stable in a reducing environment become unstable and reactive in an oxidizing environment. In these changed conditions, organic material such as lignite decays and reduced minerals undergo oxidative dissolution. Reduced-iron sulfides such as pyrite (FeS_2) are common in lignite seams, and are often observed in associated clay and mixed sediment layers (Clarke, 1995). Because the oxidative dissolution of pyrite is a common cause of AMD, it is appropriate to discuss this reaction in some detail.

The oxidative dissolution of reduced-iron sulfides is the primary acid-generating process in acid mine drainage (Singer and Stumm, 1970). The rate and mechanisms of this reaction sequence depend on pH, oxygen availability, and the presence or absence of catalysts. The "initiator reaction" (Equation 11 is slow and consists of the simple dissociation of pyrite in an oxygenated aqueous solution:

$$\mathrm{FeS_{2(s)} + 7/2\ O_{2(aq)} + H_2O \rightarrow Fe^{2+}_{(aq)} + 2SO_4{}^{2-}{}_{(aq)} + 2H^+} \qquad (11)$$

Once aqueous ferrous (Fe(II), Fe^{2+}) cations are present and assuming that oxygen is available as a reactant, the oxidative dissolution of pyrite proceeds in a two-step process in which oxygen first oxidizes ferrous iron to ferric iron (Fe(III), Fe^{3+}) (Equation 12, note ferric iron is the product in bold). Ferric iron then oxidizes pyrite (Equation 13, note ferric iron is the reactant in bold), and the Fe(III) cation is itself reduced to ferrous iron.[20]

$$\mathrm{Fe^{2+}_{(aq)} + 1/4O_{2(aq)} + H^+ \rightarrow \mathbf{Fe^{3+}_{(aq)}} + 1/2H_2O} \qquad (12)$$

$$\mathrm{FeS_{2(s)} + \mathbf{14Fe^{3+}_{(aq)}} + 8H_2O \rightarrow 15Fe^{2+}_{(aq)} + 2SO_4{}^{2-}{}_{(aq)} + 16H^+_{(aq)}} \qquad (13)$$

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[20] If ferric iron hydrolyzes water instead of oxidizing pyrite, it precipitates as an Fe(III) oxide or hydroxide and pH decreases either by the release of hydrogen protons or the consumption of hydroxide. For example, the precipitation of ferrihydrite releases three hydrogen protons for every ferric cation consumed

$$\mathrm{Fe^{3+}(aq) + 3H_2O \rightarrow Fe(OH)_3(s) + 3H^+(aq)}$$

whereas the precipitation of goethite consumes three hydroxide anions for every ferric cation consumed

$$\mathrm{Fe^{3+}(aq) + 3OH^-(aq) \rightarrow}$$

It is important to note in Equation 13 that ferric iron—not oxygen—is the oxidizing agent that is directly responsible for the oxidative dissolution of pyrite. The presence of oxygen promotes dissolution of pyrite by oxidizing ferrous iron, thereby transforming Fe(II) cations into Fe(III) cations (Equation 12) and renewing the supply of the pyrite-oxidizing agent. Once the propagation cycle (Equations 12 and 13) has been initiated, the rate of the cycle is determined by the rate of Equation 12, the rate-limiting step in sterile (abiotic) environments. The subsequent oxidation of pyrite as described in Equation 13—producing ferrous (Fe^{2+}) iron and acidity—is rapid in comparison. Furthermore, the rate of Fe(II) oxidation (Equation 12) is strongly pH-dependent for abiotic systems.[21]

However, the catalytic action of microbes in natural systems, including surface lignite mines, increase the overall rate of the oxidative dissolution of pyrite compared to abiotic settings by increasing the speed of the rate-limiting step: the oxidation of Fe(II) to Fe(III). In one series of lab experiments comparing sterilized and unsterilized acid mine drainage, Singer and Stumm (1970) found that microorganisms increase the rate of this reaction by a factor of more than 10^6. Numerous microorganisms are capable of mediating the oxidation of Fe(II) to Fe(III), the best studied of which are *Acidithiobacillus ferrooxidans* (formerly *Thiobacillus ferrooxidans*) and *Leptospirillum ferrooxidans* (Konhauser, 2007). Both of these bacteria, as well as *Acidithiobacillus thiooxidans*, are also capable of attaching directly to an exposed pyrite surface. *A. ferrooxidans* can oxidize both Fe(II) and $S^{=}$, whereas *L. ferrooxidans* is limited to Fe(II) oxidation and *A. thiooxidans* is limited to sulfide oxidation. Microbial mediation is believed to be responsible for most pyrite dissolution in natural systems (Edwards, et al. 2000; Konhauser, 2007).

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[21] At pH>4.5, the reaction rate is a exponentially related to pH; 3.5<pH<4.5 is a transitional range where pH still has some control on the reaction rate, and at pH <3.5, the reaction proceeds at a rate that is independent of pH (Singer and Stumm, 1970).

But while microbial mediation can increase the kinetic rate at which pyrite (and other reduced minerals) are oxidized, the thermodynamic equilibrium must already favor the dissolution of pyrite. If mining activity alters the environment from reducing to oxidizing, pyrite dissolution becomes thermodynamically favored. Microbial activity merely speeds up these reactions. As a result of these reactions, groundwater and surface water systems are at risk of contamination by low pH and high TDS “acid mine drainage” wherever the oxidation of iron-sulfides is significant (Woessner et al., 1979; Venburg, 1983; Holzmer, 1992; Samborska and Halas, 2010). An inverse correlation between pH and sulfate (low pH and high sulfate) was observed at the Monticello lignite mine in northeast Texas (Cagle, 2007).

Chapter 3: Description and Characterization of Historical Data Set

Two Oak Hill Mine groundwater quality data sets are analyzed in this study: the historical data set and the 2013 data set. Because of significant differences in sampling method and data quality assurance, these data sets are presented and analyzed as two distinct data sets. The smaller data set consists of data collected by this researcher in 2013 during three sampling trips, and is described in Chapter 4. Comparisons between the two data sets are presented in Chapters 4 and 5. The larger, historical data set consists of data collected at Oak Hill Mine by Luminant employees and contractors and is described below.

FREQUENCY OF SAMPLING EVENTS

Groundwater data were collected by Luminant at the Oak Hill Mine both to fulfill groundwater quality monitoring requirements from the Railroad Commission of Texas (RRC) and to provide Luminant personnel with a better understanding of the local groundwater system. Some wells were installed in undisturbed areas for initial baseline groundwater characterization studies. These wells are typically sampled on a quarterly basis for two years. After the baseline survey is complete, some of these wells continued to be sampled on a quarterly basis as part of the long-term monitoring program. Other wells became inactive, but were available for future sampling. The remaining wells were destroyed by mining activities.

In addition to baselines studies, Luminant conducts a long-term groundwater monitoring (LTGM) program that samples wells (and occasionally springs/seeps) on a quarterly basis. Sampling locations are selected for one of several reasons: to gather additional information on undisturbed (pre-disturbance) groundwater quality; to monitor groundwater quality down gradient of mined areas; or to assess groundwater quality in spoil and “disturbed underburden” after mining.[22] Once a location is selected, a monitoring well is installed (see “Well Construction” below). Occasionally, a monitoring well already exists at a location, as when a baseline well is later enrolled into the LTGM program. These wells are purged of at least three well volumes on one or more occasions prior to the quarterly sampling event to ensure that well water is representative of the immediate area.

Long-term groundwater monitoring wells were removed from the quarterly sampling program when they are destroyed by mining activities or when the purpose for their inclusion in the program was satisfied. If a well is de-enrolled from the LTGM program but not destroyed, it remains available for intermittent sampling or for later re-enrollment in the LTGM program.

WELL CATEGORIES

Samples in both the historical data set and the 2013 data set are categorized according to the relative depth and relative age of the target interval. The “relative depth” category indicates whether the well is screened at a depth above the main L4 lignite seam (overburden wells) or at a depth below the seam (underburden wells).[23] The “relative age” category indicates whether the immediate area was pre- or post-surface mining. Wells that are screened in an unmined area and are not down gradient of a mined area are “pre-disturbance” wells. Wells that are screened in an unmined area but are known to be downgradient of a mined area are separated from other pre-disturbance wells into a category designated “downgradient” wells as they may be sampling a mixture of both pre-disturbance and reclamation waters. Wells screened in a mined area are “reclamation” wells. These categories are summarized in Table 3.1. Figures 3.1 and 3.2 illustrate these

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[22] Spoil wells are referred to as “reclamation overburden” wells. Wells installed in underburden overlain by spoil (disturbed underburden) are referred to as “reclamation underburden” wells. Well categories are discussed in greater detail in the “Well Categories” section.

[23] For the 2013 data set, all seeps are “overburden” water.

well categories in the context of a conceptual model of the local (overburden) and intermediate (shallow underburden) groundwater flow systems at Oak Hill Mine.

Whenever possible, wells and samples are also categorized by the geologic formation in which the well is screened. This information was gleaned from permits which sometimes name the geologic formation in which the well is screened (as deduced from well logs). Some wells were located on or near to hydrogeologic cross sections and the geology were determined by studying these maps in conjunction with information about the depth and length of the screen interval.

WELL CONSTRUCTION

Groundwater monitoring wells were installed in a similar manner for all pre-disturbance (baseline and pre-disturbance LTGM program) wells. An initial pilot hole was drilled and logged using geophysical methods. Monitoring wells casing consists of 2-inch or 4-inch inner diameter Schedule 40 PVC casing. Slotted casing was installed at the desired sampling depth (usually along a sand-rich interval near the bottom of the borehole) and non-slotted casing was installed at all other depths. The annular space around the slotted casing is packed with frac sand. Bentonite clay was used for the upper seal (and lower seal where necessary). The rest of the annular space was filled with a mixture of Portland cement and high-yielding bentonite grout, which was then overlain by a surface seal consisting of cement and 4 foot by 4 foot concrete pad. Figure 3.3 depicts the typical construction of a pre-disturbance groundwater monitoring well. Reclamation well construction is similar but with a longer slotted casing interval and a

Relative Depth	Abbreviation	Relative Age	Abbreviation
Overburden	O	Pre-disturbance	P
Underburden	U	Downgradient (possible mixing of P and R)	G
		Reclamation	R

Table 3.1: Summary of relative depth and age categories for water samples.

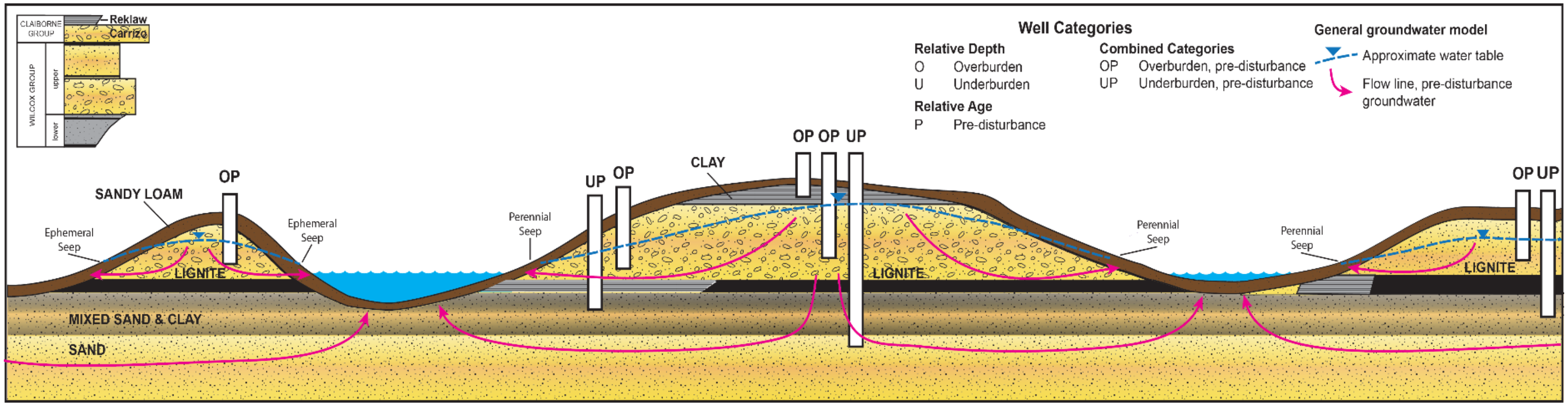


Figure 3.1: Conceptual model of the shallow groundwater system at Oak Hill Mine prior to surface mining. Note the location overburden seeps (labeled) and overburden and underburden pre-disturbance (OP, UP) wells. Pink flow lines are for pre-disturbance groundwater. Yellow layers are unmined sandy sediments. Gray layers are unmined clayey sediments.

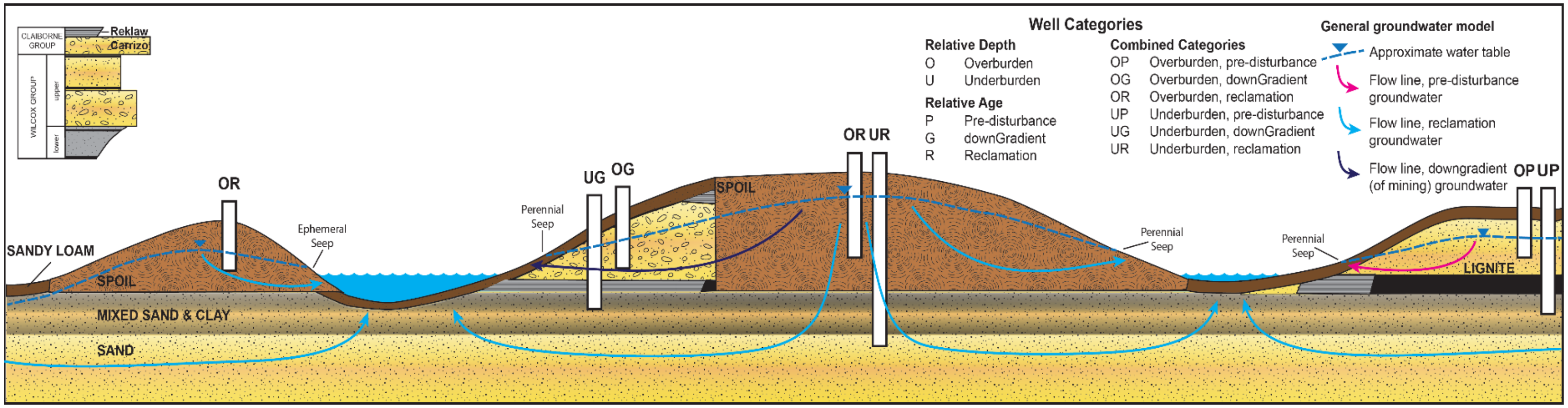
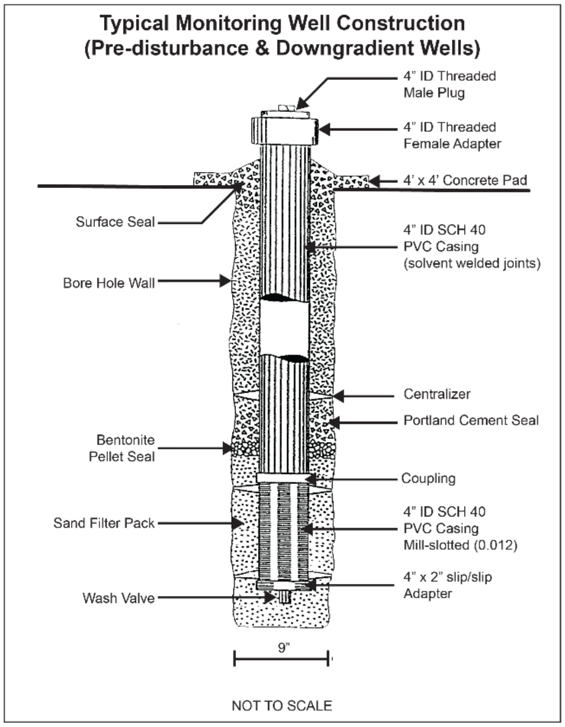


Figure 3.2: Conceptual model of the shallow groundwater system at Oak Hill Mine after surface mining. Note the location of overburden seeps (labeled), overburden and underburden pre-disturbance (OP, UP) wells, overburden and underburden reclamation (OR, UR) wells, and overburden and underburden downgradient (OG, UG) wells. Pink flow lines are for pre-disturbance (P) groundwater, purple for downgradient (G) groundwater, and blue for reclamation (R) groundwater. Yellow layers are unmined sandy sediments. Gray layers are unmined clayey sediments. Brown layers are mined areas — either being mined or mined and reclaimed.



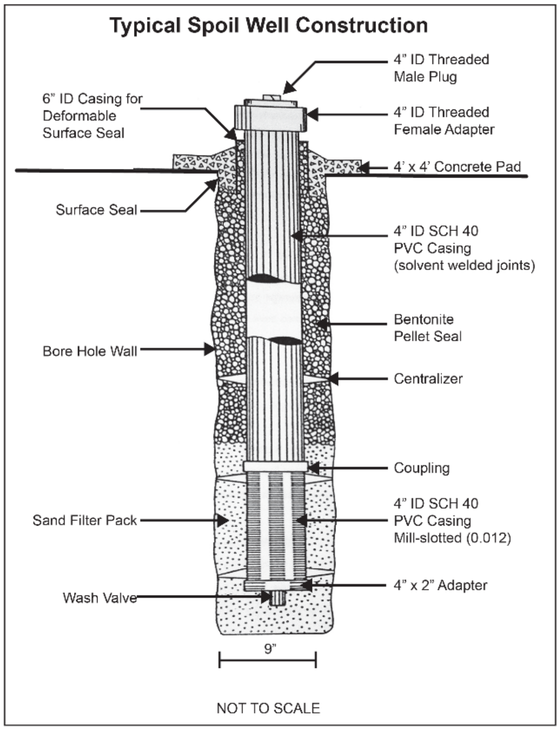


Figure 3.3: (left) Typical construction of groundwater monitoring wells for overburden pre-disturbance (OP), overburden downgradient (OG), underburden pre-disturbance (UP), underburden downgradient (UG), and underburden reclamation (UR) wells. From PBW (2008b).

Figure 3.4: (right) Typical construction of groundwater monitoring wells for overburden reclamation (OR, or spoil) wells. From PBW (2008b).

deformable surface seal (Figure 3.4). Additional details about well construction are summarized in Permit 46C, §.128 (PBW, 2008b).

SAMPLING PROCEDURE

The following description of well sampling protocol synthesizes descriptions of sampling procedures described in the Oak Hill Mine permit applications and renewals as well as this researcher's observations of two quarterly sampling events. Sampling begins by measuring the depth-to-water (DTW) from the top of the well casing (TOC). Using this information, as well as the total well depth and well diameter, the volume of water in in the well is calculated. For 4” diameter monitoring wells, a submersible pump is used to purge the well. From the pumping rate and volume of water in the well, the length of time needed to purge 3 well volumes is calculated. For 2” diameter monitoring wells, 3 well volumes is purged using hand bailers. For all wells, if the well runs dry before 3 well volumes can be purged, then the well is re-visited and sampled within 72 hours. If there is not enough water in the well to use the submersible pump (4” diameter wells) or a bailer (2” diameter wells), then the well is considered “dry.”

After the requisite amount of water is purged, samples are collected in 32 oz. plastic cubitainers from water that is first collected in a pail or bucket. Cubitainers are collapsible plastic containers with walls that are flexible like a bag but thicker and more durable. Headspace is not eliminated from the cubitainers. Once collected, samples are cooled in an ice chest until they are transported to the Oak Hill Mine environmental office and lab building, where they are refrigerated until on-site parameters (pH, EC) are measured. Water samples are then prepared and preserved for additional, off-site analyses by an external laboratory.

ANALYTIC PROCEDURES

Water temperature is measured in the field by placing an analog thermometer in a pail or bucket used to collect purged well water. Temperature is measured during the purging process, though water temperature initially falls as water is purged from the well. The pH parameter is measured using EPA Method 150.1 at the environmental office and lab building on the same day as sample collection, typically within 2-5 hours of the time when samples were collected. Water samples are then prepared and preserved for additional, off-site analyses by an external laboratory. Samples are filtered using a 0.45 micron filter and divided into two clean plastic bottles supplied by the lab. Samples for

Parameter*	Method	EPA Method**
Calcium	0.45 micron filtration followed by AA	215.1
Magnesium	0.45 micron filtration followed by AA	242.1
Sodium	0.45 micron filtration followed by AA	273.1
Potassium	0.45 micron filtration followed by AA	258.1
Aluminum	0.45 micron filtration followed by AA	202.1
Cadmium	0.45 micron filtration followed by AA	213.1
Copper	0.45 micron filtration followed by AA	220.1
Iron	0.45 micron filtration followed by AA	236.1
Iron, total	Digestion followed by AA	236.1
Manganese	0.45 micron filtration followed by AA	243.1
Manganese, total	Digestion followed by AA	243.1
Mercury, total	Manual cold vapor AA	245.1
Molybdenum	0.45 micron filtration followed by AA	246.1
Nickel	0.45 micron filtration followed by AA	249.1
Selenium	0.45 micron filtration followed by AA	270.3
Zinc	0.45 micron filtration followed by AA	289.1
Alkalinity (bicarbonate)	Electrometric titration	310.1
Chloride	0.45 micron filtration – titration	325.3
Sulfate	0.45 micron filtration – turbidimetric	375.4
TDS	Gravimetric	160.2
pH	Electrometric	150.1
Conductivity	Wheatstone bridge conductimetry (conductance)	120.1
Arsenic, total	Digestion followed by hydride AA	206.3
Chromium, total	Digestion followed by AA	218.1
Lead, total	Digestion followed by AA	239.1
Nitrate – nitrogen	Cadmium reduction colorimetric	353.3
Fluoride	Ion electrode (potentiometric)	340.2
*Parameter is dissolved unless otherwise denoted **“Methods for Chemical Analyses of Water and Wastes, USEPA, EPA-600/4-79-020, March 1979.”		

Table 3.2: Analytic Methods for individual chemical parameters as identified in the Permit 22 original application (TXU Corp., 1984) and Permit 22 renewal (HSW, 1990).

cation analysis are acidified with nitric acid to a pH of 2 to keep cations in solution. Samples are chilled to 4^{o}C in a refrigerator and then transported on ice overnight to the external laboratory, where samples are analyzed according to the current EPA Methods for Chemical Analysis of Water and Wastes (Table 3.2).

For most analyses performed by an external laboratory only a select number of inorganic analytes are measured (Table 3.3). Partial analyses typically include total dissolved solids (TDS) and dissolved chloride, sulfate, iron, and manganese. Additional metal cations associated with acid mine drainage are measured on an annual basis in reclamation overburden (spoil) wells. Several of the common inorganic ions (such as

Dissolved Analyte Measurement Frequency for Long Term Monitoring Wells (Permit 46C)		
Quarterly	Annual (overburden reclamation wells only)	Once (new/replacement wells only)
Chloride (Cl)	Aluminum (Al)	Bicarbonate (HCO_3)
Electrical Conductivity (EC)*	Arsenic (As)	Calcium (Ca)
Iron (Fe)	Boron (B)	Carbonate (CO_3)
Manganese (Mn)	Cadmium (Cd)	Magnesium (Mg)
pH*	Chromium (Cr)	Nitrate-Nitrogen (NO_3-N)
Sulfate (SO_4)	Copper (Cu)	Potassium (K)
Temperature*	Lead (Pb)	Sodium (Na)
Total dissolved solids (TDS)	Mercury (Hg)	
	Molybdenum (Mo)	
	Nickel (Ni)	
	Selenium (Se)	
	Zinc (Zn)	
*On-site parameters measured at Oak Hill Mine		

Table 3.3: Dissolved analyte measurement frequency for long term monitoring wells as described in Permit 46C, which consolidates the three separate permits for Oak Hill Mine and is the most recent approved permit the Mine at the time of this writing (PBW, 2008c).

bicarbonate, calcium, magnesium, and sodium) are measured infrequently outside of baseline studies. Without these latter analytes, the charge balances cannot be calculated and water type (e.g., Na-Cl, Na-Cl-SO4, Ca-Mg-SO4) is unknown.

SAMPLING EVENTS

The first set of monitoring wells were installed in Oak Hill Mine in 1983 and 1984 by Hall Southwest Water Consultants, Inc. The first water quality samples were collected in February 17 – April 14, 1984 at 24 monitoring locations. Groundwater

		O				U				All Relative Depths			
		n per well*	Dry	pH	pH & EC	n per well*	Dry	pH	pH & EC	n per well*	Dry	pH	pH & EC
P	**Total**	1100	36	1054	925	521	3	513	426	1621	39	1567	1351
	Min	2	0	2	0	2	0	2	2	2	0	2	0
	Median	19	0	19	17	16	0	16	11	17	0	17	15
	Mean	26.8	0.9	25.7	22.6	22.7	0.1	22.3	18.5	25.3	0.6	24.5	21.1
	Max	107	16	104	89	103	1	102	89	107	16	104	89
M	**Total**	319	18	300	249	191	0	191	161	510	18	491	410
	Min	10	0	7	6	4	0	4	4	4	0	4	4
	Median	35	0	35	28	11	0	11	8	22	0	22	17
	Mean	39.9	2.3	37.5	31.1	31.8	0.0	31.8	26.8	36.4	1.3	35.1	29.3
	Max	85	13	85	73	98	0	98	86	98	13	98	86
R	**Total**	714	34	675	620	188	0	186	181	902	34	861	801
	Min	4	0	3	0	35	0	35	34	4	0	3	0
	Median	50	0	50	47	51	0	50	49	51	0	50	47
	Mean	47.6	2.3	45.0	41.3	47.0	0.0	46.5	45.3	47.5	1.8	45.3	42.2
	Max	94	16	79	72	51	0	51	50	94	16	79	72
All Relative Ages	**Total**	2133	88	2029	1794	900	3	890	768	3033	91	2919	2562
	Min	2	0	2	0	2	0	2	2	2	0	2	0
	Median	22	0	22	18	16	0	16	12	22	0	21	17
	Mean	33.3	1.4	31.7	28.0	27.3	0.1	27.0	23.3	31.3	0.9	30.1	26.4
	Max	107	16	104	89	103	1	102	89	107	16	104	89

Table 3.4: Summary sampling events by well type for the historical data set. Total number of wells (W) is 97. By category, W_{OP} = 41, W_{OG} = 8, W_{OR} = 15, W_{UP} = 23, W_{UG} = 6, and W_{UR} = 4.

monitoring is ongoing, but the latest data analyzed for this study was collected in May of 2012 for the Q2 sampling event of that year. From all available data, only those containing a pH measurement are used for pH distribution plots. This data set consists of 2,919 measurements from 97 wells. Appendix A describes the completion (installation) date, well category, geology (where known) and location of these 97 wells. From these 2,919 measurements, only those also containing EC measurement were considered for multiple linear regression analysis (see Chapter 5). The resulting historical data set consists of 2,604 measurements from 95 wells.[24] Appendix B lists the number of total sampling events for each well and the total number of measurements of pH, pH with EC, and pH without EC. Table 3.4 summarizes this information. The locations of these wells are shown in Figures 3.5 and 3.6. From the sampling events with pH and EC data, 42 samples from 26 wells were identified as outliers and removed, leaving 2,562 measurements from 95 wells available for multiple linear regression (Chapter 5).[25] A copy of the data identified as outliers and their reason for removal is given in Appendix C. A copy of the 2,562 measurements described below is given in Appendix D.

QUALITY CONTROL

The quality of the field sampling program used during the collection of the historical data cannot be directly assessed as field blanks were not utilized. Field blanks provide a useful measure of cross-sample and outside contamination.

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[24] EC was not measured for any samples taken from wells 89-2-OB (#96), an overburden pre-disturbance well, and R-4(S) (#97), an overburden reclamation well.

[25] Of the 44 measurements, the relative "age" distribution is: 13 pre-disturbance, 6 mixed, and 25 reclamation. The relative depth distribution is: 36 overburden and 8 underburden. Of the 35 overburden samples, 3 are from three wells screened in the undifferentiated Carrizo/Wilcox, 2 are from a well screened in the Carrizo, 4 are from two wells screened in alluvium, 4 are from three wells screened in an unidentified formation, 3 are from two wells screened in the Wilcox Group, and the remaining 20 samples are from ten wells screened in spoil. Of the 8 underburden samples, 5 are screened in disturbed Wilcox Group and 3 are screened in (undisturbed) Wilcox Group.

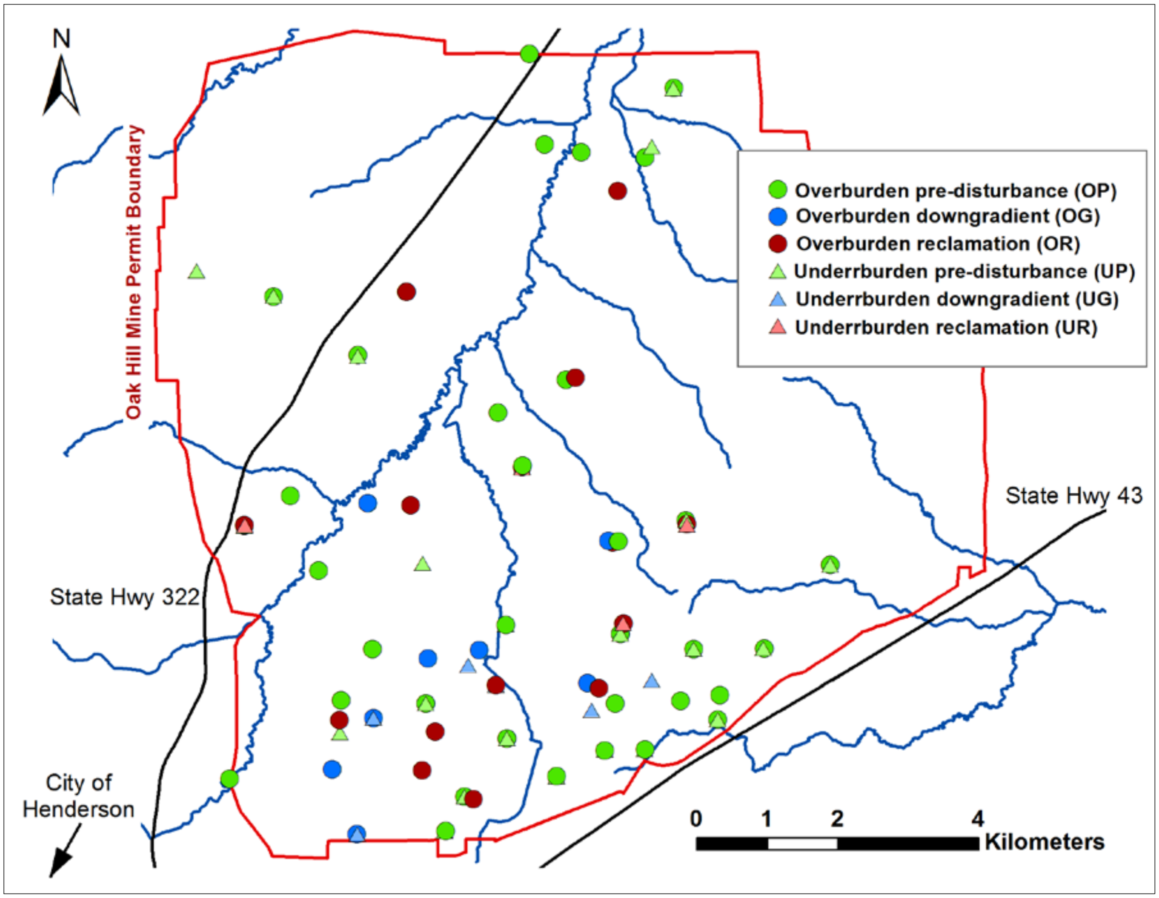

Figure 3.5: Location of 97 wells in Oak Hill Mine (2,919 samples with pH measurements), categorized by relative depth and age. Relative "age" is indicated by color. For overburden wells (circles), bright green is for pre-disturbance (P), bright blue for downgradient (G), and dark red for reclamation (R). For underburden wells (triangles), pale green is for pre-disturbance (P), pale blue for downgradient (G), and pink for reclamation (R).

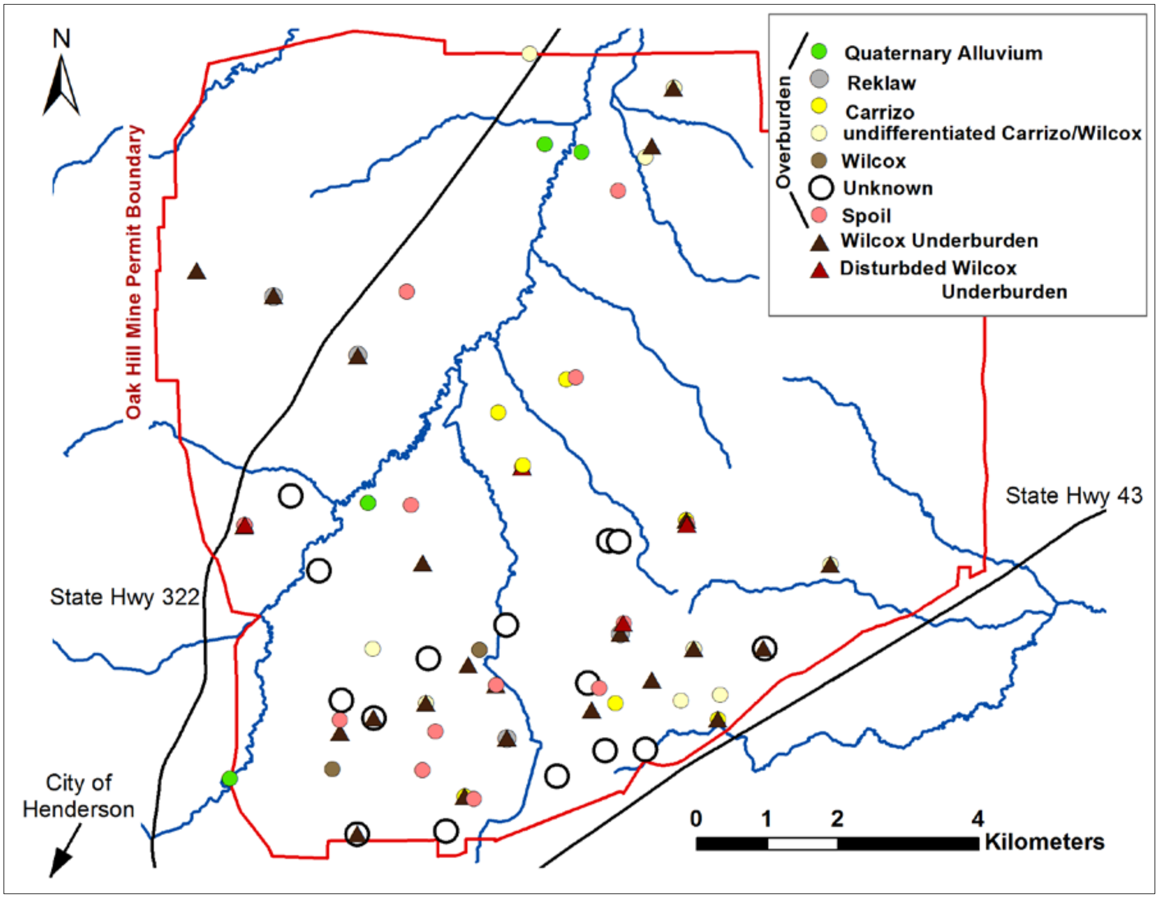

Figure 3.6: Location of 97 wells in Oak Hill Mine (2,919 samples with pH measurements), categorized by the geology of the well screen. Geology is indicated by color. For the overburden wells (circles), green is for Quaternary alluvium, grey for Reklaw, bright yellow for Carrizo, pale yellow for undifferentiated Carrizo/Wilcox, light brown for Wilcox, white for unknown geology, and pink is for spoil (overburden reclamation). For the underburden wells (triangles), dark brown is for Wilcox underburden (pre-disturbance underburden) and dark red for disturbed Wilcox underburden (reclamation underburden).

The analytic quality of the data is also difficult to assess as most sample analyses due not include the major cations (Ca, Na, and Mg) and anions (SO_4, Cl, and HCO_3 for circumneutral waters). As a result, charge balance errors cannot be computed for most samples. Charge balance errors (CBEs) compare the total milliequivalent concentration of cations to that of anions for each sample. All waters have an overall neutral charge, meaning that the amount of positive charge (cation milliequivalents) equals the amount of negative charge (anion milliequivalents). Therefore, when the analytic charge balance error deviates significantly from neutral (e.g., greater than 10%), the sample is flagged as containing significant ion concentration errors.

CBEs are reported only for the original 1984-1986 baseline wells, which constitutes 213 (8%) of the 2,562 samples containing both pH and EC responses (outliers removed, see above section “Sampling Events”). This baseline study was conducted for most of the DI and part of the DII area of the mine; none of the DIII or DIV areas were included in the first permit application (Permit 22). However, CBEs reported by the lab could not be reproduced using the reported analyte concentrations. Several combinations of variables were used, including field pH versus lab pH, with Fe and Mn, and without Fe and Mn. Because these CBEs could not be reproduced, CBEs calculated by this researched for reported analyte concentrations are used instead. The mean CBE is 2.2% with a standard deviation of 10.4%. The minimum, 25th, 50th, and 75th centile, and maximum are -36.6, -3.05, 0.8, 5.9, and 44.3 %, respectively. 39 (18%) of the sample have a CBE less than -10%, 14 (7%) of which are also less than -20%. 18 (8%) of the samples have a CBE greater than 10%, 4 (2%) of which are also greater than 20%. The CBEs calculated by this researcher and those reported by the third-party laboratory for the 1984 – 1986 baseline wells are listed in Appendix E.

Of the 2,349 (92%) samples for which CBE is not reported, sodium is reported for 582 of the samples. These samples also have Cl and SO_4 measurements but often do not have corresponding Ca, Mg, and HCO_3 concentrations. All three major cations (Ca, Mg, and Na) as well as Cl and SO_4 are reported for 200 (8.5%) of the samples for which CBE is not reported. The calculated CBEs for these 200 samples were calculated for this study and are also listed in Appendix E. The mean CBE is 2.3% with a standard deviation of 10.2%. The minimum, 25th, 50th, and 75th centile, and maximum are -29.1, -3.1, 0.65, 5.8, and 44.3 %, respectively. 16 (8%) of the samples have a CBE less than -10%, 3 (1.5%) of which are also less than -20%. 37 (18.5%) of the samples have a CBE greater than 10%, 14 (7.0%) of which also have a CBE greater than 20%.

The quality of the ensemble of data can be indirectly assessed by the means of *a priori* relationships among variables. For example, TDS is the sum of the concentrations of all dissolved constituents. Therefore, TDS is always greater than the concentration of any single constituent or subset of constituents. This criterion is satisfied for most of the 2,562 samples available for multiple linear regression (see section "Sample Events" above). Figure 3.7 displays the relationship between TDS and the sum of SO_4, Cl, and dissolved Fe for all 2,562 samples. Most points plot above the 1:1 line, indicating that TDS is greater than the subset of analytes. Figure 3.8 displays the relationship between TDS and the sum of SO_4, Cl, dissolved Fe, and Na for the 795 samples in which sodium is reported. Again, most points plot above the 1:1 line, indicating that TDS is greater than the subset of analytes.

Furthermore, TDS is linearly related to EC for a given water type. Some deviation occurs when different types of waters are compared (e.g., Fe-Na-SO_4 vs Na-Cl vs. Ca-Na-SO_4). However, the overall linear relationship between EC and TDS is well-established. Therefore, a scatter plot of the two parameters should approximate a straight line. Significant deviation indicates significant inaccuracy with at least one of the measurements. Graphing TDS vs EC for this historical data indicate that, while most data corresponds to the expected linear relationship, a few points deviate from the linear trend.

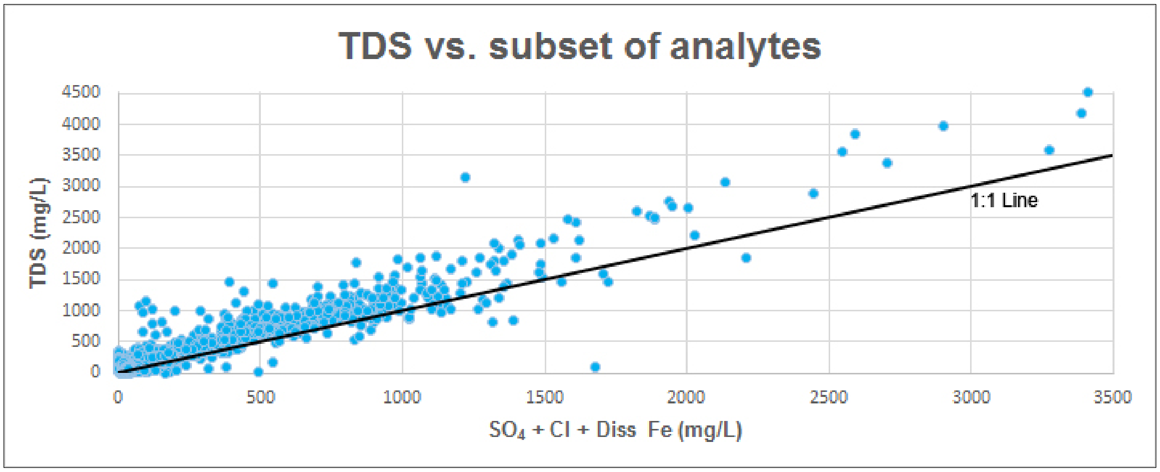

Figure 3.7: Relationship between TDS and a subset of the analytes (sum of SO_4, Cl, and dissolved Fe) which were measured for all 2,562 samples with pH and EC data. Most points plot above the 1:1 line as expected. For points plotting below the 1:1 line, either the reported concentration for TDS is too low or that of one or more of the analytes is too high.

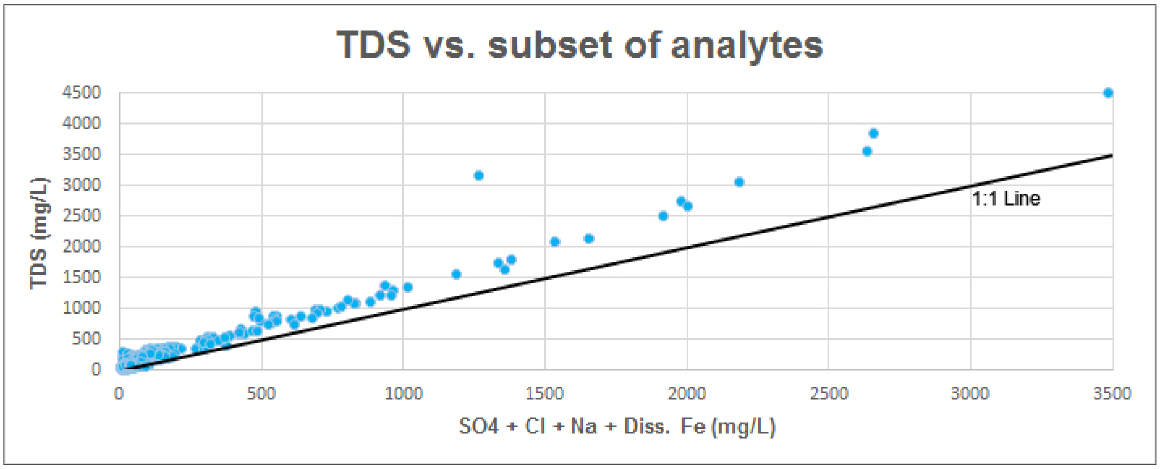

Figure 3.8: Relationship between TDS and a subset of the analytes (sum of SO_4, Cl, Na, and dissolved Fe) which were measured for the 795 samples with Na in addition to pH and EC data. Most points plot above the 1:1 line, as expected.

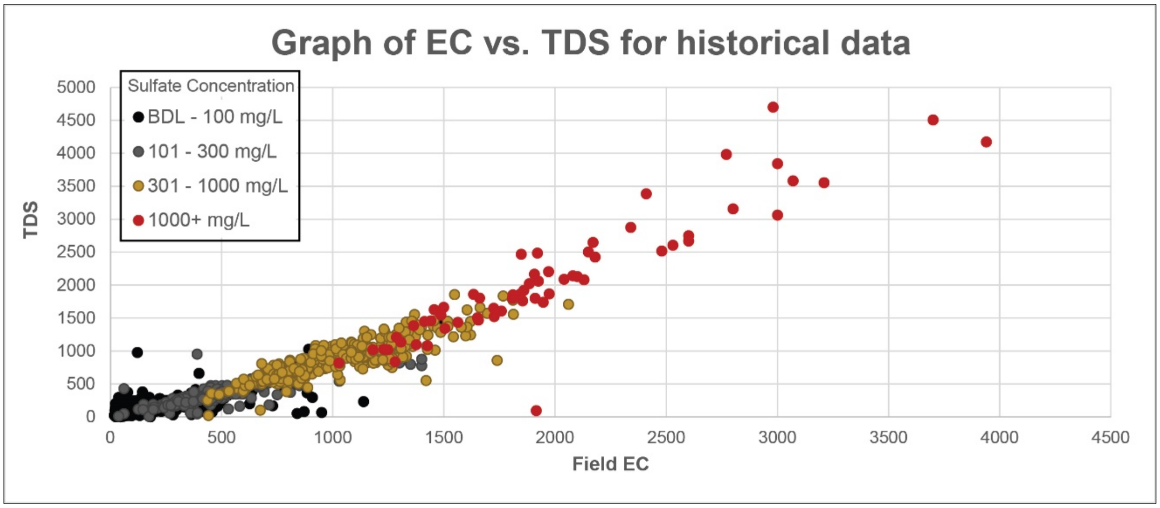

Figure 3.9: Graph of total dissolved solids (TDS, mg/L) versus electrical conductivity (EC, µmhos/cm) for the 2,562 samples containing both pH and EC responses (outliers removed). Sulfate concentration is indicated by color: black for BDL to 100 mg/L, gray for 101 – 300 mg/L, mustard for 301 – 1000 mg/L, and red for >1000 mg/L. For the historical data set, TDS is calculated gravimetrically by weighing the residue after a known volume of sample is dried.

The most likely explanations for these aberrant points are transcription errors (e.g., shifting a decimal point to the right or left) or misreading the conductivity meter units (e.g., µmho/cm vs mmho/cm)—resulting in misreporting of the conductivity by 1 or more orders of magnitude (Joel Palin, personal communication). These samples are identified as outliers and removed from the data set (Appendix C). For a sample in which EC and TDS do not correlate and in which other parameters (pH, sulfate, etc.) deviate from the range of observations for a particular well, it is possible that the sample was mislabeled during sample preservation. Figure 3.9 displays the EC and TDS values for the 2,562 samples containing both pH and EC responses (outliers removed). TDS and EC measure the same physical phenomenon (salinity), therefore, only one parameter should be incorporated into multiple linear regression. As EC is measured on the same day as sample collection and therefore limits the amount of time during which precipitation reactions can reduce salinity, EC but not TDS outliers were removed from data set.

RESULTS

pH Distribution of Historical Data

The pH distribution of the historical data set display different patterns for subsets of the wells. When the samples are categorized by relative depth, the median overburden sample is slightly above a pH of 4.5 whereas the median pH of underburden wells is approximately 6.4 (Figure 3.10). When the samples are categorized by relative "age" (pre-disturbance, reclamation, or downgradient of mining), the reclamation samples have the lowest median pH (slightly less than 4.5) whereas downgradient samples have the highest median pH (slightly less than 6.5) (Figure 3.11). It is interesting to note that the downgradient samples have a higher median pH than that of the reclamation samples and the pre-disturbance samples. Finally, Figure 3.12 illustrates the pH distribution of the historical data set by age and depth for a total of 6 categories. Of these categories, overburden reclamation samples have the lowest median pH of about 4.1 while underburden wells downgradient of mining have the highest median pH of about 7.0.

A time series plot of sample pH by well category reveals characteristics of the pH variable (Figure 3.13). The range of sample pHs from downgradient wells greatly overlaps with those of pre-disturbance wells. The spread (variance) of downgradient samples is also similar to that of pre-disturbance samples. These observations suggest that downgradient wells are merely a subset of their respective pre-distribution wells (i.e., OG wells are a subset of OP wells and UG wells are a subset of UP wells). Though, the distinctly higher median pH of OG and UG wells compared to OP and UP wells, respectively, suggests that

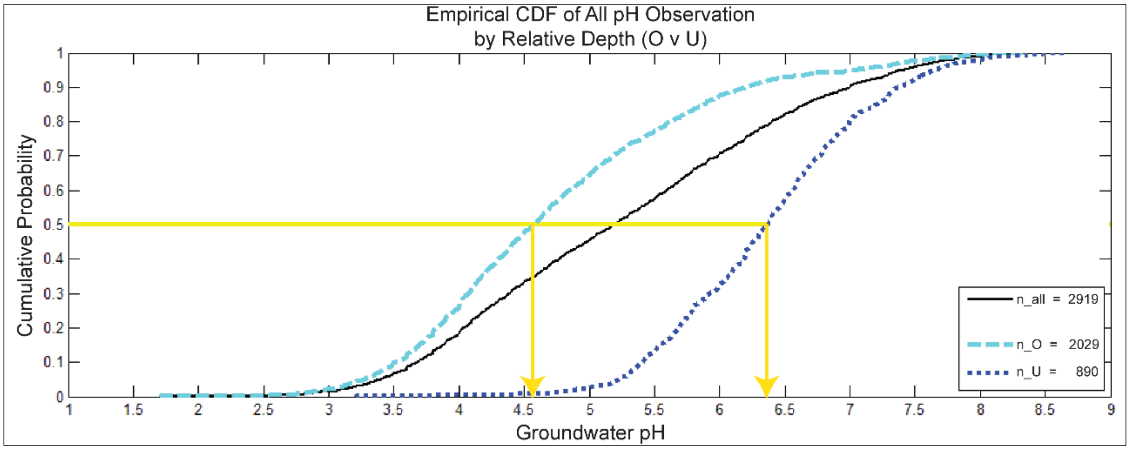

Figure 3.10 : Empirical cumulative distribution function (CDF) of pH by relative depth for the historical data set (includes samples with no EC variable). The light blue dashed line is for overburden (O) wells and the dark blue dotted line is for underburden (U) wells.

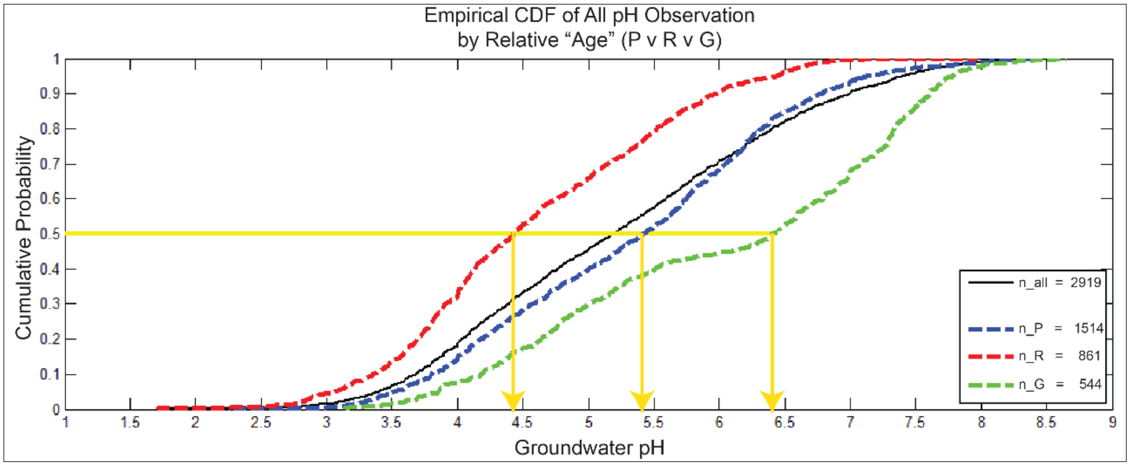

Figure 3.11: Empirical cumulative distribution function (CDF) of pH by relative "age" for the historical data set (includes samples with no EC variable). Relative age categories are: pre-disturbance (P, dark blue line), downgradient (G, green line), and reclamation (R, red line).

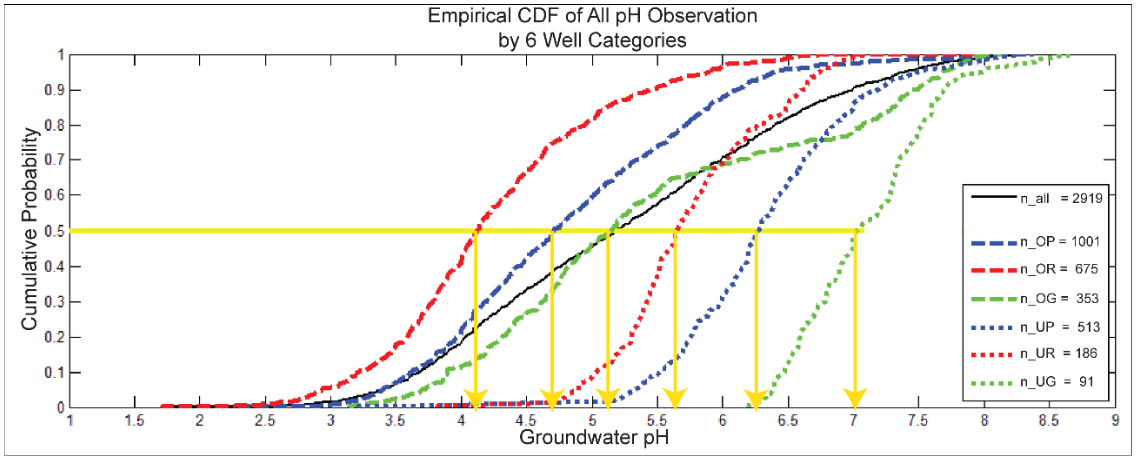

Figure 3.12: Empirical cumulative distribution function (CDF) of pH by relative depth and age for the historical data set (includes samples with no EC variable). Well categories are: overburden pre-disturbance (OP, dark blue dashed line), overburden reclamation (OR, red dashed line), overburden downgradient (OG, green dashed line), underburden pre-disturbance (UP, dark blue dotted line), underburden reclamation (UR, red dotted line), and underburden downgradient (UG, green dotted line).

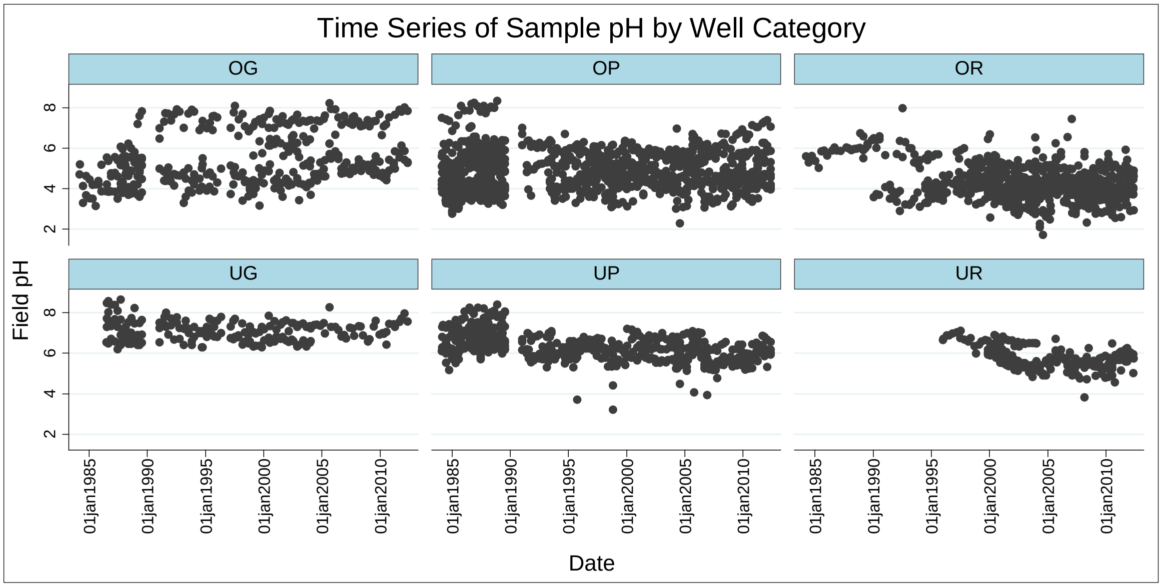

Figure 3.13: A time series plot of sample pH by well category. Well categories are overburden downgradient (OG), overburden pre-disturbance (OP), overburden reclamation (OR), underburden downgradient (UG), underburden pre-disturbance (UP), and underburden reclamation (UR).

these wells do form their own distinct population. The relationship between downgradient wells and pre-disturbance wells is examined further in Chapter 5. The time series graph of the pH of samples by well category (Figure 3.13) also shows that overburden samples have a larger variance than underburden wells, that median overburden pH < median underburden pH (as seen in Figures 3.10 and 3.12), and that median reclamation pH < median pre-disturbance pH (as seen in Figures 3.11 and 3.12). In chapter 5, hypothesis testing is used to confirm that these differences are not due to random chance.

The pH distribution of overburden pre-disturbance wells can be further categorized by the geologic formation in which the well is screened (Figure 3.14). Carrizo and undifferentiated Carrizo-Wilcox samples have similar pH distributions. Most of these wells are screened in high-transmissivity sand intervals; the sand is often described as a "clean channel sand." These wells have the lowest median pH. Wilcox

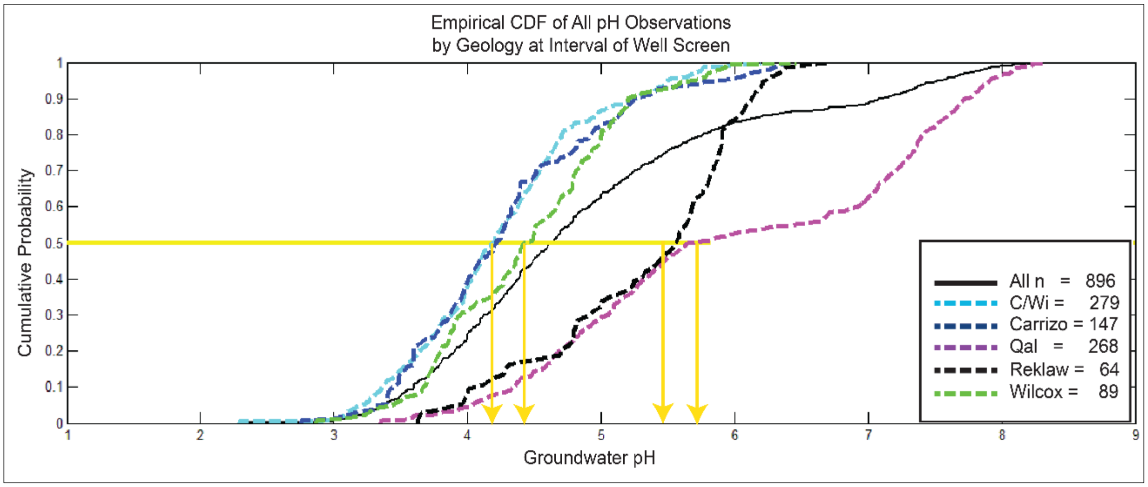

Figure 3.14: Empirical cumulative distribution function (cdf) of pH by the geology of the screened interval of the well (overburden pre-disturbance samples only). The solid black line is the cdf for all 896 samples. Dashed lines show the cdf by geology: cyan for undifferentiated Carrizo/Wilcox, blue for Carrizo, green for Wilcox, black for Reklaw, and magenta for Quaternary alluvium.

wells have a slightly higher median pH at approximately 4.5. These wells are often screened in sand or a mix of sand and finer sediments. Reklaw and Quaternary alluvium (Qal) wells have similar median pH values at about 5.5 and 5.75, respectively, though Qal samples have the widest range and the highest pH values.

Piper and Durov Diagrams

Piper and Durov diagrams for samples with the major cations (Ca, Mg, and Na + K) and anions (SO_4 and Cl) indicates a large degree of variation among overburden wells (Figures 3.15 and 3.16). Overburden wells are plotted without bicarbonate as the bicarbonate is often missing and the reported values sometimes contradict the pH values. There are no noticeable hydrochemical facies trends for the overburden well categories in the Piper diagram (Figure 3.15). Similarly, there are no noticeable hydrochemical facies trends in the Durov diagram (Figure 3.16), except that pH decreases and TDS increases for some overburden reclamation (spoil) wells.

The Piper diagram of samples from overburden wells by the geology of the screened interval of the well shows a large degree of variability within geologic categories (Figure 3.17). However, there are some weak trends among hydrochemical facies between geology categories. Alluvium samples tend to have higher calcium concentrations than any other category except spoil; for most samples the Ca concentration is between 35-55%, and Na+K is never greater than 60% of the major cations. Carrizo and Wilcox samples both exhibit a large SO_4 to Cl chloride ratios. While they have a similar range of Na+K percentages, Wilcox samples have an unimodel distribution (one “peak”) centered around 65% Na+K whereas Carrizo samples have a bimodal distribution with one mode centered around 35% Na+K and one mode centered around 80% Na+K. Reklaw samples exhibit a smaller range of concentrations which is probably due to the smaller number samples in this category, but are otherwise similar to Wilcox samples. Spoil (overburden reclamation) samples tend to have higher SO_4/Cl ratios than other samples. Spoil samples tend to have similar Ca percentages as alluvium samples but more Mg than alluvium or any other sample category.

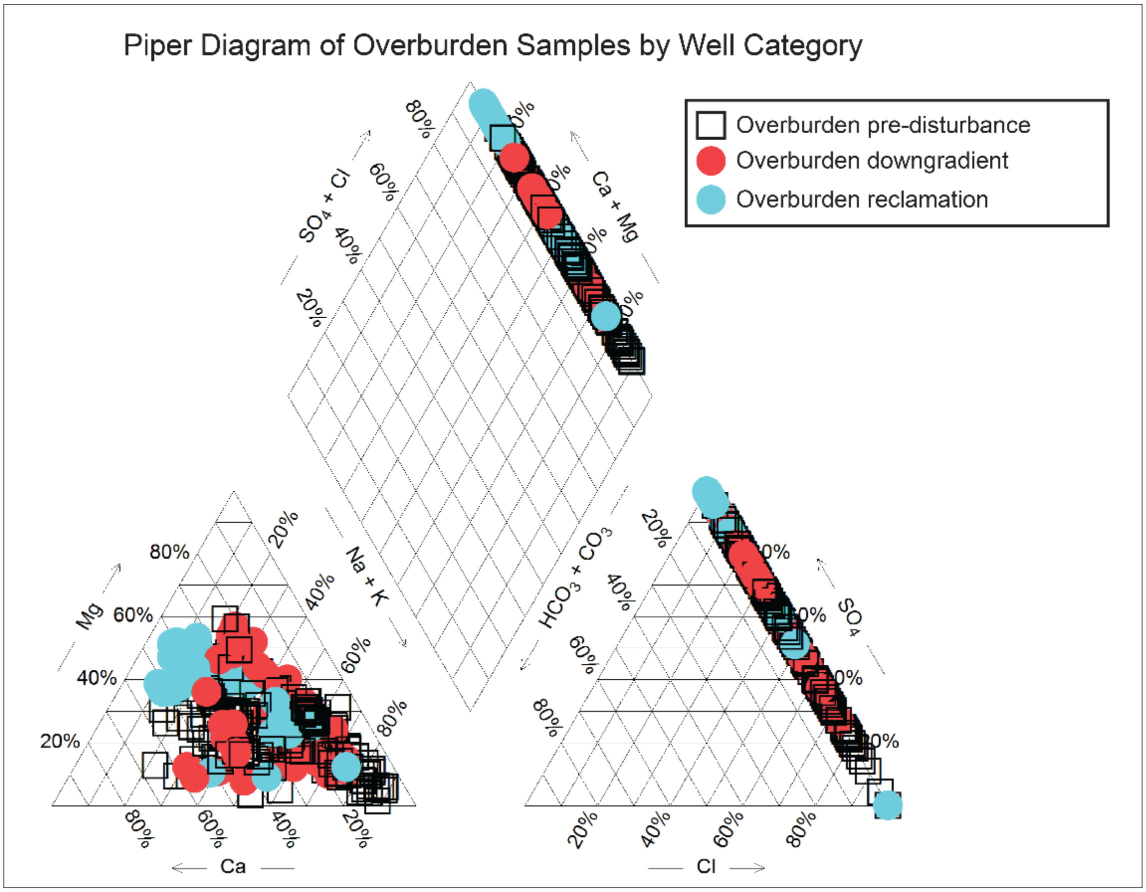

Figure 3.15: Piper diagram of samples from overburden wells by relative age: white boxes for pre-disturbance, mauve circles for downgradient, and pale blue circles for reclamation. Bicarbonate has been omitted for samples with a reported bicarbonate value.

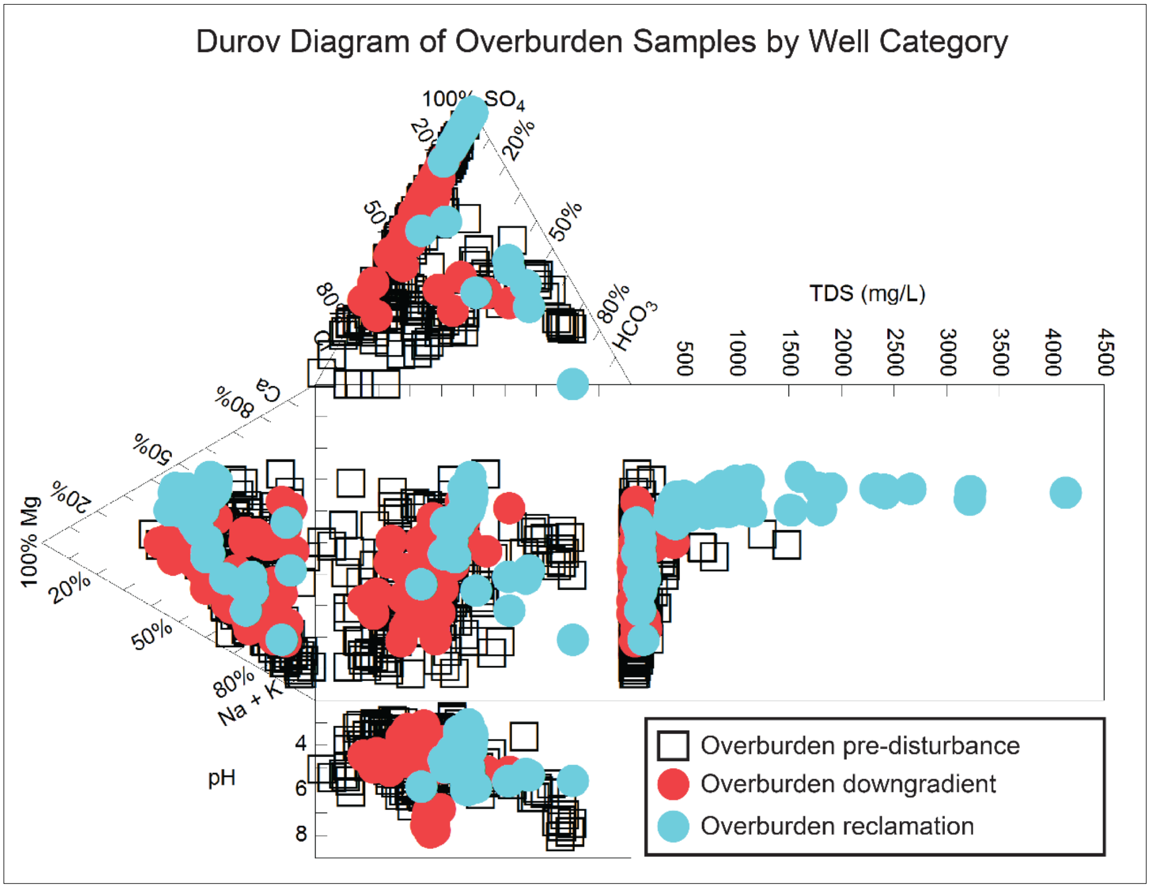

Figure 3.16: Durov diagram of overburden wells by relative age: white boxes for pre-disturbance, mauve circles for downgradient, and pale blue circles for reclamation. Bicarbonate has been omitted for samples with a reported bicarbonate value.

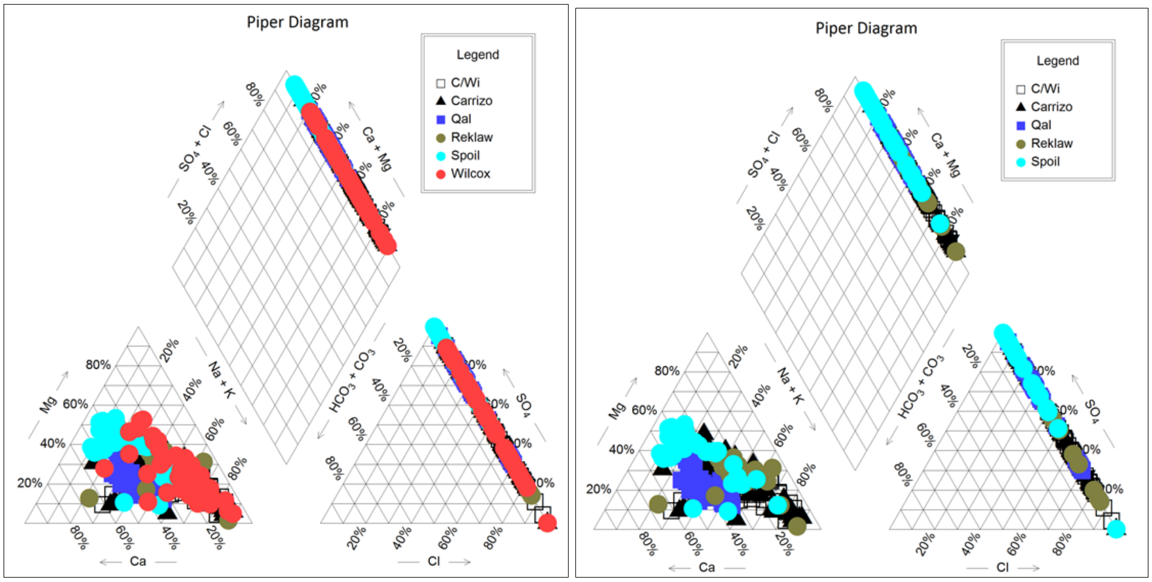

Figure 3.17: Piper diagrams of overburden samples categorized by the geology of the screened interval of the well: white for undifferentiated Carrizo/Wilcox, black for Carrizo, bright blue for quaternary alluvium, brown for Reklaw, cyan for spoil, and mauve for (overburden) Wilcox. The diagram on the left includes samples from Wilcox Group overburden wells. The diagram on the right omits samples from Wilcox Group overburden wells.

The pH and dissolved solids (TDS) axes in Durov diagrams allow for additional differentiation among geologic categories (Figure 3.18). Alluvium range from acidic to circumneutral. Alluvium samples have the highest pH values of any category and very low TDS. Carrizo and Wilcox samples both tend to have low pH (3.0-6.0) and TDS (<300), though Wilcox samples tend to plot in a tighter cluster (less variance). Reklaw samples have the smallest pH range, probably due to the limited number of samples. They also tend to be fresher than Carrizo and Wilcox samples. Spoil samples have a largest range in and concentrations of TDS. Spoil samples appear to be similar to Reklaw samples in pH.

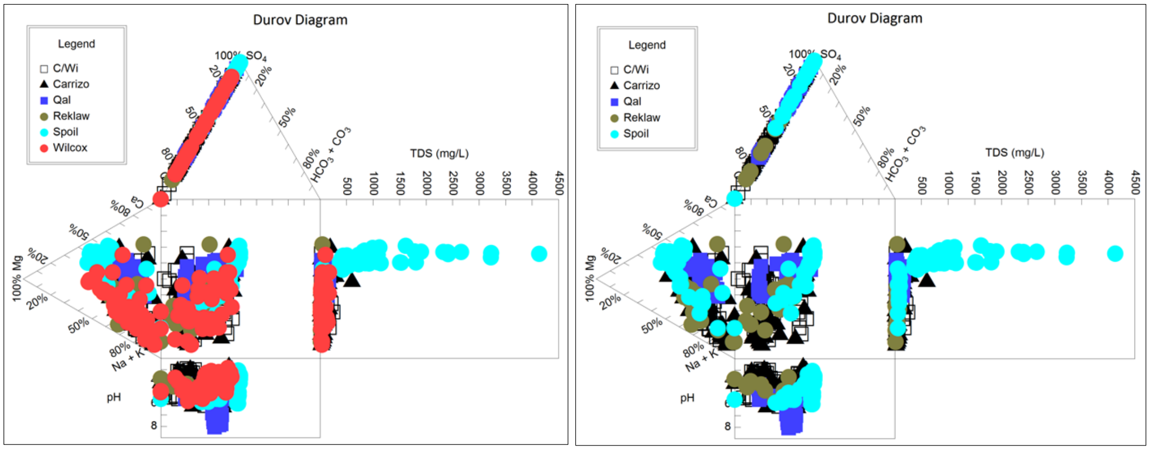

Figure 3.18: Durov diagrams of overburden samples categorized by the geology of the screened interval of the well. The diagram on the left includes samples from Wilcox Group overburden wells. The diagram on the right omits samples from Wilcox Group overburden wells.

Underburden samples are split into samples with bicarbonate values reported and those without bicarbonate values reported and then plotted by relative "age" in Piper and Durov diagrams (Figures 3.19 and 3.20). All sample categories tend to plot in a tight cluster on the cation portion of the Piper diagram, indicating that there is a low variance in cation percentages. For samples with bicarbonate data (all of which are pre-disturbance wells), the bicarbonate anion has the greatest range, though significant variability is observed among all three major anions. Downgradient and reclamation underburden samples tend to have lower Na+K percentages, higher sulfate percentages, and higher pH values than pre-disturbance samples. These categories plot in tighter clusters (smaller variance and range) than pre-disturbance samples, but this difference is at least partially due to significant differences in sample sizes among the categories.

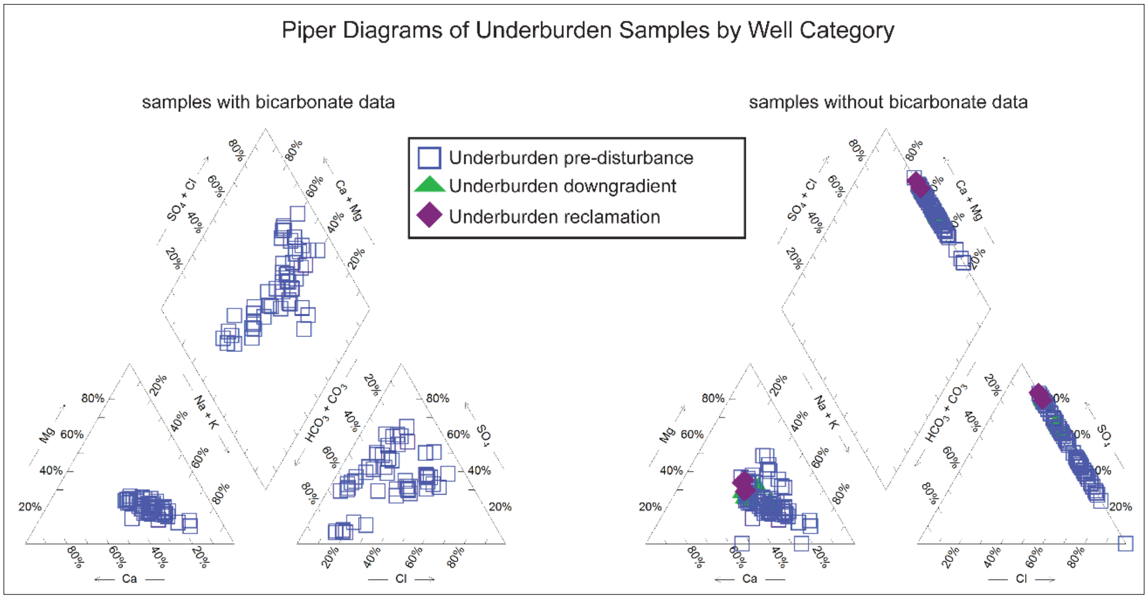

Figure 3.19: Piper diagrams of underburden wells by relative age (pre-disturbance, downgradient, and reclamation). The diagram on the left contains samples with the bicarbonate value reported, which are all from overburden pre-disturbance wells. The diagram on the right contains samples that are missing the bicarbonate variable.

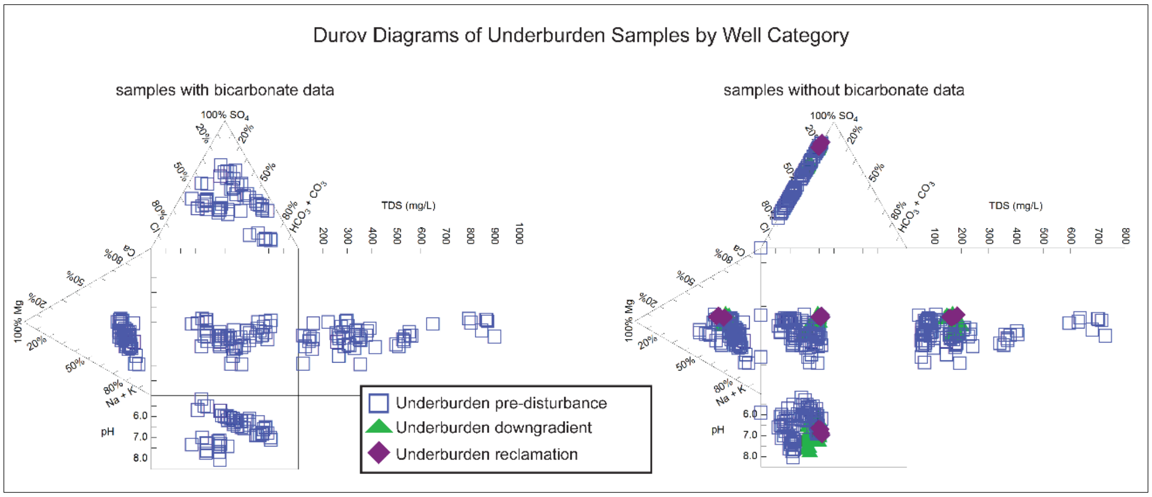

Figure 3.20 Durov diagrams of underburden wells by relative age (pre-disturbance, downgradient, and reclamation). The diagram on the left contains samples with the bicarbonate value reported, which are all from overburden pre-disturbance wells. The diagram on the right contains samples that are missing the bicarbonate variable.

Parameter-Parameter Plots

Scatter plot matrices by well category (Figures 3.21 – 3.24) can be used to survey the general relationships between water quality parameters. For example, Figures 3.22 and 3.24 shows that pH appears to be uncorrelated with sulfate for all well categories. This apparent lack of correlation is explored further in Chapter 5. Figures 3.21 and 3.23 shows that pH is positively correlated with all of the major cations (Ca, Mg, and Na) for underburden pre-disturbance (UP) samples, but not for any other well category. In general, the observation that parameter-parameters correlations vary across well categories suggests that these may be meaningful categories. If these categories did not correspond to different groundwater populations at Oak Hill Mine, then the well categories would be a random selection from one population, and parameter-parameter relationships are likely to remain unchanged across well categories. Scatter plot matrices of overburden wells by the geology of the screened interval of the well (Figures 3.25 and 3.26) also suggest that these are be meaningful categories.

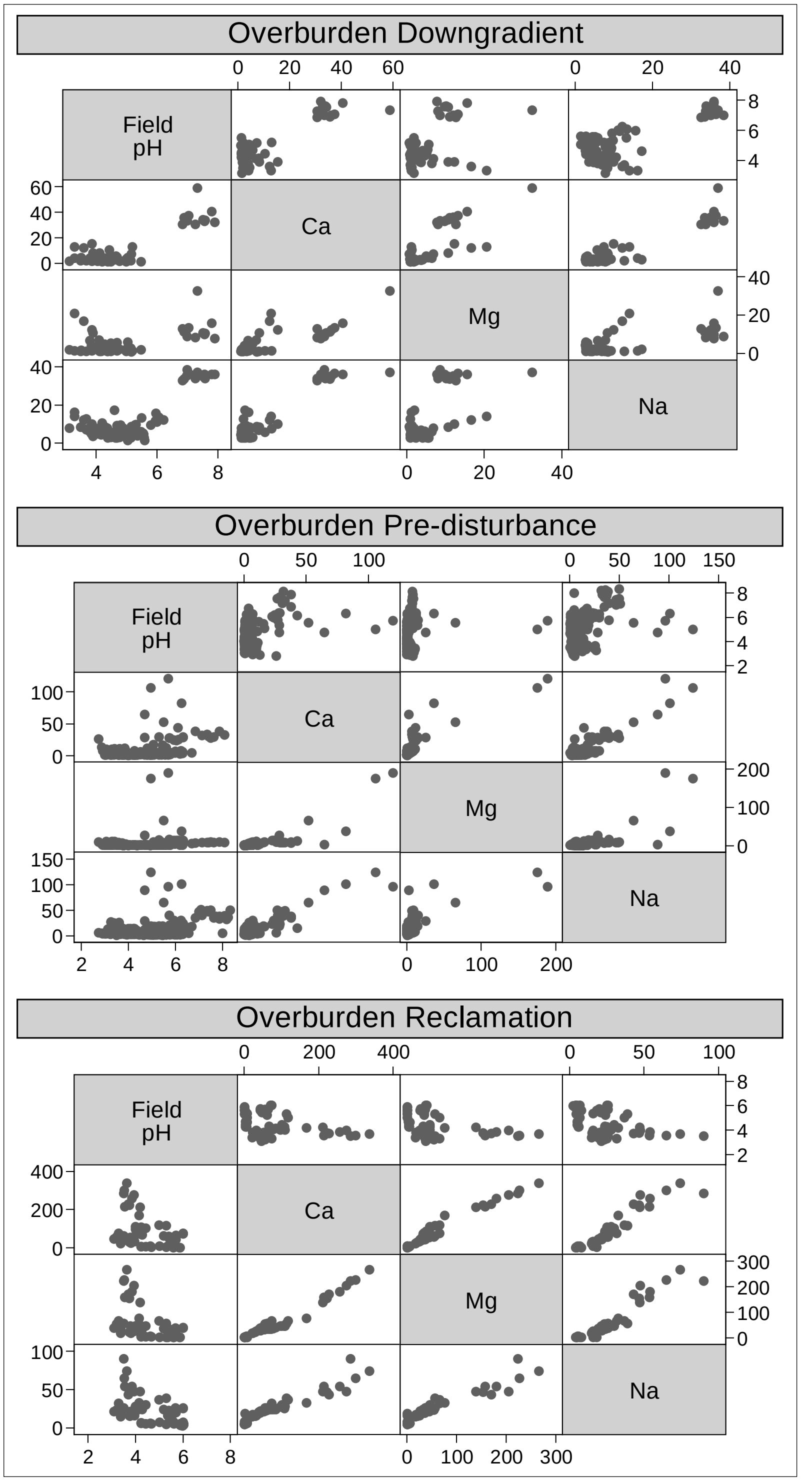

Figure 3.21: Scatter plot matrix of wells and seeps by relative age for overburden wells, showing field pH, Ca, Mg, and Na parameters. Concentrations are in mg/L.

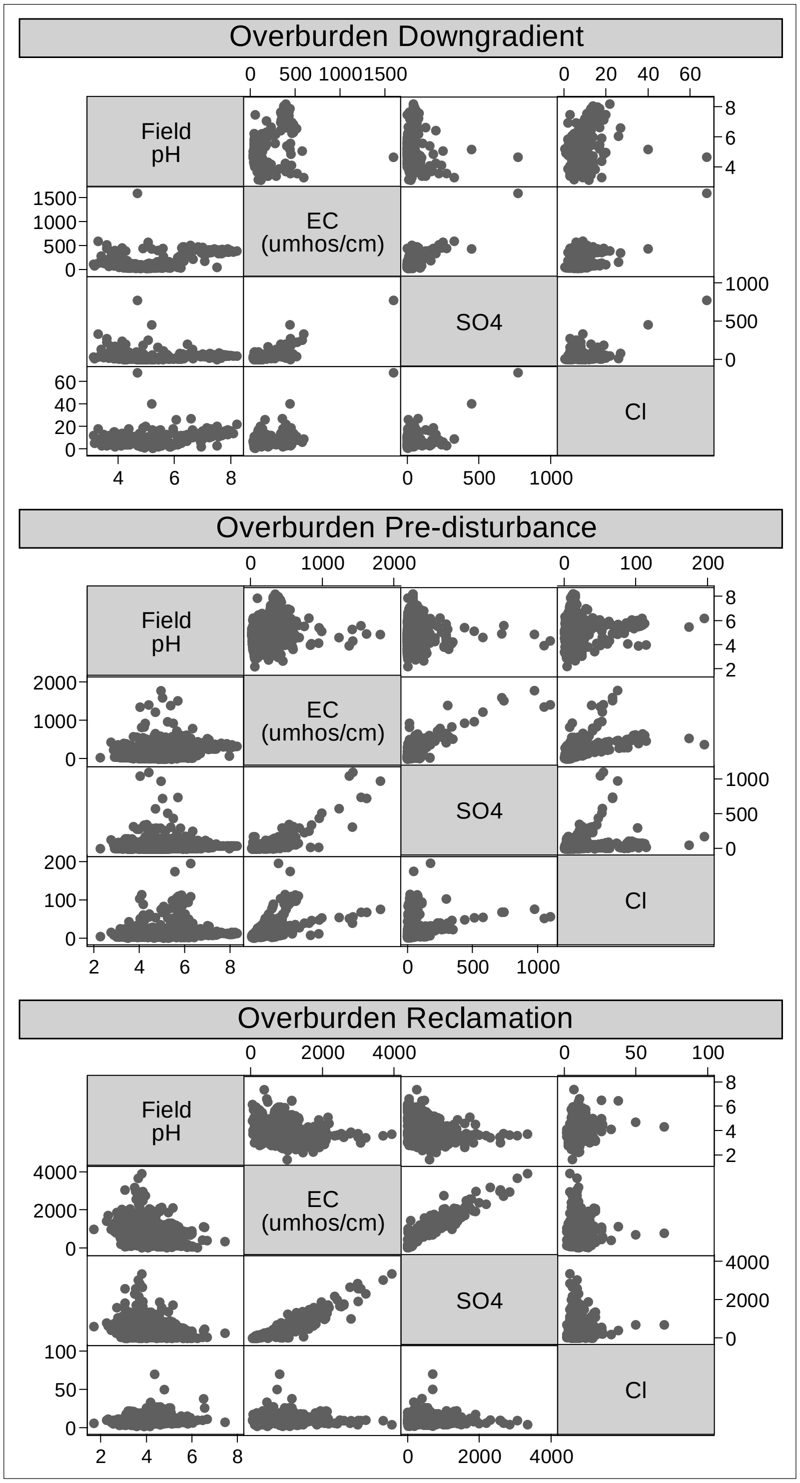

Figure 3.22: Scatter plot matrix of wells and seeps by relative age for overburden wells, showing field pH, EC, SO_4, and Cl parameters. Concentrations are in mg/L.

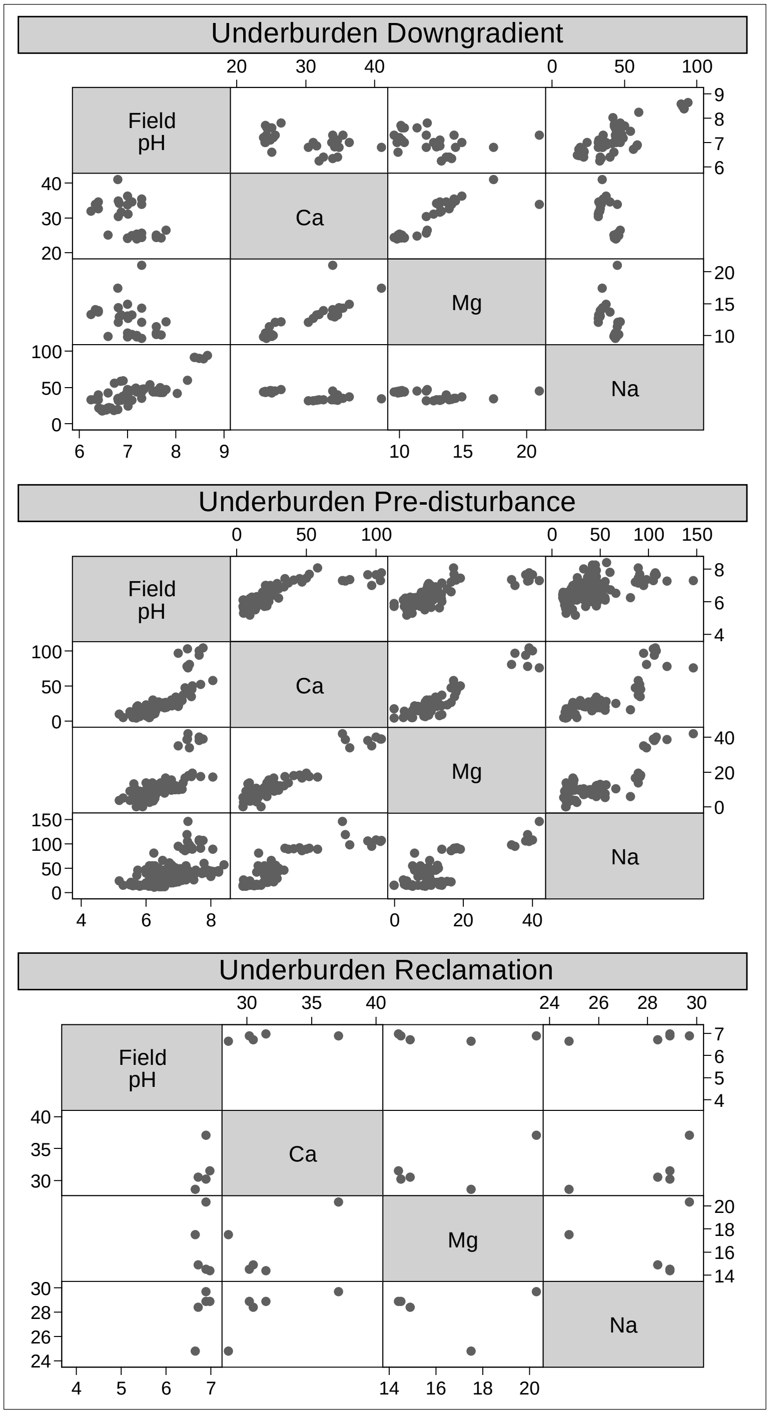

Figure 3.23: Scatter plot matrix of wells and seeps by relative age for underburden wells, showing field pH, Ca, Mg, and Na parameters. Concentrations are in mg/L. Note that only 5 underburden reclamation samples (all from the same well) have Ca, Mg, and Na measurements.

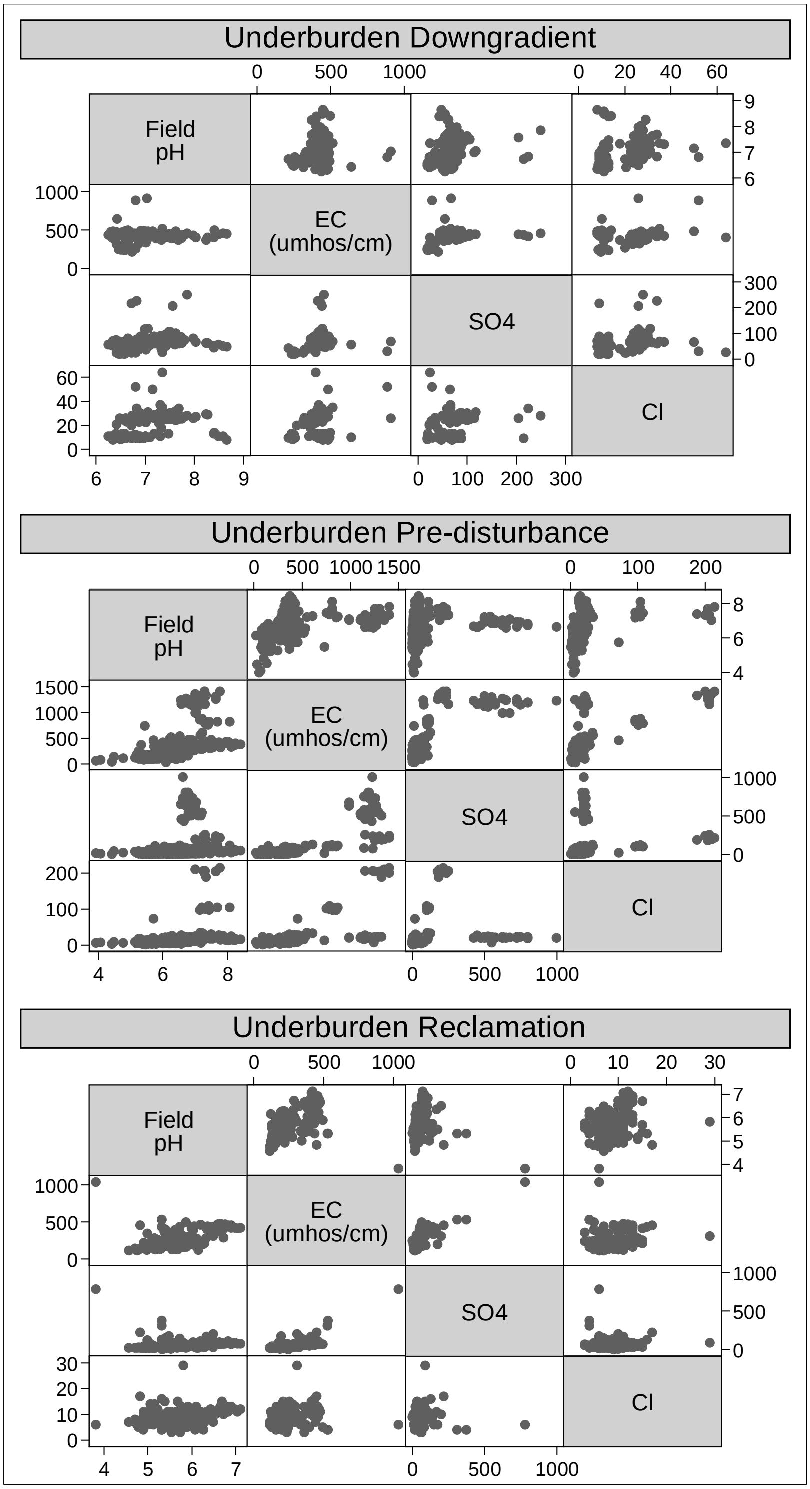

Figure 3.24: Scatter plot matrix of wells and seeps by relative age for underburden wells, showing field pH, EC, SO_4, and Cl parameters. Concentrations are in mg/L.

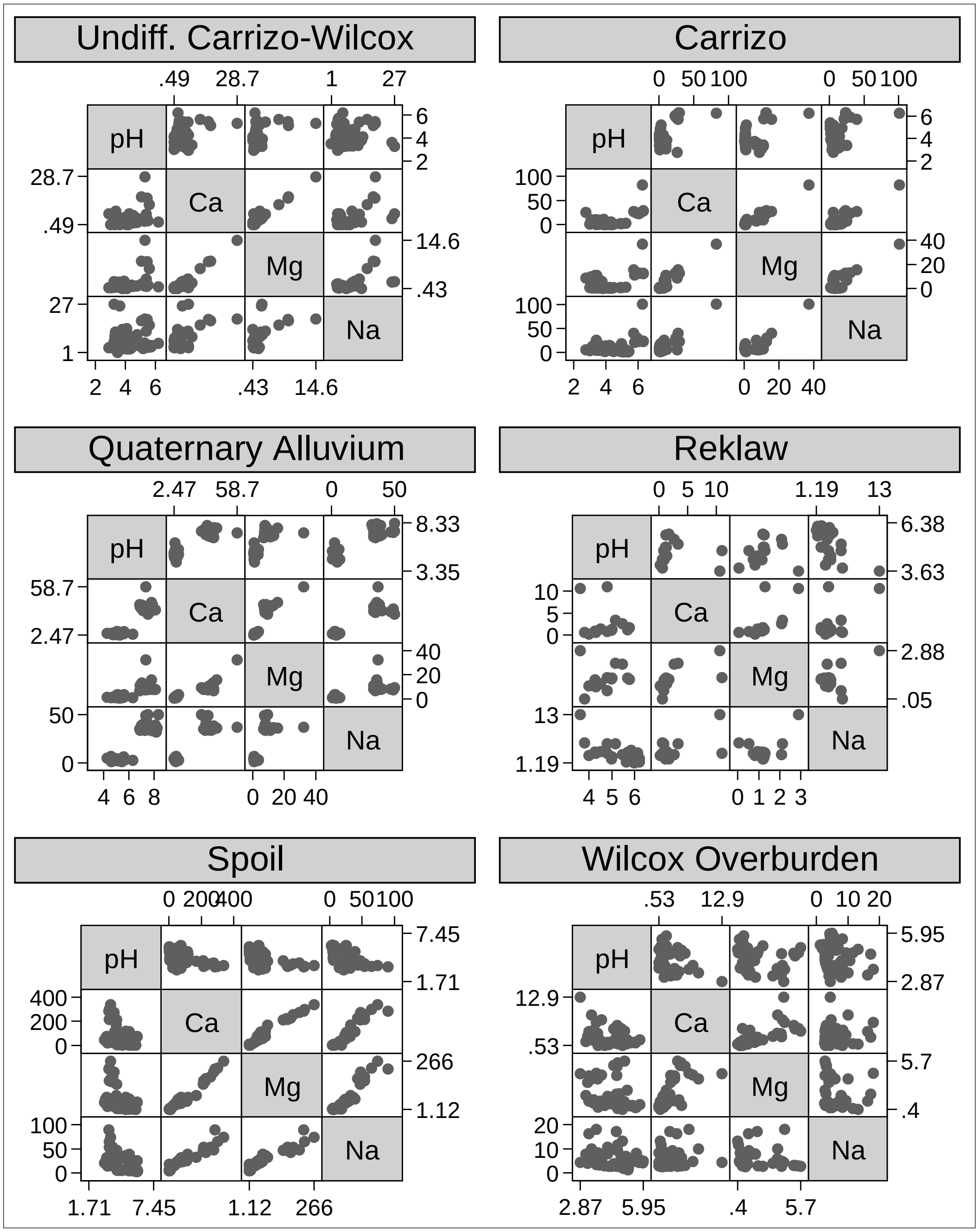

Figure 3.25: Scatter plot matrix of overburden wells by the geology of the screened interval, showing field pH, Ca, Mg, and Na parameters. All concentrations are in mg/L. The upper 4 plots are of overburden pre-disturbance (OP) wells sample. Spoil wells are overburden reclamation (OR) wells. Seeps are plotted together (all seeps but one are in reclaimed areas). Underburden wells and overburden wells of unknown geology are omitted from this figure.

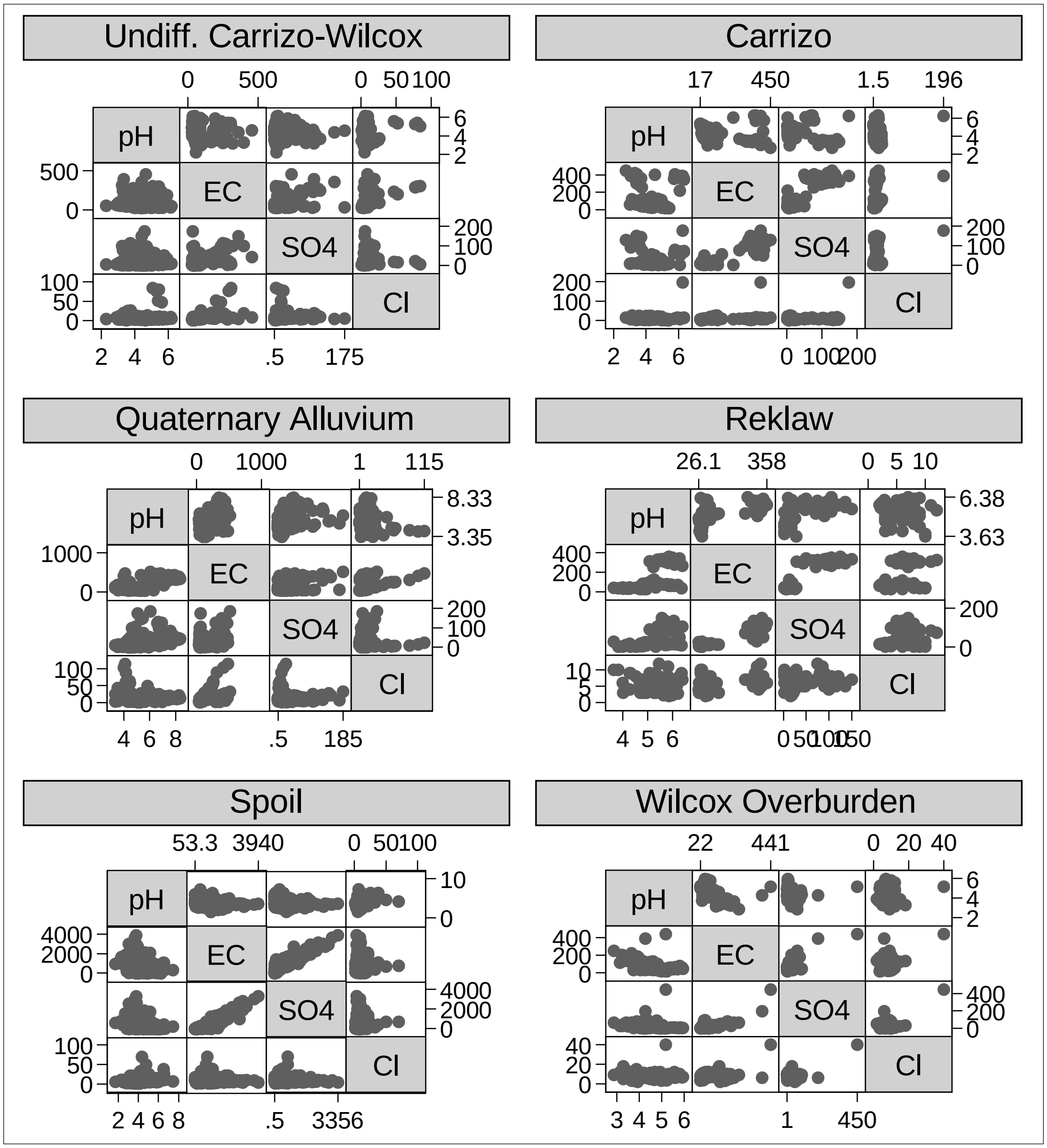

Figure 3.26: Scatter plot matrix of overburden wells by the geology of the screened interval, showing field pH, EC, SO_4, and Cl parameters. All concentrations are in mg/L. The upper 4 plots are of overburden pre-disturbance (OP) wells sample. Spoil wells are overburden reclamation (OR) wells. Seeps are plotted together (all seeps but one are in reclaimed areas). Underburden wells and overburden wells of unknown geology are omitted from this figure.

Chapter 4: Description and Characterization of 2013 Data Set

The 2013 data set was collected by this researcher on three separate sampling trips to Oak Hill Mine. This chapter describes the sampling and analytic methods for this data set, discusses the quality of the data, and presents descriptive statistics and plots that summarize the data.

SAMPLING EVENTS

Groundwater samples were collected from monitoring wells and seeps in three sampling events in June, August, and October of 2013. August and October events were coordinated with quarterly sampling events as this allowed for a larger number of wells to be sampled. Samples were therefore collected and analyzed independently by mine employees and by this researcher. For the October sampling event, some water samples that were collected by mine employees were analyzed by this researcher to see if differences in sample collection and preservation or in sample analysis, would result in differences of analytic results. The location of wells and seeps sampled for the 2013 data set are shown in Figures 4.1 and 4.2.

WELL CATEGORIES

The same well categories are applied to the historical and 2013 data sets. Relative "age" categories indicate whether the well is pre- or post-disturbance (pre-disturabance, P, and reclamation, R). And additional category indicates a pre-disturbance wells that is downgradient of a mined area and may therefore intercept both pre-disturbance and reclamation waters (downGradient, G). Relative depth categories indicate whether the well is installed at a depth above or below the main lignite seam (overburden, O, and underburden, U, respectively). Figures 3.1 and 3.2 depict these well categories in a conceptual model of the shallow groundwater system at Oak Hill Mine.

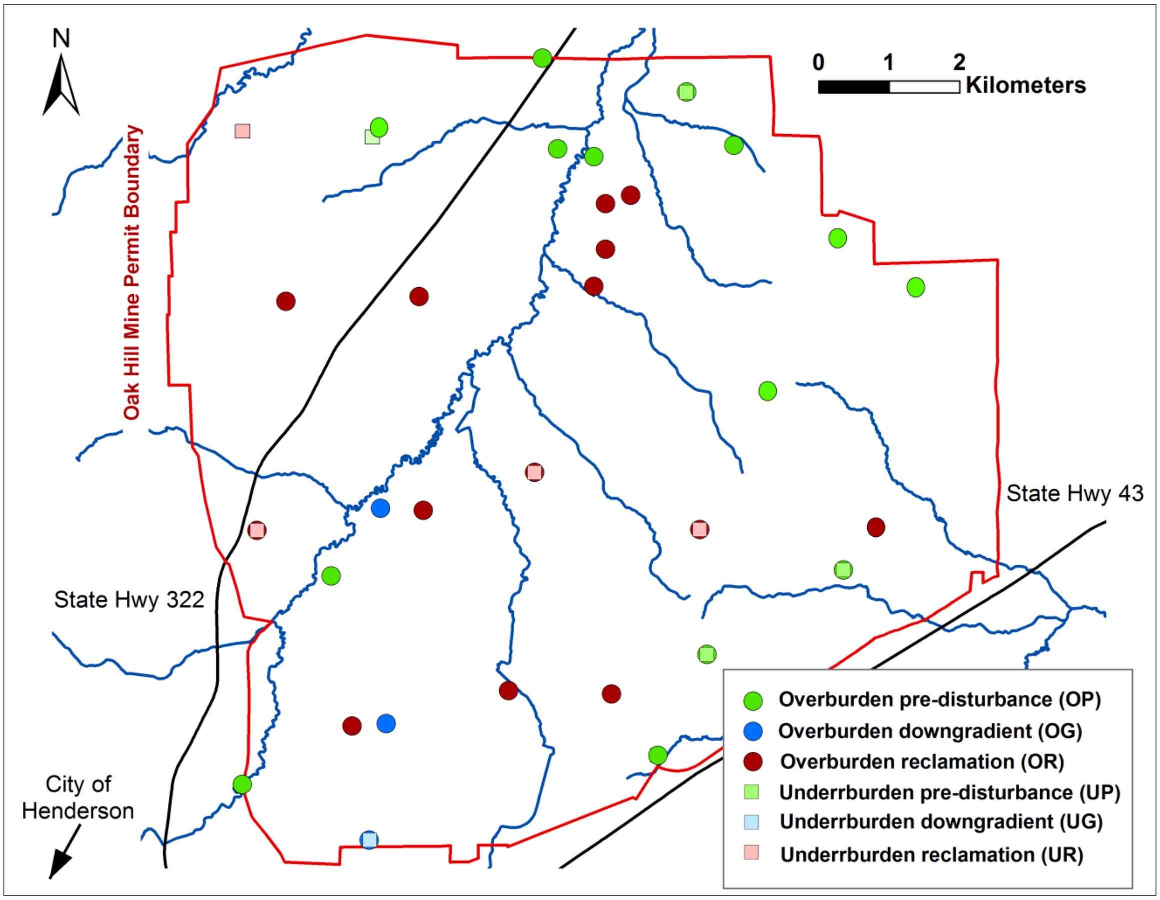

Figure 4.1: Location of wells and seeps sampled for the 2013 data set, categorized by relative depth and age. Relative "age" is indicated by color. For overburden wells (circles), bright green is for pre-disturbance (P), bright blue for downgradient (G), and dark red for reclamation (R). For underburden wells (triangles), pale green is for pre-disturbance (P), pale blue for downgradient (G), and pink for reclamation (R).

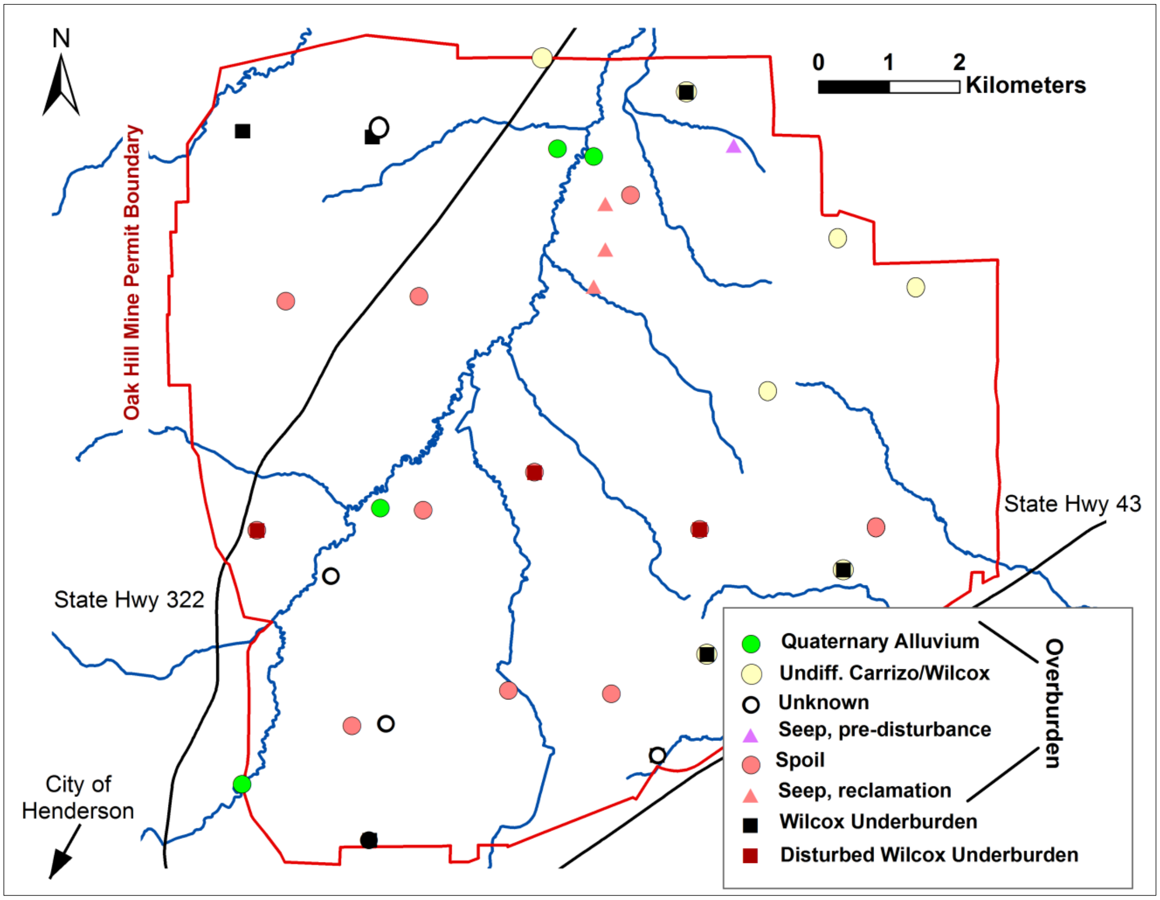

Figure 4.2: Location of wells and seeps sampled for the 2013 data set; wells are categorized by the geology of the well screen. For the overburden wells (circles), green is for Quaternary alluvium, pale yellow for undifferentiated Carrizo/Wilcox, white for unknown geology, and mauve for spoil (overburden reclamation). Overburden seeps (triangles) are categorized by relative "age": pink for pre-disturbance and mauve for reclamation. For the underburden wells (squares), black is for Wilcox underburden (pre-disturbance underburden) and dark red for disturbed Wilcox underburden (reclamation underburden).

SAMPLING PROCEDURE

Micropurging was attempted on the first sampling trip to the mine (Puls and Barcelona, 1996), but temperature and EC parameters did not stabilize sufficiently, and this method was abandoned. Subsequently, a minimum of 3 well volumes were purged from each well prior to sampling. For 4” diameter monitoring wells, a submersible pump was used to purge the well. From the pumping rate and volume of water in the well, the length of time needed to purge 3 well volumes was calculated. For 2” diameter monitoring wells, 3 well volumes were purged using hand bailers. For all wells, if the well ran dry before 3 well volumes could be purged, then the well was sampled as soon as a sufficient amount of water could be collected from the well.

Each sample was initially collected in a large container that was re-used at each well after being rinsed 3-5x with deionized water and 3-5x with sample water. Field parameters (temperature, pH, and EC) were measured in the field. Both measurements were generally collected immediately after sample collection. On occasion, pH was measured after driving to the next well location. A Fisher Scientific Accumet AP125 portable pH meter was used to measure temperature and pH. A Myron L. Company 9P Ultrameter III was used to measure EC and obtain a secondary pH reading. The EC and pH calibrations of field instruments were checked at the beginning and end of each day and during the day. The Accumet pH meter was calibrated using four calibration points: 2, 4, 7, and 10. Two acidic pH standards (2 and 4) were used to maximize the accuracy of pH readings <7. Post-calibration, pH readings were taken with each calibration standard as well as with a standard of pH 6 to ensure the accuracy of the calibration. The ultrameter generally required at least one recalibration a day, but the pH meter tended to maintain its calibration for multiple days.

Samples were transferred from the large collection contain to individual, clean polyethylene bottles in the field.[26] 15 ml polyethylene bottles were used for ion samples and the bottle for cation analysis was acid-washed. Headspace was minimized in all alkalinity, raw, and anion sample bottles. Samples for cation, anion, and filtered alkalinity samples were filtered in the field with 0.45 micron pore diameter disposable filter cartridges. Raw samples were collected for raw alkalinity. At the end of each day, alkalinity titrations were performed and cation samples were acidified to $\text{pH} \leq 2$ with nitric acid. At the completion of each sampling event, samples were transported in coolers to The University of Texas at Austin for trace analysis.

ANALYTIC PROCEDURES

Field parameters (temperature, electrical conductivity, and pH) were collected as soon as possible after sample collection. Alkalinity as bicarbonate was measured by titrating to pH of 4.5 with H_2SO_4 at the end of the day. Additional analyses were performed using in-house laboratories at The University of Texas at Austin. Sulfate, chloride, fluoride, nitrite, nitrate, bromide, and phosphate anion concentrations were measured by ion chromatography (Dionex ICS-2000; Bureau of Economic Geology, University of Texas at Austin). Samples collected during the June and August sampling trips were analyzed within two weeks of collection. Samples collected during the October sample trip were analyzed four months after collection. This delay is believed to have resulted in a higher number of samples with an unacceptable charge balance error (>10% or <-10%) for the October sampling event (see "Quality Control" below).

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[26] For June and August, some duplicate samples were also collected in bulk bottles and pH was subsequently measured 2-9 days later. For October, some duplicate samples were collected in (smaller) bulk bottles and pH was subsequently measured a few hours later. The results are discussed in Appendix H along with the effect of delaying pH measurements. This appendix concludes with a set of recommendations for a sampling procedure and water analyses for Oak Hill Mine.

Major and minor cations were analyzed by an inductively-coupled plasma mass spectrometer (ICP-MS) using collisions and reaction modes reduce interferences (Agilent 7500ce quadrupole; Jackson School of Geosciences, The University of Texas at Austin). August and October samples were analyzed within one month of collection. The June samples were analyzed three months after collection. Both cation and anion samples were chilled to 4 ^{o}C until during storage prior to analysis.

QUALITY CONTROL

Multiple quality control and quality assurance measures were implemented during the collection of the 2013 data set to provide estimates of data precision and accuracy. Lab blanks with ultrapure water were collected during the October sampling event. Two lab blanks were used to confirm that the polyethylene sample bottles were not sources of contamination. All anions were below detection limits (BDL) for the lab blanks except for one measurement 0.01 ppm SO_4. Trace amounts of some cations (Si, V, Ni, Cu, Zn, Ba, Pb) were detected in concentrations. All concentrations were low (parts per billion range). For silicon, one sample was BDL and on was measured at 14 ppb. For zinc, concentrations were 7.4 and 4.2 ppb. For barium, concentrations were 2.5 and 1.0 ppb. The other cation concentrations were measured at less than 1 ppb. These results indicate that the cleaning procedure for sample bottles is sufficient.

Field blanks were also collected during the October sample event to provide a measure of potential cross-sample contamination. Field blanks were collected at the end of two sampling days by pouring ultrapure water into the rinsed bulk collection bottle used to collect water from each well. Field blanks were then collected from the bulk bottle following normal sampling procedures. Chloride and sulfate were detected in both field blanks at 0.01 ppm in one blank and 0.02 ppm in the other. No other anion were detected.

Trace amounts of some cations (Na, Al, Si, K, Ca, V, Fe, Ni, Cu, Zn, Zr, Ba, and Pb) were detected in the ppb range. The highest concentration detected was for Ca (24 and 14 ppb) and Zn (10.57 ppb). Al, V, Ni, Cu, Zr, and Pb concentrations were all under 1 ppb. Na, K, and Ba concentrations were under 10 ppb. As the highest detected concentrations (0.024 mg/L of calcium and 0.02 mg/L of chloride and sulfate) are all quite low in comparison to the concentrations in samples, cross-contamination of samples does not appear to be a problem.

Complete analyses were performed on all samples so that charge balance errors (CBEs) could be computed. Individual CBE results are listed in Appendix F. These results are summarized in Table 4.1 and in the box-and-whisker plots in Figure 4.3. While most acceptable range (excess cations, or conversely, anion deficit). These results emphasize the need for rapid analysis of anions for systems with groundwater samples that are not in equilibrium with the atmosphere. If acidic, dilute, high iron groundwaters such as those at Oak Hill Mine undergo even a limited number of redox or precipitation reactions, the CBE can be greatly affected due to low concentration of total cations and anions.

Summary of CBEs by Sampling Event

Sampling Event	Minimum	25th Percentile	50th Percentile (median)	75th Percentile	Maximum	Count
June	-9.8	-4.9	-2.9	2.5	48.81	21
August	-31.9	-3.6	-1.6	2.9	34.8	46
October	-7.3	-0.8	0.1	8.0	64.2	23
Overall	-31.9	-3.6	-0.7	4.5	64.2	90

Table 4.1: Summary of charge balance errors (CBEs) by 2013 sampling event. Most CBEs are within the acceptable range of +/- 10%.

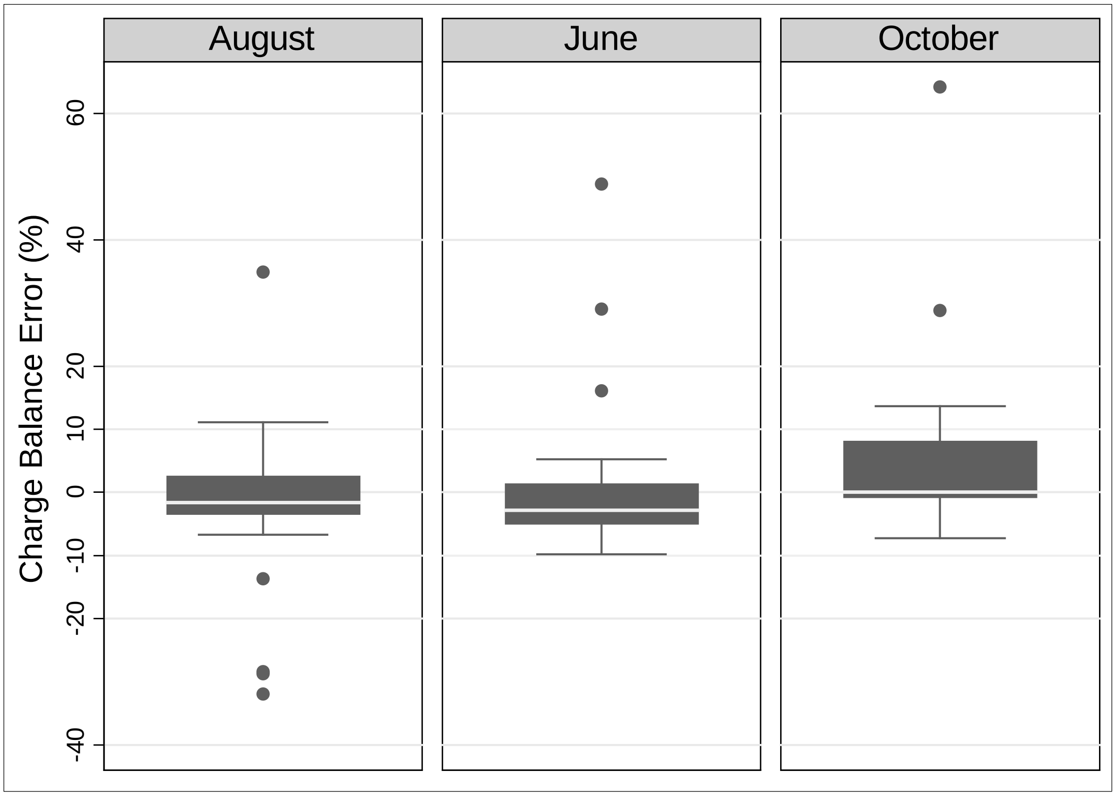

Figure 4.3: Box-and-whiskers plots of charge balance errors by 2013 sampling event. Most CBEs are within the acceptable range of +/- 10%.

Most samples were within a +/-10% charge balance error, 15 (17% of) CBEs exceeded the cut-off value. By month, excessive CBEs were observed in 3 June samples (14%), 7 August samples (15%), and 5 October samples (22%). The larger CBE for the October sampling event is attributed to a mistaken delay in anion analysis, causing anions to be lost through precipitation reactions between collection and analysis for select samples. This conclusion was reached after observing that (1) the samples with the longest delay between collection and IC analysis (October samples) had the highest number of CBEs outside the acceptable range where the samples with the shortest delay. Furthermore, (2) August samples were re-analyzed for anions at the same time as the October samples to provide a control group to observe changes in measure anion concentrations. While similar anion results were reported for most samples, some samples had undergone reactions that resulted in significantly different reported anion concentrations (Table 4.2). Finally, (3) the samples with the shortest delay between collection and IC analysis (August samples) have both positive and negative CBEs outside the acceptable range (excess cations and excess anions, respectively), whereas the other sampling events (June and October) have only positive CBEs outside of the acceptable +/- 10% range. Samples with CBEs that are > +10% or < -10% were identified removed from the 2013 data set and are not included in subsequent analyses except for pH distributions, as pH was measured in the field.

Summary of Effect of Delaying Anions Analysis by 4 months on August Samples		
	Chloride Loss	**Sulfate Loss**
Minimum	1%	1%
Median	5%	6%
Average	6%	9%
Maximum	47%	73%
Greatest 5 losses (%)	47, 16, 11, 10, 6	73, 48, 15, 10, 10

Table 4.2: Summary of the effect of delaying anion analysis by 4 months by comparing the loss of chloride and sulfate anions in a repeated analysis of the August samples. While most samples were relatively stable, a few samples experienced significant chloride and sulfate losses.

For completeness, the indirect data quality assessments performed on the historical data set were also performed on the 2013 data set for the 68 samples that remain after samples with CBEs outside the +/- 10% range are removed. Figures 4.4 and 4.5 show that the concentration of the total dissolved solids (TDS, in mg/L) is higher than subsets of the analytes for each sample. Because TDS was calculated by summing the concentrations of all the analytes, this relationship is true for any subset of analytes. (In contrast, TDS was calculated gravimetrically for the historical data set.) Figure 4.6 illustrates the linear relationship between electrical conductivity (EC) and TDS. The precision of the TDS calculations in the 2013 data set results in less scatter in compared to the graph of EC versus TDS for the historical data set (Figure 3.9).

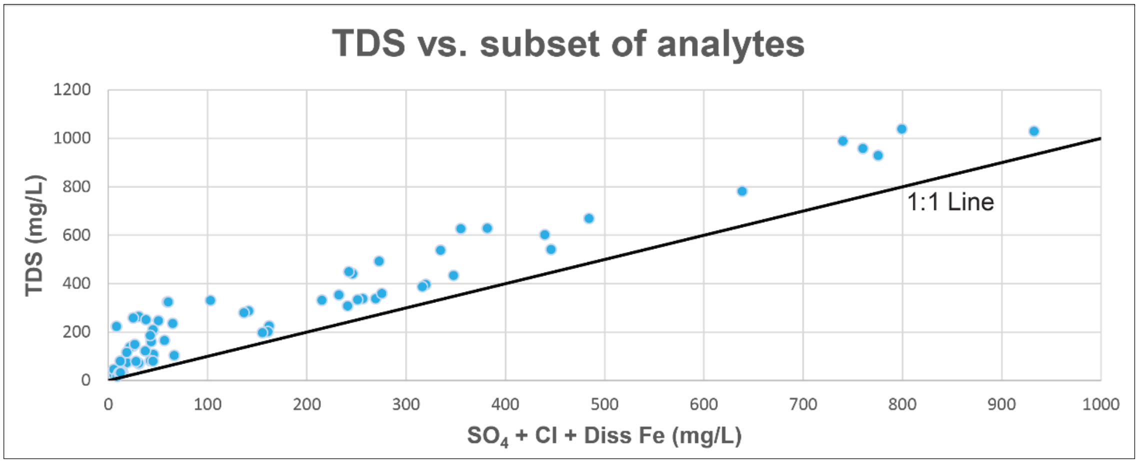

Figure 4.4: Relationship between TDS (mg/L) and a subset of the analytes (sum of SO_4, Cl, and dissolved Fe) similar to Figure 3.7. All 68 samples plot above the 1:1 line as expected.

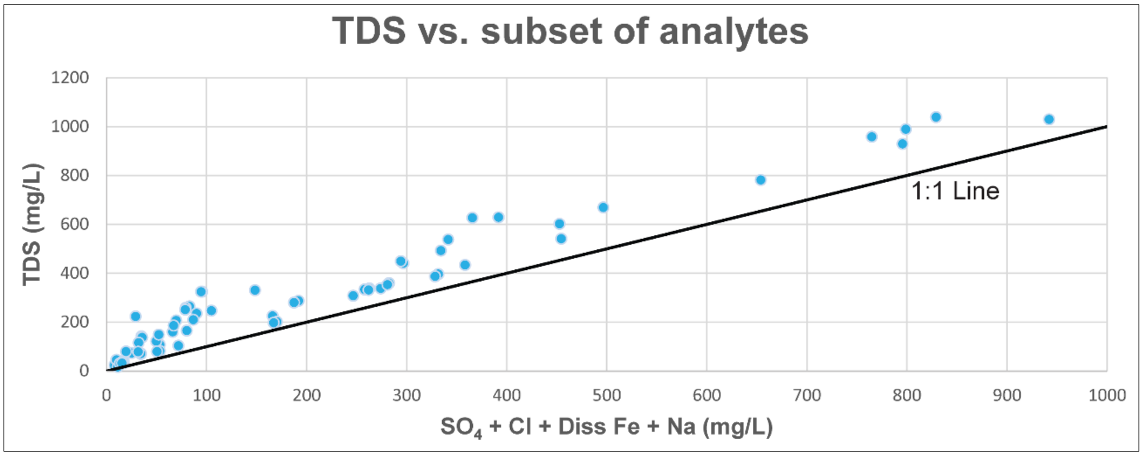

Figure 4.5: Relationship between TDS (mg/L) and a subset of the analytes (sum of SO_4, Cl, dissolved Fe, and Na) similar to Figure 3.8. All 68 samples plot above the 1:1 line as expected.

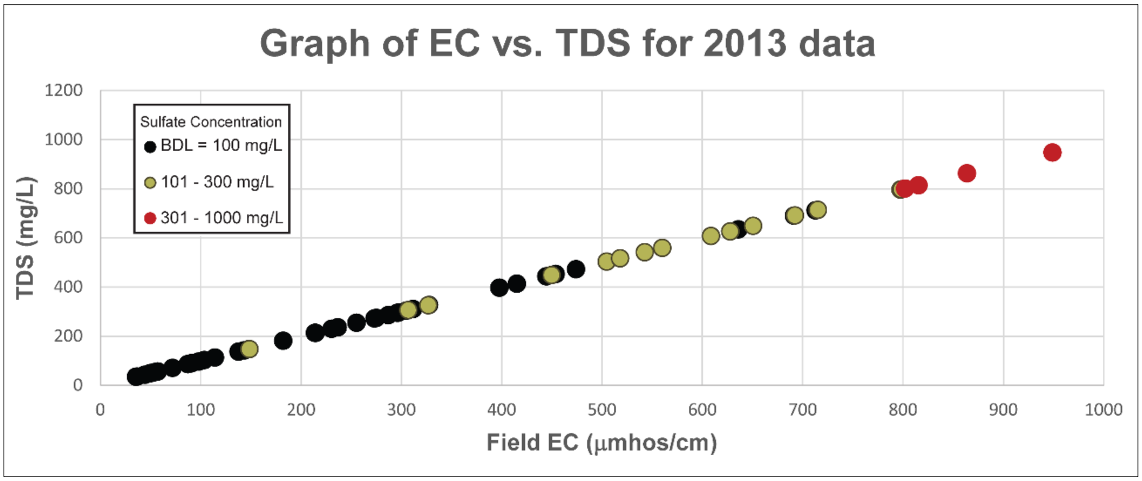

Figure 4.6: Graph of total dissolved solids (TDS, mg/L) versus electrical conductivity (EC, μmhos/cm) for the 68 samples in the 2013 data set. For the 2013 data set, TDS is calculated as the sum of all analyte concentrations.

RESULTS

A copy of the 2013 data set is included in Appendix G. Appendix H discusses the complication of post-collection pH variability in water samples. This issue was discovered during the collection of the 2013 data set but also applies to the historic data set.

pH Distribution of 2013 Data

The pH distribution of the 2013 data set displays patterns for subsets of wells that mimic those patterns observed in the historical data set. When the samples are categories by relative depth, the median overburden sample has an approximate pH of 4.75 whereas the median underburden sample has an approximate pH of 6.25 (Figure 4.7). When the samples are categorized by relative "age" (pre-disturbance, reclamation, or downgradient of mining), the reclamation samples have the lowest median pH (approximately 4.75) whereas downgradient samples have the highest median pH (approximately 6.75) (Figure 4.8). It is interesting to note that, just as with the historical data set, the downgradient samples have a higher median pH than those of the pre-disturbance and the reclamation

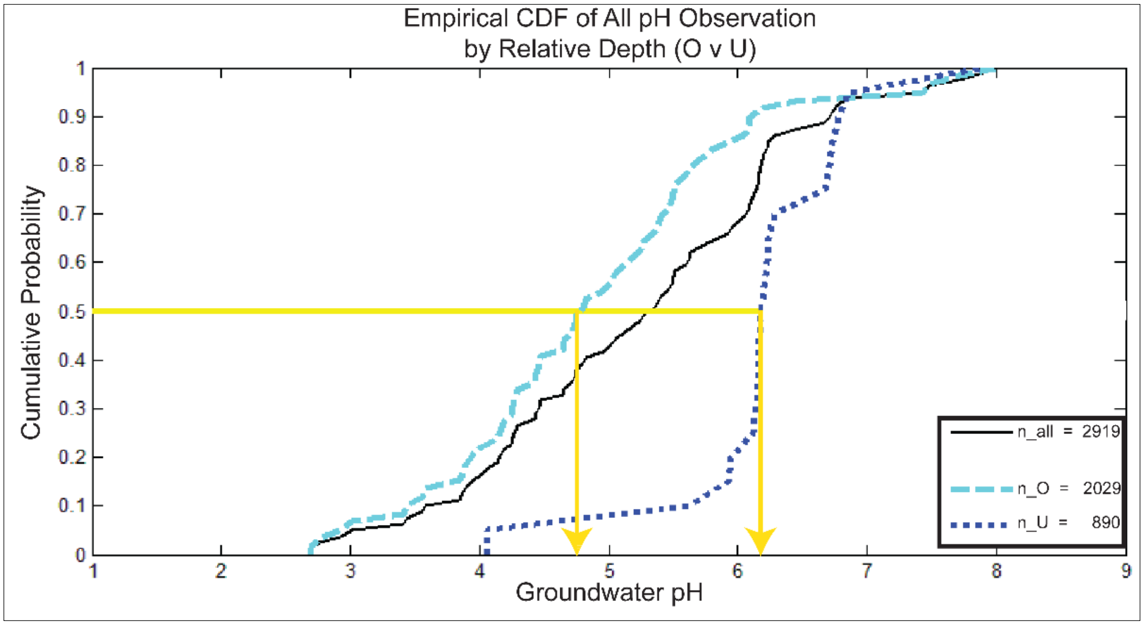

Figure 4.7: Empirical cumulative distribution function (CDF) of pH by relative depth for the 2013 data set. The light blue dashed line is for overburden (O) wells and the dark blue dotted line is for underburden (U) wells.

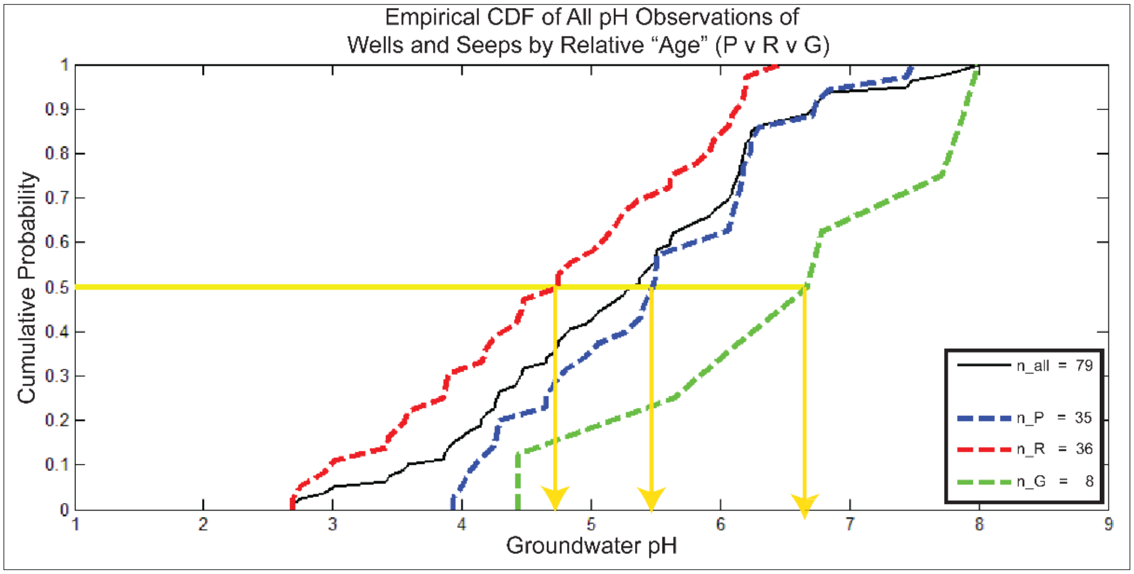

Figure 4.8: Empirical cumulative distribution function (CDF) of pH by relative "age" for the 2013 data set. Relative age categories are: pre-disturbance (P, dark blue line), downgradient (G, green line), and reclamation (R, red line).

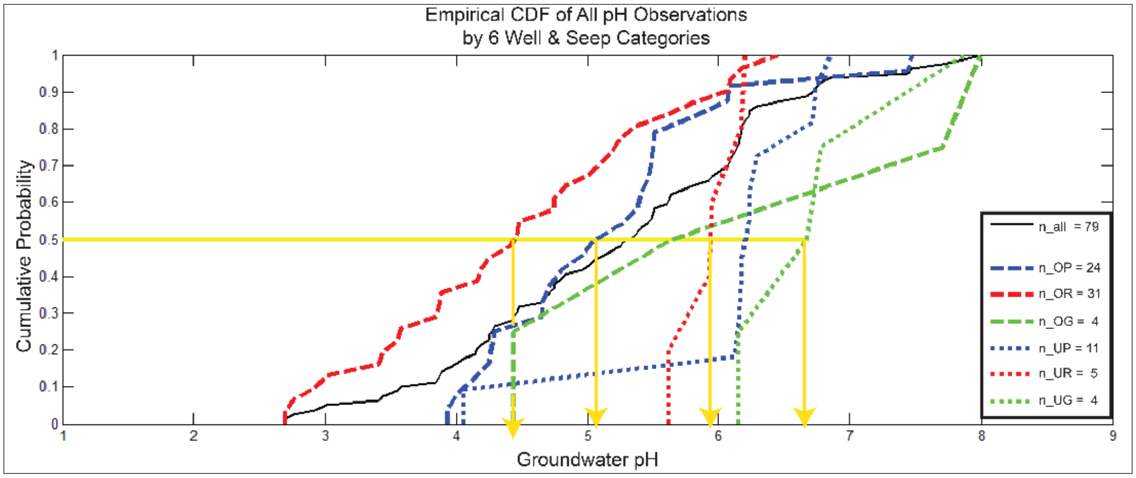

Figure 4.9: Empirical cumulative distribution function (CDF) of pH by relative depth and age for the 2013 data set. Well categories are: overburden pre-disturbance (OP, dark blue dashed line), overburden reclamation (OR, red dashed line), overburden downgradient (OG, green dashed line), underburden pre-disturbance (UP, dark blue dotted line), underburden reclamation (UR, red dotted line), and underburden downgradient (UG, green dotted line).

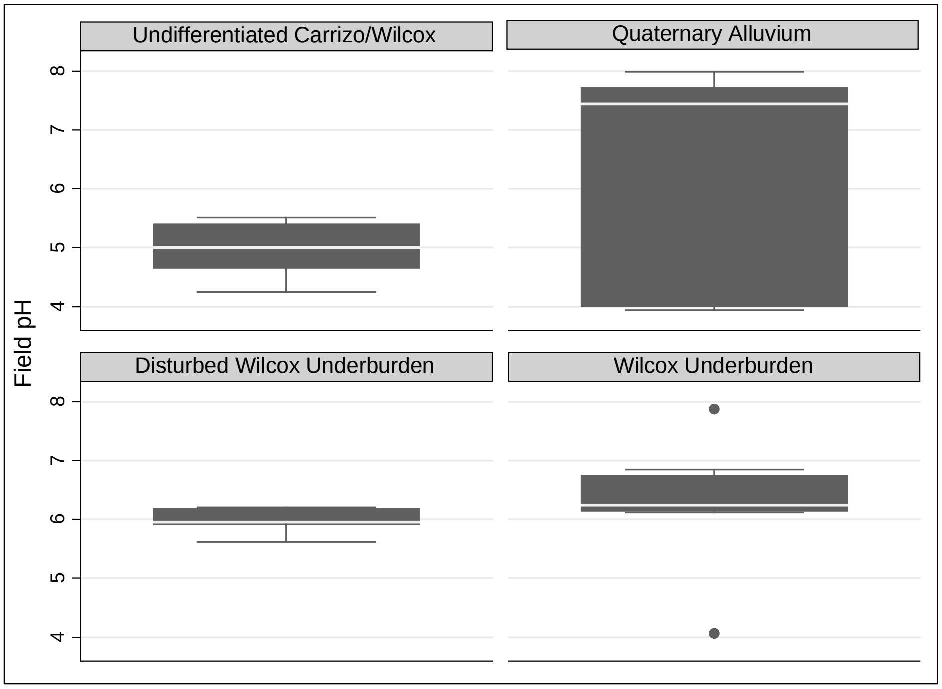

Figure 4.10: Box-and-whiskers plot of well samples by the geologic formation in which the well is screened (where known).

samples. Finally, Figure 4.9 illustrates the pH distribution of the 2013 data set by age and depth for a total of 6 categories. Of these categories, overburden reclamation samples have the lowest median pH of about 4.5 while underburden wells downgradient of mining have the highest median pH of about 6.75.

A box-and-whiskers plot (Figure 4.10) shows that groundwater samples from the undifferentiated Carrizo/Wilcox have a median pH of 5 and a narrow range. Groundwater samples from alluvium have a circumneutral median pH and a wide range. Wilcox underburden samples (both pre-disturbance and reclamation) have a median pH of 6 and about 6.25, respectively.

Piper and Durov Diagrams

Piper and Durov diagrams of the seeps and overburden wells with the major cations (Ca, Mg, and Na + K) and anions (SO_4 and Cl) indicates a large degree of variation among overburden wells, but with some patterns evident (Figures 4.11 – 4.14). Overburden wells are plotted with bicarbonate when present. The Piper diagram of overburden samples by well/seep category (Figure 4.11) shows that overburden reclamation (OR) wells and seeps tend to have higher Ca + Mg and SO_4 percentages whereas overburden pre-disturbance (OP) wells and seeps tend to have higher Na + K and Cl percentages. Overburden downgradient (OG) wells do not appear to be distinct from the OP and OR categories. The Durov diagram of overburden samples by well/seep category (Figure 4.12) shows that reclamation samples have a higher mean and greater variance in TDS. And while there is a significant degree of overlap in groundwater pH measurements for OR and OP samples, the lowest pH samples are found among OR samples while the highest pH samples are found among the OP samples (and one OG sample). As with the Piper diagram, the Durov diagram does not display a unique pattern among the OG samples.

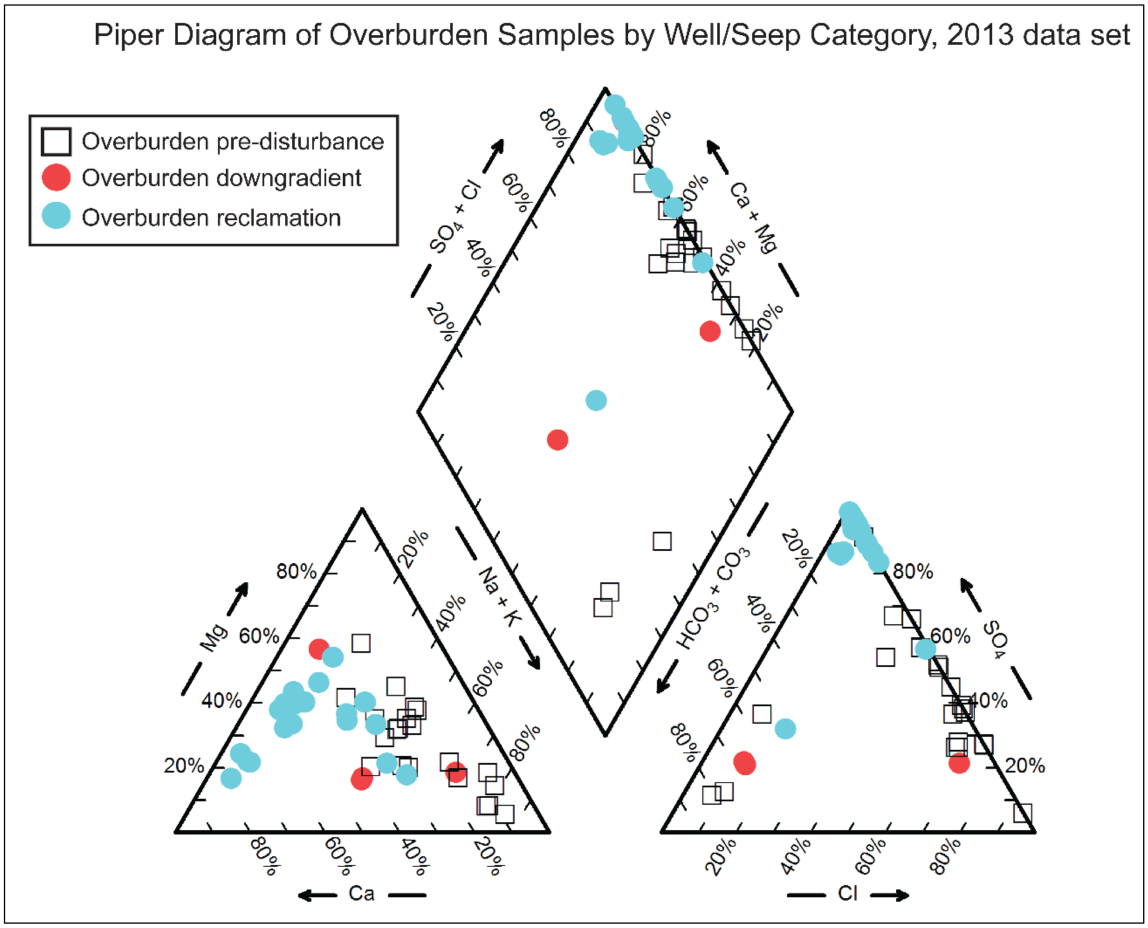

Figure 4.11: Piper diagram of seeps and overburden well samples from the 2013 data set by relative age: white boxes for pre-disturbance, mauve circles for downgradient, and pale blue circles for reclamation.

Piper and Durov diagrams of the seeps and overburden wells by the geology of the screened interval of the monitoring well (not applicable to seeps) also shows certain patterns (Figures 4.13 – 4.14). The Piper diagram (Figure 4.13) shows that alluvium wells resemble undifferentiated Carrizo/Wilcox wells in cations but fall into two distinct groups by anions. One of these alluvium groups has a similar anion pattern as undifferentiated Carrizo-Wilcox wells, but the other group contains a significantly greater percentage of

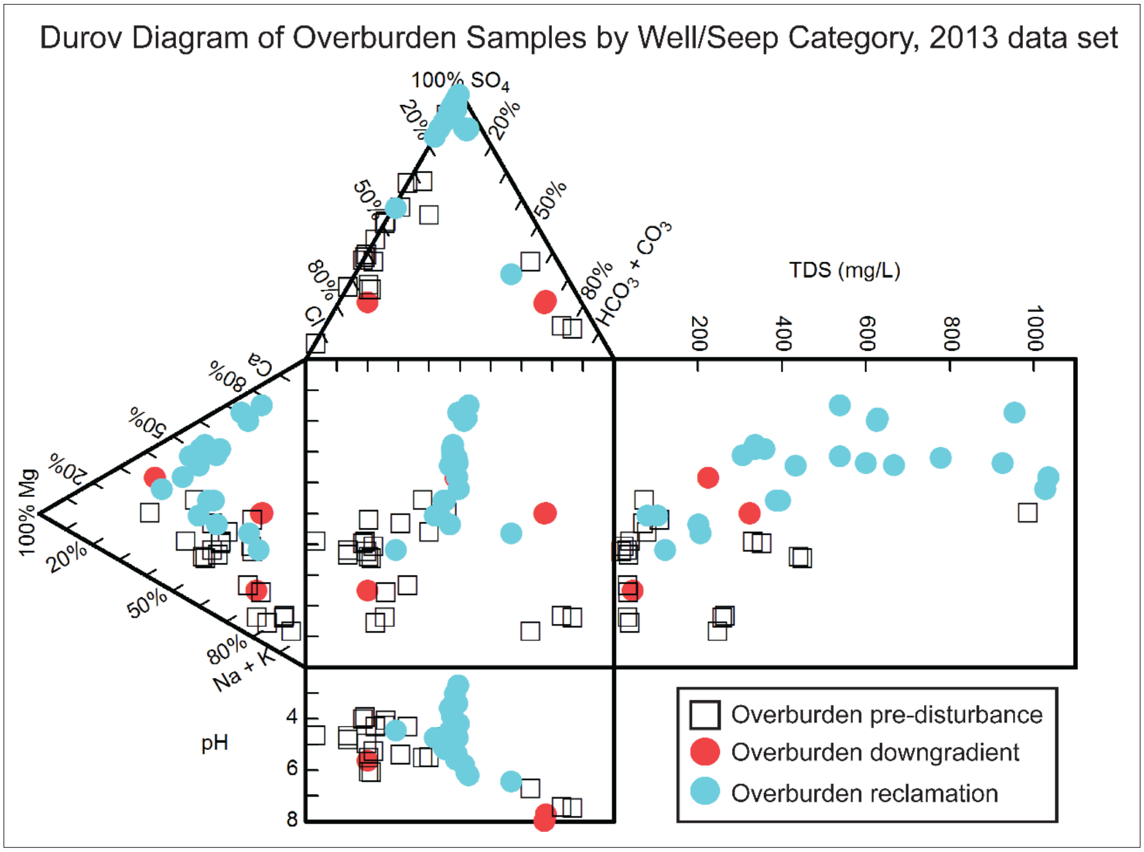

Figure 4.12: Durov diagram of seeps and overburden well samples from the 2013 data set by relative age: white boxes for pre-disturbance, mauve circles for downgradient, and pale blue circles for reclamation.

bicarbonate than any other overburden group. Spoil wells display large variability in cation percentages. Overburden reclamation (spoil) seeps have an anion pattern that is similar to spoil wells and a cation pattern that is similar to the high Mg + Ca / low Na + K spoil wells. Undifferentiated Carrizo/Wilcox (C/Wi) wells do not contain bicarbonate and appear to be influenced by cation exchange between Na and Ca+Mg, typically containing lower Ca percentages than any other category. With only one measurement, it is not possible to determine if the overburden pre-disturbance (OP) seep is most similar to the C/Wi, alluvium, or spoil wells. However, it does have a chemistry that is distinct from the OR (spoil) seeps.

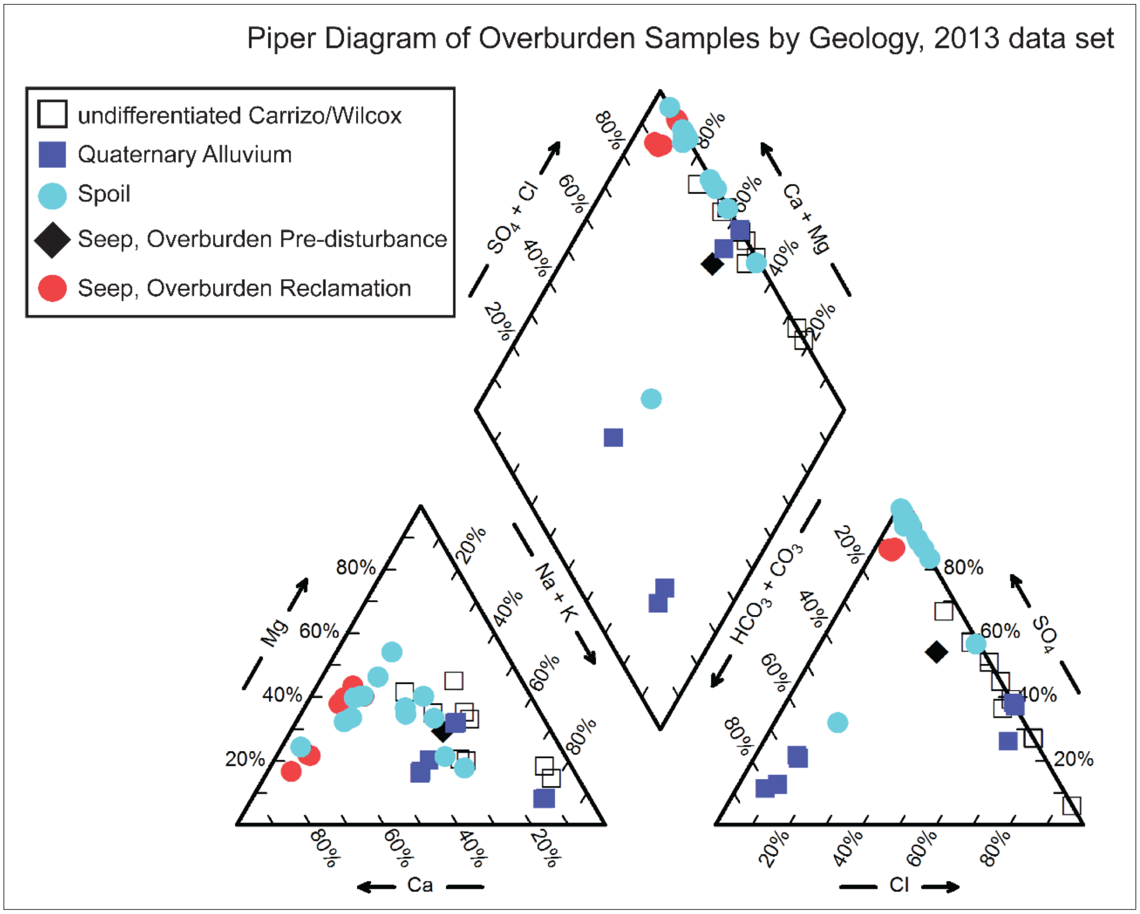

Figure 4.13: Piper diagram of overburden well and seep samples categorized by the geology of the screened interval of the well: white boxes for undifferentiated Carrizo/Wilcox, periwinkle boxes for quaternary alluvium, and cyan for spoil. Seeps are included, but are classified by relative age as the exact flow paths are unknown: black diamond for the overburden pre-disturbance (OP) seep and mauve circles for the overburden reclamation (OR, i.e., spoil) seeps.

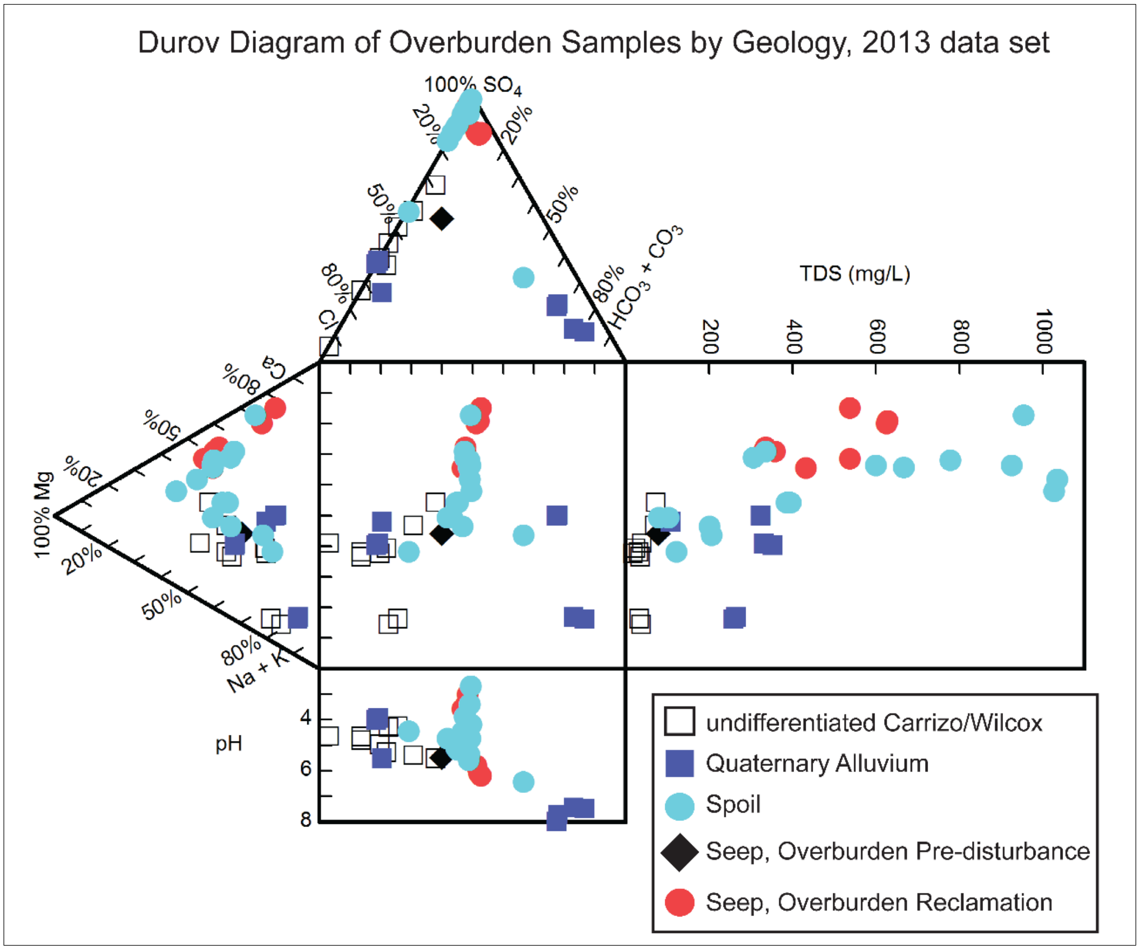

Figure 4.14: Durov diagram of overburden well and seep samples categorized by the geology of the screened interval of the well: white boxes for undifferentiated Carrizo/Wilcox, periwinkle boxes for quaternary alluvium, and cyan for spoil. Seeps are included, but are classified by relative age as the exact flow paths are unknown: black diamond for the overburden pre-disturbance (OP) seep and mauve circles for the overburden reclamation (OR, i.e., spoil) seeps.

The Durov diagram of overburden wells by geology (Figure 4.14) shows a large amount of overlap among pH values, though the lowest pH values occur in overburden reclamation (spoil) seeps and spoil wells; not surprisingly, the highest pH values occur in high bicarbonate alluvium wells. The freshest (lowest TDS) waters are the C/Wi wells and the overburden pre-disturbance seep, which suggests that this seep is most similar to C/Wi wells, which are completed in the SD2 “clean” channel sands. Spoil wells have a larger range TDS range than any other group, though the OR (spoil) seeps and spoil wells appear to have the same mean TDS. The smaller range of TDS observed for OR seeps may be due to the smaller number of seep samples.

Parameter-Parameter Plots

A scatter plot matrix by relative age for overburden wells/seep (Figures 4.15 and 4.16) and underburden wells (Figures 4.17 and 4.18) can be used to survey the general relationships between water quality parameters. For example, Figures 4.16 and 4.18 show that pH appears to be uncorrelated with sulfate for overburden pre-disturbance (OP) wells/seeps but inversely correlated for underburden pre-disturbance (UP) wells and both reclamation categories. Sodium and pH appear to be positively but nonlinearly correlated for OP wells/seeps and possibly for underburden reclamation (UR) wells, but there is no apparent correlation for the other well categories (Figures 4.15 and 4.17). The possible correlations between pH and sodium as well as between pH and sulfate are explored further in Chapter 5. In general, the observation that parameter-parameters correlations vary across well categories suggests that these may be meaningful categories. However, because the 2013 data set contains a smaller number of samples than the historical data set, some well/seep categories (e.g., downgradient wells at both depth) do not contain enough samples to observe any clear parameter-parameter relationship.

With fewer categories, a scatter plot matrix of overburden wells by the geology of the screened interval of the well (Figures 4.19 and 4.20, overburden seeps are included as a separate category) offers a better opportunity to survey parameter-parameter relationships. There may be a weak inverse relationship between pH and sulfate for spoil and alluvium wells, but no relationship is evident for undifferentiated Carrizo/Wilcox

(C/Wi) wells or for overburden seeps (Figure 4.20). There is no apparent relationship between pH and sodium for any category (Figure 4.19). These results suggest that categorizing groundwater sample by geology may not correspond to factors delineating actual groundwater populations. However, the relatively small number of samples (compared to the historical data set) may be obscuring small magnitude relationships between parameters. The significance of geology as a meaningful category is explored further in Chapter 5.

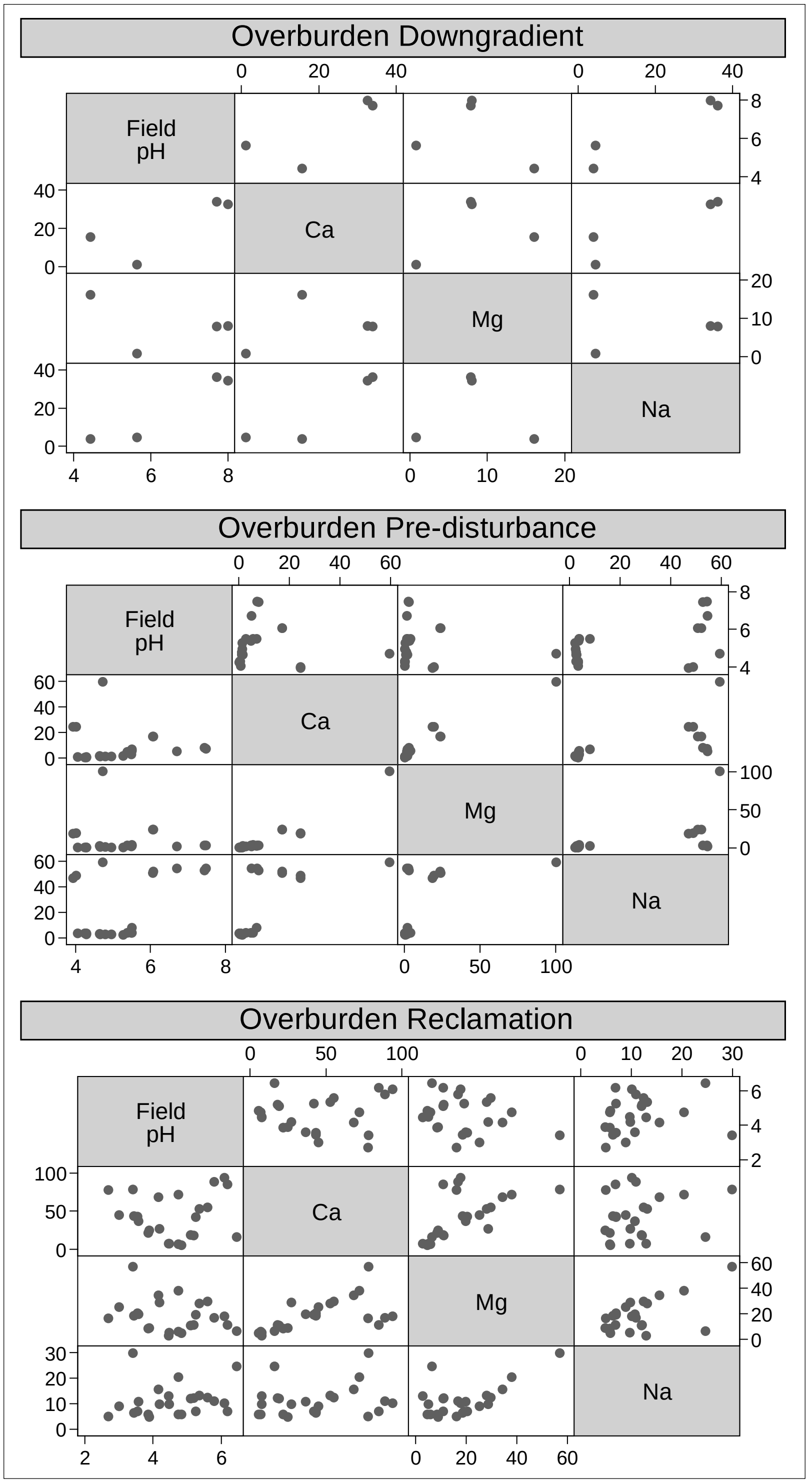

Figure 4.15: Scatter plot matrix of wells and seeps by relative age for overburden wells, showing field pH, Ca, Mg, and Na parameters. Concentrations are in mg/L.

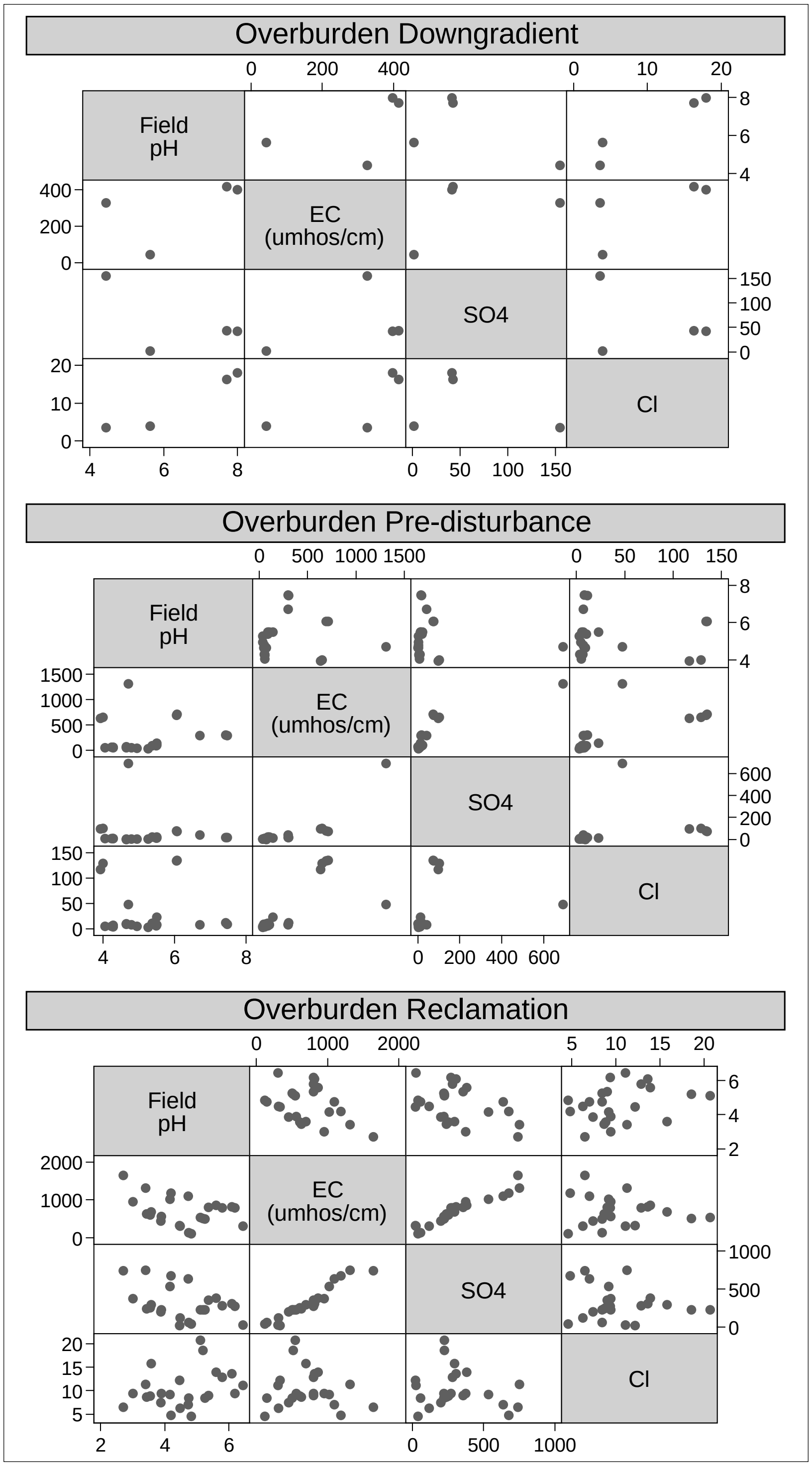

Figure 4.16: Scatter plot matrix of wells and seeps by relative age for overburden wells, showing field pH, EC, SO_4, and Cl parameters. Concentrations are in mg/L.

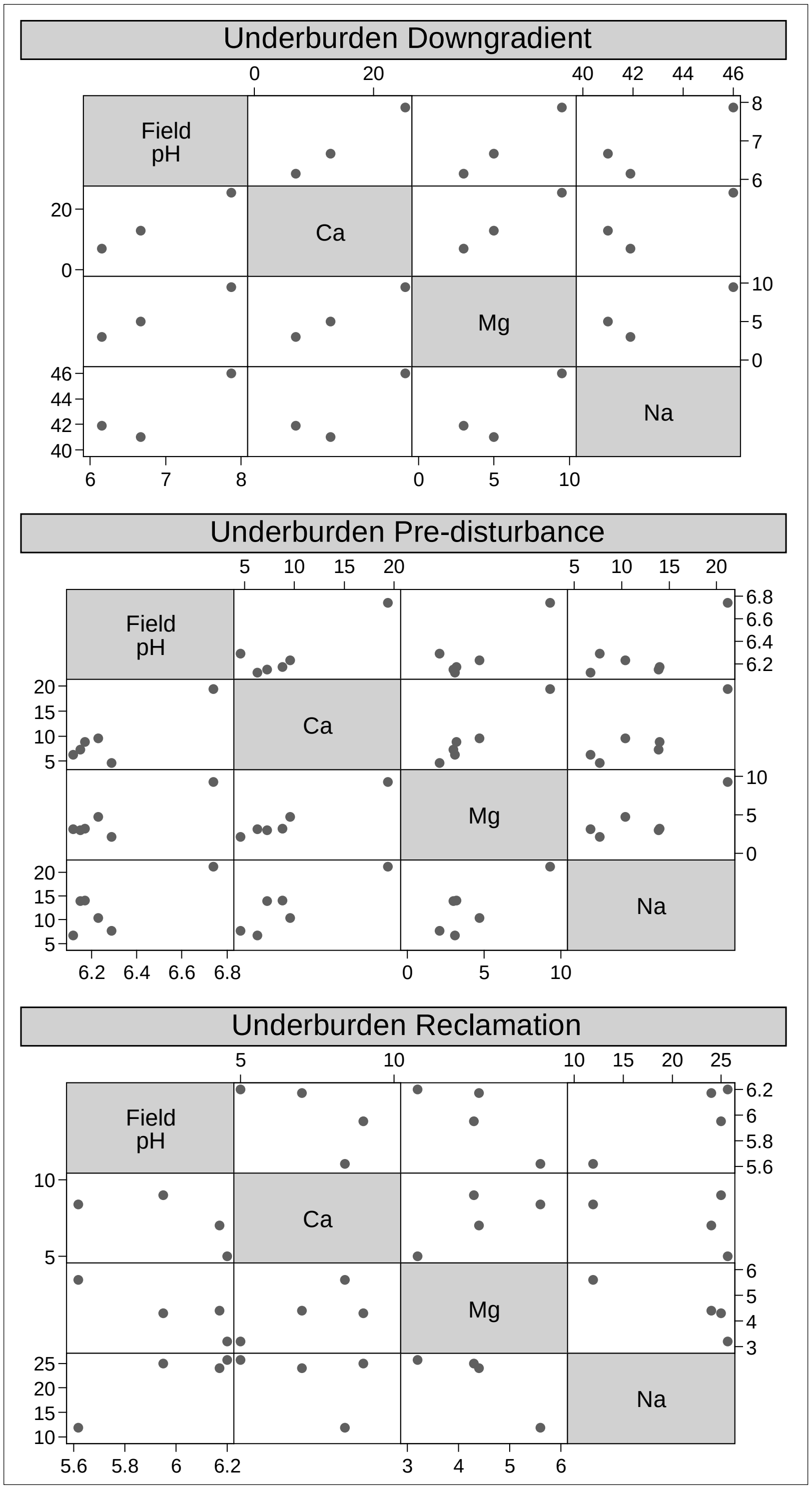

Figure 4.17: Scatter plot matrix of wells and seeps by relative age for underburden wells, showing field pH, Ca, Mg, and Na parameters. Concentrations are in mg/L.

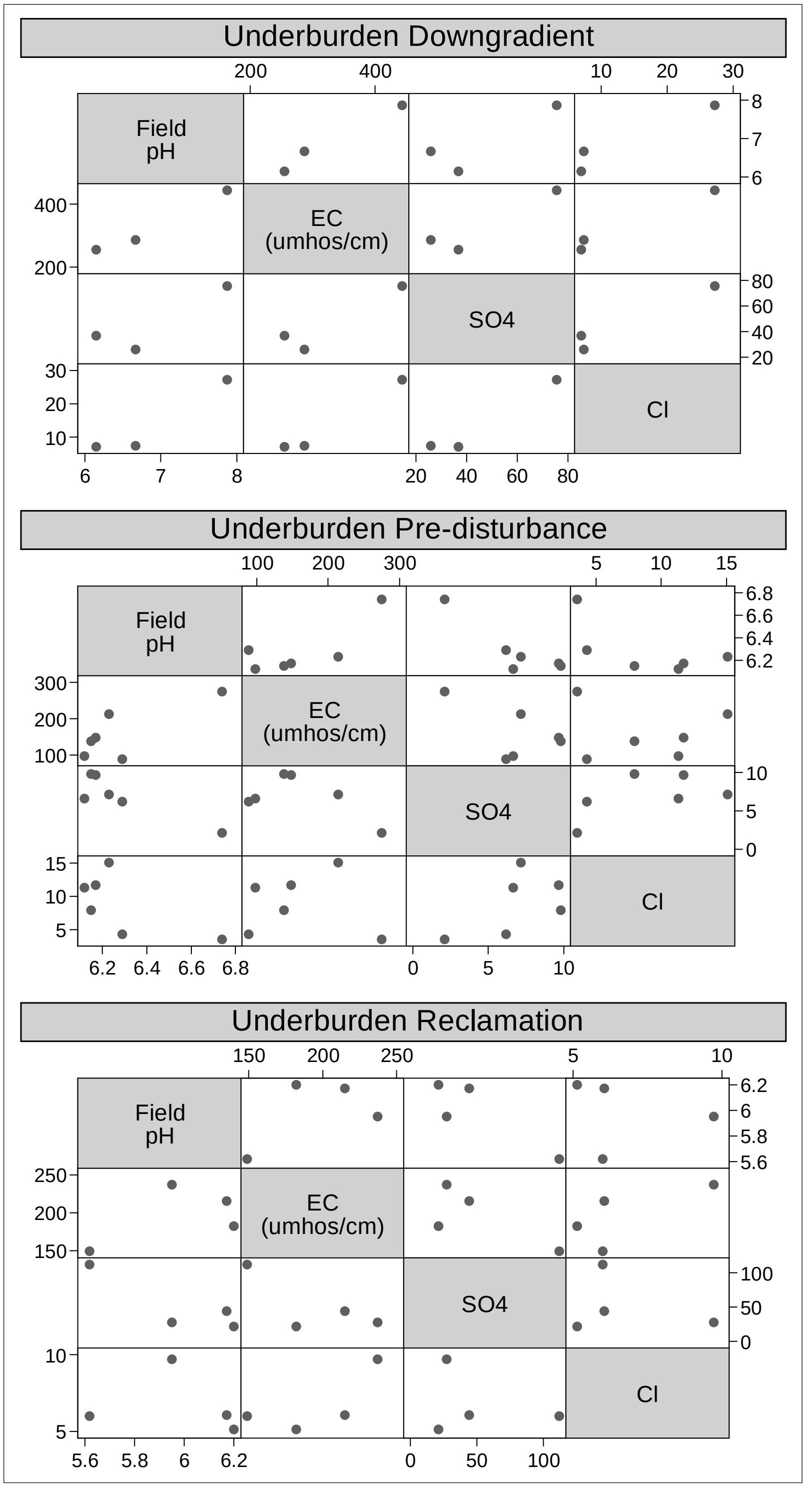

Figure 4.18: Scatter plot matrix of wells and seeps by relative age for underburden wells, showing field pH, EC, SO$_4$, and Cl parameters. Concentrations are in mg/L.

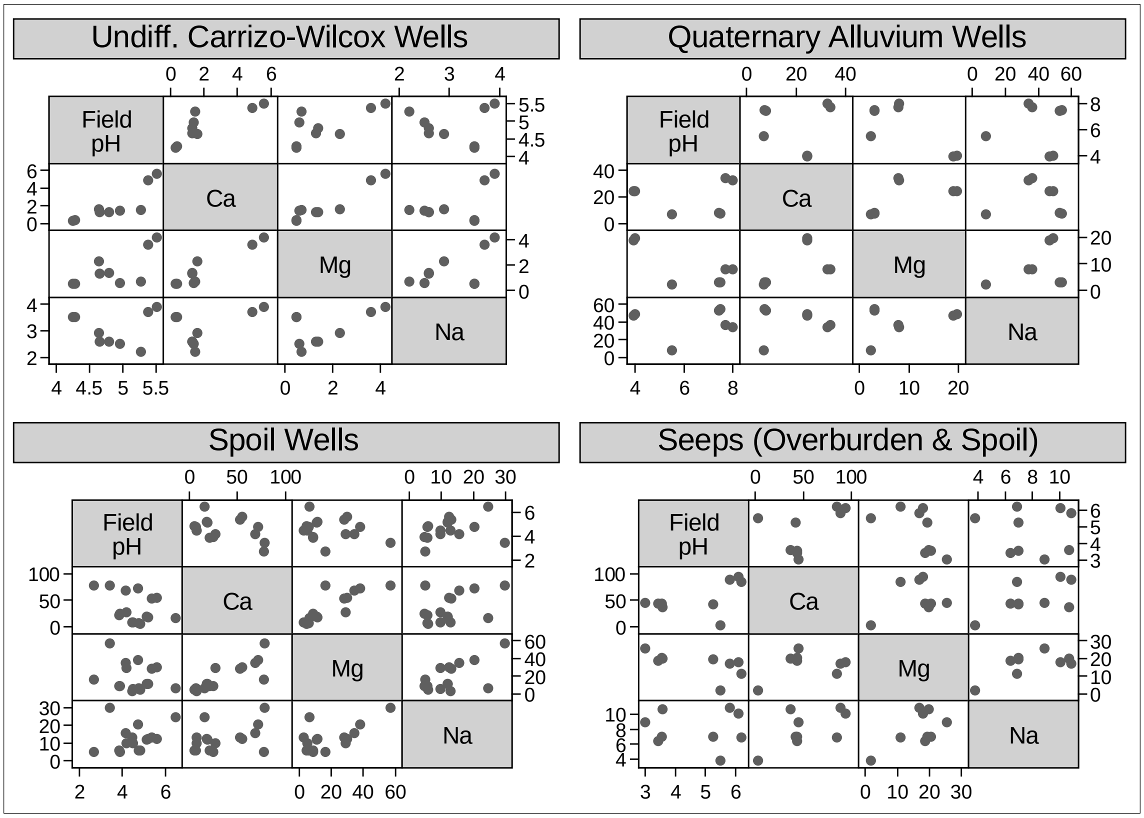

Figure 4.19: Scatter plot matrix of overburden wells by the geology of the screened interval, showing field pH, Ca, Mg, and Na parameters. All concentrations are in mg/L. The upper 2 plots are of overburden pre-disturbance (OP) wells sample. Spoil wells are overburden reclamation (OR) wells. Seeps are plotted together (all seeps but one are in reclaimed areas). Underburden wells and overburden wells of unknown geology are omitted from this figure.

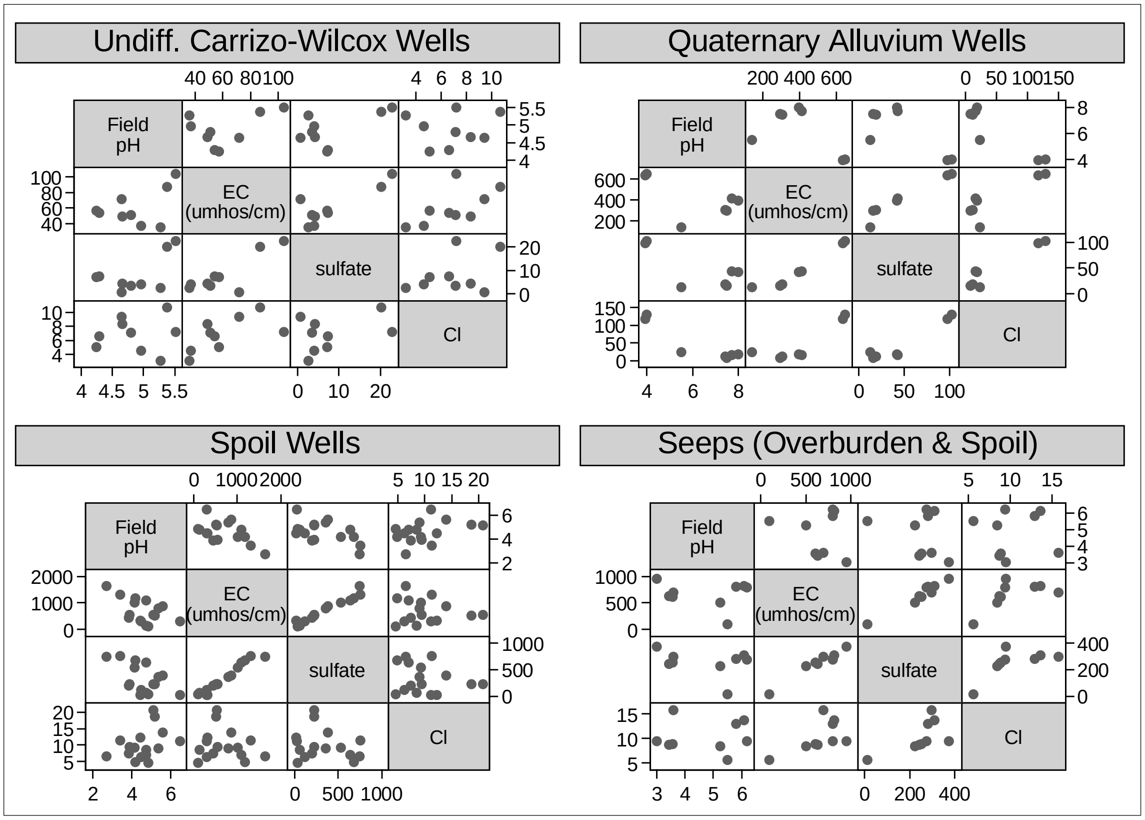

Figure 4.20: Scatter plot matrix of overburden wells by the geology of the screened interval, showing field pH, EC, SO_4, and Cl parameters. All concentrations are in mg/L. The upper 2 plots are of overburden pre-disturbance (OP) wells sample. Spoil wells are overburden reclamation (OR) wells. Seeps are plotted together (all seeps but one are in reclaimed areas). Underburden wells and overburden wells of unknown geology are omitted from this figure.

Chapter 5: Statistical Analysis of the Data Sets

This chapter presents the results of hypothesis testing, median parameter estimation, and multiple linear regression (MLR) analysis of the data. Reasons for using these methods are also discussed. For further reading on the use of statistics for water-related topics, the reader is referred to Helsel and Hirsch (1992), Maidment (1993), and McBride (2005). Kleinbaum et al. (1988) and Stevens et al. (2007) provide practical discussions of various statistical methods. For more information on nonparametric statistics, the reader is referred to Daniel (1990), Conover (1999), and Corder and Foreman (2009).

PART ONE: INVESTIGATING TEMPORAL TRENDS

Importance of trends

Before calculating the confidence interval for the pH medians of well categories or performing hypothesis tests (Part Two), it is important to assess a time-series of pH to look for systematic trends at the timescale of interest. The importance of establishing stationarity (lack of temporal trend in the mean and variance) for a data set depends on the question being asked and the statistical method being employed. For example, air temperature at a given location has daily, seasonal, and multi-year trends. The importance of accounting for one or more of these trends when reporting the average temperature depends on the motivation. To determine whether a eucalyptus tree can grow in Austin, one should calculate average seasonal temperatures (as well as average maximum and minimum temperatures by season). The presence of a long term trend in seasonal temperatures should also be investigated if one wanted the eucalyptus tree to live for many decades. On the other hand, to predict the temperature inside Whirlpool Cave in Austin, one should calculate the average annual temperature, and seasonal trends could be ignored.

Whether one should be concerned about the presence of a long-term trend in average annual temperature would then depend on the timescale of interest.[27]

This study explicitly incorporates one time scale into the categorization of wells (and seep in the 2013 data set) as "pre" or "post" disturbance (viz., pre-disturbance or reclamation). If a multi-year trend were observable in pre-disturbance or reclamation wells, then the comparison of medians would be qualified. Depending on the magnitude of the trend in such a case, it may be more accurate to report and compare the slopes (change in pH per year) for pre-disturbance and reclamation wells rather than the medians.

Figure 3.13 in Chapter 3 shows a time-series of pH for the historical data by well category. It is not obvious if there are any significant temporal trends, but the most suspect categories are the overburden reclamation (OR) wells, underburden pre-disturbance (UP) wells, and the underburden reclamation (UR) wells.

Runs Test for Randomness

Long-term trends in a data set are a form of correlation in which times is one of the variables being analyzed. Statistics used to measure correlation are therefore commonly used to assess a time-series data set for trends. The most commonly used parametric measure of correlation is Pearson correlation coefficient, and the most commonly used nonparametric measures of correlation are Spearman's rank correlation coefficient and Kendall's tau[28] (Daniel, 1990). However, the nature of both data sets – with multiple pH observations per sampling event – would result in a large number of "ties" for the time

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[27] For example, do you want to know how to dress for a caving trip, or do you want to know whether the evolution of flora and fauna has been accompanied (and perhaps driven by) changing air temperature in the cave?

[28] The use Kendall's tau to detect monotonic temporal trends is also called the Mann-Kendall test (Helsel and Hirsch, 1992).

variable as there is no logical order for observations collected during the same sampling event.

Instead, the runs test for randomness is used as it compares each observation to the median rather than to neighboring observations. The runs test is applied to each of the six well categories to test for a monotonic trend, that is, whether pH is increasing or decreasing with time. The application of the same test to subgroups of the same data set is referred to as multiple inferences. Multiple inferences are problematic, and should be avoided when possible because the significance of a test decreases with multiple iterations. The chance of committing a type 1 error (i.e., rejecting a true null hypothesis; a "false positive") for one iteration of a hypothesis test is denoted by the significance level, by α. With multiple repetitions of the test on the same data set, this chance of committing a type 1 error increases.[29] In this case, however, it is necessary to make multiple inferences. The results are shown in Table 5.1. The null hypothesis is that the pH observations are random. The null hypothesis is rejected for underburden pre-disturbance and underburden reclamation wells, confirming the suspicion that these wells have a temporal trend. The null hypothesis is not rejected for overburden reclamation wells at the significance level of $\alpha = .05$ per test, but it would have been rejected if a significance level of $\alpha = .10$ per test had been chosen.

PART TWO: COMPARING PH DATA BETWEEN GROUPS USING NONPARAMETRIC TESTS

In this section, the multivariate nature of the data sets are largely ignored. pH data between groups are compared and median pH values are estimated by group. Nonparametric tests are so-designated because they do not make assumptions about the shape of the population distribution. Some nonparametric tests—such as the medians test described immediately below—also do not assume that groups have equal variance (spread).

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[29] However, the question of how to adjust the significance level for multiple inferences does not have a straightforward answer.

Historical Data Set			Runs Test	
Well Categories	**Count**	**median pH**	**Z**	**p**
All	2919	5.19		
Overburden Pre-disturbance	1001	4.71	-1.04	0.30
Overburden Downgradient	353	5.16	1.33	0.18
Overburden Reclamation	675	4.13	-1.82	0.07
Underburden Pre-disturbance	513	6.28	-4.04	0.00
Underburden Downgradient	191	7.05	0.8	0.42
Underburden Reclamation	186	5.66	-4.37	0.00

Table 5.1: Results of runs tests on samples by well category. Z is the calculated test statistic, and p is the p-value associated with the Z statistic. The null hypothesis, H_o, is that the sample group is free of monotonic trends. H_o is rejected when $p < 0.05$. H_o is rejected for underburden pre-disturbance and underburden reclamation samples.

Confidence intervals for pH Medians

To compare the pH of groundwater among groups, it is helpful to estimate the "location" of pH by group along with a specified confidence interval. The two most common measures of location, or central tendency, are mean and median (Helsel and Hirsch, 1992). Many hydrologists object to using the mean to report the central tendency of pH data as the mean of pH data is actually the geometric mean of H^+ concentration[30], and therefore reporting the mean of pH data along with the mean of other analytes can be misleading. Furthermore, the mean is more susceptible to outliers than the median, which makes the median the preferred metric for reporting the location of pH data.

A two-sided nonparametric prediction interval is calculated using the equation:

$$\text{Prediction Interval (nonparametric)} = \chi_{\alpha/2 \bullet (n+1)} \text{ to } \chi_{[1-\alpha/2 \bullet (n+1)]} \qquad (1)$$

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[30] Recall that $pH = -\log(H^+)$ where H^+ is reported in activity (dimensionless). For practical purposes, the activity of H^+ is approximately equal to the molarity of H^+ in mol/L, or M.

The resulting prediction interval mimics the shape of the distribution of the variable, eliminating the need to assume a normal distribution of the data. Tables 5.2 and 5.3 list the medians and 95% confidence intervals by well/seep category. For the historical data set (Table 5.2), we see that the 95% confidence intervals (CI) of the median pH for overburden pre-disturbance and overburden downgradient wells do not overlap, though both categories overlap with the much wider CI of overburden downgradient median pH. Similarly, the CI of the median pH for underburden pre-disturbance and underburden downgradient wells do not overlap, and neither does that of the underburden downgradient wells. Table 5.3 shows that the much smaller size of the 2013 data set results in larger confidence intervals than for the historical data set. OP, OD, and OR wells all have overlapping CIs. Similarly UP, UD, and UR wells all have overlapping CIs. Due to the much larger sample size of the historical data set, the 95% confidence intervals for the pH medians of the combined data set is essentially the same as the intervals for the historical data set (Table 5.4).

Historical Data Set			**95% confidence interval**	
Well Categories	**Count**	**median pH**	**lower pH**	**upper pH**
All	2919	5.19	5.1	5.3
Overburden Pre-disturbance	1001	4.71	4.7	4.8
Overburden Downgradient	353	5.16	5.0	5.3
Overburden Reclamation	675	4.13	4.1	4.2
Underbuden Pre-disturbance	513	6.28	6.2	6.4
Underburden Downgradient	191	7.05	7.0	7.2
Underburden Reclamation	186	5.66	5.6	5.8

Table 5.2: Sample medians and 95% confidence interval for the population median for the historical data set by well categories.

2013 Data Set			95% confidence interval	
Well and Seep Categories	**Count**	**median pH**	**lower pH**	**upper pH**
All	79	5.36	4.8	5.6
Overburden Pre-disturbance	24	5.16	4.7	5.5
Overburden Downgradient	4	6.68	4.4	8.0
Overburden Reclamation	31	4.46	3.9	5.1
Underbuden Pre-disturbance	11	6.23	6.1	6.7
Underburden Downgradient	4	6.725	6.2	7.9
Underburden Reclamation	5	5.95	5.6	6.2

Table 5.3: Sample medians and 95% confidence interval for the population median for the historical data set by well categories. Boxes with a gray background indicate that the upper confidence limit has been held at the maximum of the samples.

Combined Historical + 2013 Data Set			95% confidence interval	
Well and Seep Categories	**Count**	**median pH**	**lower pH**	**upper pH**
All	2998	5.2	5.1	5.3
Overburden Pre-disturbance	1025	4.72	4.7	4.8
Overburden Downgradient	357	5.16	5.0	5.3
Overburden Reclamation	706	4.14	4.1	4.2
Underbuden Pre-disturbance	524	6.28	6.2	6.3
Underburden Downgradient	195	7.03	6.9	7.2
Underburden Reclamation	191	5.67	5.6	5.8

Table 5.4 Sample medians and 95% confidence interval for the population median for the combined historical and 2013 data set by well categories.

Kruskal-Wallis *H*-Test

The rank sum test is actually a family of related, nonparametric tests. For all rank sum tests, the null hypothesis (H_o) is that the sample groups were drawn from populations with the same median and distribution. The Kruskal-Wallis *H*-test[31] is used for comparing

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[31] . The Kruskal-Wallis *H*-test is also called the Kruskal-Wallis one-way analysis of variance by ranks test and the Kruskal-Wallis equality-of-populations test (Daniel 1990; Corder and Foreman, 2009).

more than two unrelated data sets to see if they come from the same population; it is the nonparametric equivalent of the ANOVA test (Kruskal and Wallis, 1952 and 1953). When only two sample groups are being compared, the equivalent nonparametric tests are the Mann-Whitney *U*-test (for two unrelated of equal or unequal samples) and the Wilcoxon rank-sum test[32] (for two related samples of equal size) (Daniel, 1990; McBride, 2005; Corder and Foreman, 2009). Both the Mann-Whitney and the Wilcoxon tests are the nonparametric equivalents of the family of *t*-tests (e.g., the paired *t*-test). Rank sum tests combine the observations of all sample groups, assigning each observation a rank. Ranks are then summed by sample groups and compared for statistical significance.

To reduce the amount type 1 error due to the use of multiple inferences, the Kruskal-Wallis test is first applied to all six well categories (OP, OG, OR, UP, UG, UR) in the historical data set. The χ^2 value with 5 degrees of freedom is 1378.0, and the probability that H_o is true is ≤ 0.0001. With strong evidence that the pH distribution of at least 1 well category is different from the pH distributions of the other 5 well categories, it is now permissible to conduct two pairwise tests so that the pre-disturbance and reclamations wells can now be tested by depth. For overburden wells (pre-disturbance and reclamation), the χ^2 value with 1 degree of freedom is 141.2, and the probability that H_o is true is just 0.0001. For underburden wells (pre-disturbance and reclamation), the χ^2 value with 1 degree of freedom is 98.8, and the probability that H_o is true is ≤ 0.0001. Therefore, one should reject the null hypotheses in favor of the alternative hypotheses: that the pre-disturbance and reclamation samples were drawn from different populations.

The Kruskal-Wallis *H*-test can also be applied to the overburden pre-disturbance wells for which the geology of the screened interval is known. For example, Pastor,

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[32] The Wilcoxon rank-sum test is also known as Wilcoxon signed ranks test and the Wilcoxon matched-pairs signed-ranks test.

Behling and Wheeler (2008a) state that the Carrizo and overburden Wilcox sands cannot be reliably distinguished in the Oak Hill Mine. Therefore, most wells installed by PBW and screened in overburden sands are classified “C/Wi” (undifferentiated Carrizo/Wilcox). However, Hall Southwest (1990, 1991) typically distinguishes between Carrizo and Wilcox overburden wells with clean sands identified as a Carrizo layer. Similarly, this researcher identified thick sand units as part of the Carrizo when consulting hydrogeologic maps constructed by Hall Southwest (Chapter 3). A statistically significant result from a Kruskal-Wallis test for C/Wi and Carrizo overburden wells would indicate that these wells should not combined into one category. H_o is that the samples are drawn from populations with the pH distribution (these may in fact be the same population). The χ^2 with 1 degree of freedom is 0.201; the corresponding probability that H_o is true is 0.65. The null hypothesis cannot be rejected.

The Median Test

The K-sample equality-of-medians test (also known more simply as the medians test) is used to test if two or more sample groups are drawn from populations with equal medians (Wilcoxon, 1945). For two sample groups, the medians test is merely an application of the binomial distribution sign test to the median parameter (Conover, 1999), though other distributions can be used to compute and evaluate the test statistic (Daniel, 1990). The expansion of this test to more than two sample groups is an application of the chi-square test of homogeneity (Daniel, 1990). In the median test, the null hypothesis (H_o) is that the sample groups were drawn from populations with the same median value. H_o is tested by comparing the observations in the sample groups to the grand median (median calculated from the combined observations of all the groups). This test can compare two more samples, and samples need not contain the same number of observations. The median test uses less information than the Kruskal-Wallis test. The former tests only the location (median) of the sample groups, whereas the latter tests both the location (median) and distribution (shape and range) of the sample groups. Sample groups with the same location (median) but differently shaped distributions (e.g., normal, bimodal, log-normal) will fail the Kruskal-Wallis test but pass the median test. Thus, to test whether the median pH is different for OP vs. OR and for UP vs. UR (irrespective of changes in distribution shape), the medians test is appropriate.

To reduce the amount type 1 error due to the use of multiple inferences, the median test is first applied to all six well categories (OP, OG, OR, UP, UG, UR) in the historical data set. The Pearson $\chi^2 = 1200$, the probability that H_o is true is ≤ 0.001. H_o is therefore rejected. With strong evidence that at least 2 of the 6 well categories come from populations with unequal medians, it is permissible to test for differences in the two sets of “pre” and “post” disturbance wells. Applying the median test to overburden pre-disturbance (OP) and overburden reclamation (OR) wells yields a Pearson χ^2 of 100.2; the corresponding probability that H_o is true is ≤ 0.001. Applying the median test to underburden pre-disturbance (UP) and underburden reclamation (UR) wells yields a Pearson χ^2 of 67.1; the corresponding probability that H_o is true is ≤ 0.001. For both the overburden and underburden pairs, we reject the null hypotheses in favor of the alternative hypotheses: that the pre-disturbance and reclamation samples were drawn from medians with different medians.

PART THREE: MULTIPLE LINEAR REGRESSION

Regression is the use of one or more input (independent, explanatory) variables to predict the value of an output (dependent, response) variable.

Benefits of multiple linear regression

Linear regression models are parametric in that they do make assumptions about certain parameters describing the distribution of a variable. Specifically, regression models make assumptions about the distribution of the errors, which are the differences between the predicted value of a response (dependent) variable and explanatory (independent) variables.[33] In other words, errors are the unexplained variation of a regression model. Thus, whereas parametric hypothesis tests make assumptions about the distribution of variables, regression models make assumptions about the errors.

To perform a regression analysis on the Oak Hill Mine groundwater data, therefore, one does not need to ensure that the pH measurements are normally distributed or stationary over time. Instead, the errors of a proposed regression model are analyzed. Errors are assumed to be independent and have constant variance. These assumptions are easily tested using diagnostic plots of the residuals against independent variables (residuals versus parameters plots) and against predicted pH (residuals versus fitted plot). Systematic clustering of the residuals, or an increasing/decreasing of the observed variance of the residuals, indicates that the model assumptions have been violated (Kleinbaum et al., 1988; Stevens, et al., 2007).

Main effects and interactions terminology

The two types of effects that variables can exert on the response variable in multiple linear models are “main effects” and “interactions”. A main effect is the effect that an independent variable exerts on all response variables. The rate of change of the response variable to the independent variable (slope) is fixed regardless of the value of the other

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[33] “Errors” and “residuals” are used interchangeably in this chapter. Technically, errors are the unexplained variance in the mathematical model that are estimated by the residuals calculated from the actual data.

independent variables. In contrast, the rate of change of the response variable to the independent variable in an interaction is a function of some other independent variable. Interactions are modeled by adding the product of the two interacting independents variables to the MLR model.

Discussion of available variables

Because of the incomplete nature of the water sample analyses in the historical data set, there is a trade-off between the number of analytes that can be considered for an MLR model and the number of observations desired for model conditioning. 789 samples have pH, EC, SO_4, Cl, Na, and dissolved Fe. 413 samples have pH, EC, SO_4, Cl, Ca, Mg, Na, K, and dissolved Fe. (Ca, Mg, and K occur as a set of analytes; filtering for all of the samples with Ca also selects all of the samples with Mg and K measurements.) To determine whether Ca, Mg, or K are meaningful analytes, an MLR model is developed without these variables using the larger data set. The resulting model is then applied to a combined data set of historical and 2013 data containing Ca and Mg to explore the significance of these analytes.

Development of a multiple linear regression model from the historical data set

An examination of an overall covariance matrix (Table 5.5) provides a framework for determining which variables are related to pH and therefore should be considered as “main effects” for the MLR model. From Table 5.5, it appears that either Fe or SO_4 and either Cl or Na should be included as main effects in the MLR model. The minimum value for consideration in an MLR model is 0.10, making SO_4, Cl, Na, and Fe candidates for an MLR model. However, SO_4 and Fe are strongly collinear (covariance = 0.847); including both variables in the MLR model may result in a lack of statistical significance for one or both of these variables. Similarly, Cl and Na are moderately collinear (covariance =

0.659); it may be necessary to include only one of these two variables so as to maintain the statistical significance of each variable in the MLR model.

An examination of covariance matrices by well category (Table 5.6) provides some guidance as to whether interactions exist between the continuous variables and this categorical variable. Table 5.6 shows that EC and Na are positively correlated with pH for all well categories except for OR wells, where a large negative correlation exists. Iron is negative correlated with pH for all well categories except underburden reclamation. SO_4 is positively correlated with pH for underburden wells but negatively correlated for overburden wells. Chloride is positively correlated with pH for pre-disturbance and downgradient wells but negatively correlated with pH for reclamation wells. In fact, all parameters are negatively correlated with pH for overburden reclamation wells. However, as these relationships are derived from only 5 UR samples drawn from 1 well, it is not clear whether these relationships represent a general trend for UR wells. In general, the presence of changes in analyte correlations (including changes from direct to inverse correlation) indicates that dimensionless analyte ratios are candidates as a new set of explanatory variables.

The initial MLR model (Equation 2) includes only the categorical dummy variables for relative depth (overburden and underburden), and relative age (pre-disturbance, reclamation, and downgradient):

$$\text{Predicted pH} = 4.83 + 1.95 * X_{\text{underburden}} - 0.13 * X_{\text{reclamation}} + 0.22 * X_{\text{downgradient}} \tag{2}$$

In this initial model (Equation 2), the overall F statistic is statistically significant with $p < .0001$ and all variables are statistically significant with $p < .0001$. The coefficient of determination (R^2) is 0.47 and the adjusted coefficient of determination (adj-R^2) is 0.47.

Covariance Matrix of All Samples						
	pH	EC	SO_4	Cl	Na	Fe
pH	1					
EC	0.053	1				
SO_4	-0.193	0.906	1			
Cl	0.260	0.353	0.093	1		
Na	0.601	0.602	0.319	0.659	1	
Fe	-0.251	0.769	0.847	-0.022	0.123	1

Table 5.5 Covariance matrix for the 789 samples in the historical data set containing pH, EC, SO_4, Cl, Na, and dissolved Fe.

Covariance Matrix By Well Category													
Overburden Pre-disturbance							Underburden Pre-disturbance						
	pH	EC	SO_4	Cl	Na	Fe		pH	EC	SO_4	Cl	Na	Fe
pH	1						pH	1					
EC	0.14	1					EC	0.49	1				
SO_4	-0.04	0.86	1				SO_4	0.33	0.91	1			
Cl	0.11	0.47	0.44	1			Cl	0.36	0.93	0.85	1		
Na	0.42	0.80	0.70	0.65	1		Na	0.52	0.93	0.90	0.83	1	
Fe	-0.06	0.26	0.29	0.11	0.12	1	Fe	-0.40	-0.19	0.00	-0.19	-0.22	1
Overburden Downgradient							Underburden Downgradient						
	pH	EC	SO_4	Cl	Na	Fe		pH	EC	SO_4	Cl	Na	Fe
pH	1						pH	1.00					
EC	0.44	1					EC	0.44	1.00				
SO_4	-0.10	0.74	1				SO_4	0.39	0.82	1.00			
Cl	0.20	0.34	0.01	1			Cl	0.31	0.21	0.32	1.00		
Na	0.74	0.81	0.28	0.47	1		Na	0.81	0.52	0.43	0.08	1.00	
Fe	-0.23	0.43	0.82	0.02	0.00	1	Fe	-0.52	-0.87	-0.82	-0.20	-0.55	1
Overburden Reclamation							Underburden Reclamation						
	pH	EC	SO_4	Cl	Na	Fe		pH	EC	SO_4	Cl	Na	Fe
pH	1						pH	1					
EC	-0.68	1					EC	0.90	1				
SO_4	-0.65	0.97	1				SO_4	0.96	0.90	1			
Cl	-0.66	0.27	0.21	1			Cl	-0.15	-0.44	-0.16	1		
Na	-0.52	0.93	0.92	0.11	1		Na	0.77	0.96	0.77	-0.66	1	
Fe	-0.63	0.84	0.79	0.38	0.71	1	Fe	0.27	0.24	0.00	-0.01	0.23	1

Table 5.6 Covariance matrix for the 789 samples in the historical data set containing pH, EC, SO4, Cl, Na, and dissolved Fe, by well category.

R^2 is an approximate measure of how much variation in the response variable (pH) is explained by the categorical, or factor, variables (relative depth and age).

In the initial model (Equation 2), the categorical variables of relative depth and relative age are represented by dummy variables: $X_{underburden}$, $X_{reclamation}$, and $X_{downgradient}$. Dummy variables are binary variables that take a value of 0 or 1. The baseline for this model (all dummy variables = 0) is overburden pre-disturbance, and the predicted pH for the baseline is equal to the intercept, 4.83. The effect of relative depth is given when $X_{underburden} = 1$; for underburden wells, the predicted pH is 1.95 higher than pre-disturbance wells (the baseline level, when $X_{underburden} = 0$). The effect of relative age is given when $X_{reclamation} = 1$ or when $X_{downgradient} = 1$. The baseline level is pre-disturbance wells ($X_{reclamation} = 0$ and $X_{downgradient} = 0$). The effect of the reclamation level ($X_{reclamation} = 1$) is to decrease pH by 0.13 compared to baseline (pre-disturbance). The effect of the downgradient level ($X_{downgradient} = 1$) is to increase the pH by 0.22 compared to baseline (pre-disturbance).

To develop a more complicated MLR model from this initial model, continuous variables are added only when they improve the adjusted coefficient of determination or when they can be used to replace a categorical variable (thereby giving insight into the "work" being done by that variable). Subsequent attempts to add continuous variables — informed by the possible flushing, dissolution, precipitation, and ion exchange reaction discussed in Chapter 2— yield unsatisfactory models.

Dimensionless analyte ratios are given in Table 5.7 for all samples in and in Table 5.8 by well category. EC, Na, SO_4, and Fe are divided by Cl concentration, yielding, yielding dimensionless ratios, with the exception of EC/Cl.[34] Table 5.8 shows that, for

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[34] Though the EC/Cl ratio is not dimensionless, it could be made so by converting EC to TDS. However, EC was not converted as it would not improve the statistical significance of EC as an explanatory variable, EC is dropped as a candidate for the MLR model in favor of other variables.

overburden wells, both SO4/Cl and Fe/Cl ratios are inversely correlated to pH, though this correlation is weak for OP samples. UR samples have positive correlations between both ratios and pH; but recall that only 5 UR samples from 1 well are present in this data set. Na/Cl is positively correlated with pH for all but the OR samples, though the magnitude of this correlation is small for UP samples.

Motivated by these observations about analyte ratios, an MLR model using dimensionless ratios is used to describe the factors effecting pH at Oak Hill Mine:

$$\text{Predicted pH} = 4.35 + 2.28*(X_{\text{underburden}}) + 0.86*(X_{\text{Na/Cl}}) - 0.08*(X_{\text{SO4/Cl}})$$
$$+ 0.05*(X_{\text{reclamation}})*(X_{\text{SO4/Cl}}) - 0.68*(X_{\text{underburden}})*(X_{\text{Na/Cl}}) \qquad (3)$$

The categorical variables of relative depth and relative age are represented by dummy variables: $X_{\text{underburden}}$ and $X_{\text{reclamation}}$, Dummy variables are binary variables that take a value of 0 or 1. $X_{\text{Na/Cl}}$ and $X_{\text{SO4/Cl}}$ are ratios with a theoretical range of 0 to infinity. The overall F statistic is statistically significant with $p < .0001$ and all terms are individually statistically significant with $p < .001$. The coefficient of determination is 0.65 and the adjusted coefficient of determination is 0.65. Visual inspection of diagnostic plots of the residuals as a function of predicted pH, SO_4/Cl, and Na/Cl indicate that the residuals are homoscedastic and independent, as required by model assumptions (Appendix I). A plot of the model residuals as function of absolute time (Figure 5.1) suggests that the residuals may not independent with respect to time for the 1984 – 1989 observation, which would violate an assumption of the model. The correlation coefficient is 0.0821. However, adding absolute time (as a main effect and/or with interactions between time and the categorical variables) does not improve the randomness of the residuals> When the main effect and both interactions are added, the correlation coefficient for residuals with absolute time (date) increases to 0.0945, which is slightly worse than the residuals of the model

Covariance Matrix of All Samples					
	pH	EC/Cl	Na/Cl	SO_4/Cl	Fe/Cl
pH	1				
EC/Cl	-0.11	1			
Na/Cl	0.45	0.57	1		
SO_4/Cl	-0.21	0.94	0.43	1	
Fe/Cl	-0.22	0.84	0.32	0.84	1

Table 5.7 Covariance matrix for the analyte ratios with pH for the 789 samples in the historical data set containing pH, EC, SO4, Cl, Na, and dissolved Fe.

Covariance Matrix By Well Category											
Overburden Pre-disturbance						**Underburden Pre-disturbance**					
	pH	EC/Cl	Na/Cl	SO_4/Cl	Fe/Cl		pH	EC/Cl	Na/Cl	SO_4/Cl	Fe/Cl
pH	1					**pH**	1				
EC/Cl	-0.05	1				**EC/Cl**	0.01	1			
Na/Cl	0.47	0.48	1			**Na/Cl**	0.05	0.89	1		
SO_4/Cl	-0.23	0.82	0.29	1		**SO_4/Cl**	-0.06	0.62	0.69	1	
Fe/Cl	-0.02	0.30	0.10	0.34	1	**Fe/Cl**	-0.39	0.07	0.07	0.17	1
Overburden Downgradient						**Underburden Downgradient**					
	pH	EC/Cl	Na/Cl	SO_4/Cl	Fe/Cl		pH	EC/Cl	Na/Cl	SO_4/Cl	Fe/Cl
pH	1					**pH**	1				
EC/Cl	0.18	1				**EC/Cl**	-0.05	1			
Na/Cl	0.64	0.59	1			**Na/Cl**	0.45	0.73	1		
SO_4/Cl	-0.20	0.80	0.24	1		**SO_4/Cl**	0.00	0.90	0.65	1	
Fe/Cl	-0.22	0.49	0.05	0.75	1	**Fe/Cl**	-0.51	-0.11	-0.16	-0.29	1
Overburden Reclamation						**Underburden Reclamation**					
	pH	EC/Cl	Na/Cl	SO_4/Cl	Fe/Cl		pH	EC/Cl	Na/Cl	SO_4/Cl	Fe/Cl
pH	1					**pH**	1				
EC/Cl	-0.43	1				**EC/Cl**	0.64	1			
Na/Cl	-0.26	0.94	1			**Na/Cl**	0.50	0.99	1		
SO_4/Cl	-0.48	0.96	0.91	1		**SO_4/Cl**	0.82	0.92	0.86	1	
Fe/Cl	-0.38	0.84	0.75	0.80	1	**Fe/Cl**	0.27	0.15	0.13	-0.01	1

Table 5.8 Covariance matrix for the analyte ratios with pH for the 789 samples in the historical data set containing pH, EC, SO4, Cl, Na, and dissolved Fe, by well category.

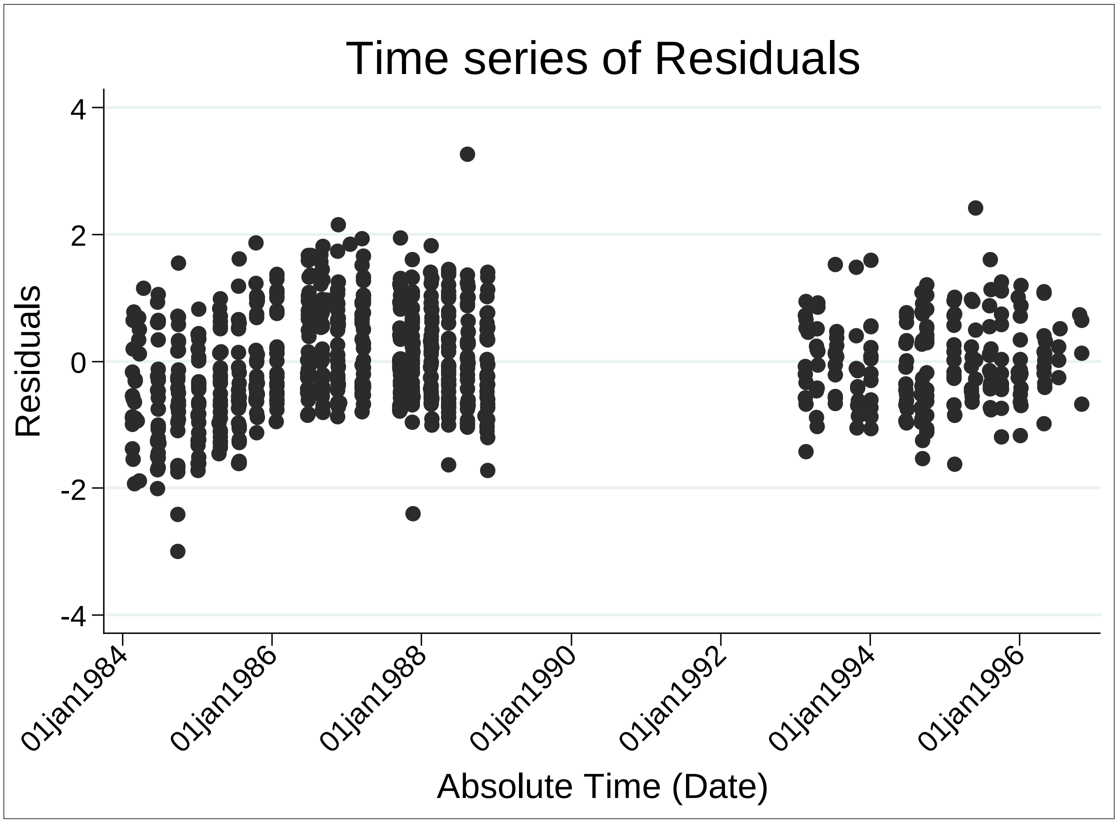


Figure 5.1: Plot of residuals of MLR model versus absolute time (date).

without time. Given the limited number of regularly measured analytes in the historical data set, it is concluded that Equation 3 gives the best model that can be developed from the available data.

Investigation of Ca and Mg using a combined data set

To answer the question of whether Ca and Mg would have improved the model if they had been available, the MLR model developed above is applied to a combined data set consisting of the 62 observations from the 2013 data set and the 413 observations from the historical data set with Ca and Mg measurements. If a pattern exists between the residuals and either of these variables, then that variable could be used to reduce the unexplained variation of pH. Both Ca and Mg and the Ca/Cl and Mg/Cl ratios are positive correlated with the residuals for the combined data set. These correlations are particularly strong for Ca and Mg in underburden samples.

Though the correlation between the residuals of the MLR model in Equation 3 with Ca and Mg suggests that these variables should be added to the model, but the additional explanatory power of adding Ca to the MLR model is not great. Ca and Mg cannot be jointly added to the model due to their high degree of collinearity (Tables 5.9 and 5.10). The largest increase in the coefficient of determination is from .60 to .67 when Ca and an interaction term for Ca with reclamation samples are jointly added to the model. Both terms are statistically significant. The Ca main effect is positively correlated with pH. However, the interaction with reclamation is negative and results in an overall negative correlation between Ca and pH for reclamation wells.

The coefficient of determination increases only slightly less (from 0.60 to .66) when ratio of calcium to chloride is used instead of calcium. All terms are statistically significant. The Ca/Cl main effect is positively correlated with pH. The interaction with reclamation is negative but of lesser magnitude than the main effect. As a result, the overall correlation between Ca/Cl and pH for reclamation wells is positive by decreased in magnitude by the value of the interaction term (0.49 – .46 = 0.03). The resulting model is given in Equation 4:

$$\begin{aligned}\text{Predicted pH} = {} & 4.25 + 2.35*(X_{\text{underburden}}) + 0.55*(X_{\text{Na/Cl}}) + 0.49*(X_{\text{Ca/Cl}}) \\ & - 0.09*(X_{\text{SO4/Cl}}) - 0.46*(X_{\text{reclamation}})*(X_{\text{Ca/Cl}}) \\ & + 0.07*(X_{\text{reclamation}})*(X_{\text{SO4/Cl}}) - 0.76*(X_{\text{underburden}})*(X_{\text{Na/Cl}})\end{aligned} \qquad (4)$$

An improvement on the model given in Equation 4 was attempted for overburden pre-disturbance (OP) and overburden downgradient (OG) samples by adding a categorical variable for the geologic unit in which the well is screened (Quaternary alluvium, Reklaw, Carrizo, undifferentiated Carrizo/Wilcox, and overburden Wilcox). However, the incorporation of either Ca or Ca/Cl into a statistical model is a more powerful explanatory variable than well geology. The adjusted-R^2 is not improved by incorporating dummy variables for geology or by incorporating an interaction term between a dummy variable for geology and a continuous variable. This result suggests that the same set of chemical reactions involving Ca, Na, and SO_4 can be used to explain how natural weathering of these overburden geologic units influences groundwater pH. Differences in pH due to natural weathering are due to differences in the rate of weathering reactions (which are already incorporated into the model as changes in Ca/Cl, Na/Cl, and SO_4/Cl ratios) rather than as differences in type of weathering reactions.

Covariance Matrix of All Samples					
	pH	**Ca**	**Mg**	**Ca/Cl**	**Mg/Cl**
pH	1				
Ca	0.23	1			
Mg	0.17	0.93	1		
Ca/Cl	0.15	0.91	0.86	1	
Mg/Cl	0.12	0.88	0.90	0.97	1

Table 5.9 Covariance matrix for the analyte ratios with pH for the 2013 data set and the historical data set containing Ca and Mg.

Covariance Matrix of All Samples By Depth					
Overburden					
	pH	Ca	Mg	Ca/Cl	Mg/Cl
pH	1				
Ca	0.19	1			
Mg	0.14	0.94	1		
Ca/Cl	0.17	0.95	0.87	1	
Mg/Cl	0.13	0.92	0.91	0.97	1
Underburden					
	pH	Ca	Mg	Ca/Cl	Mg/Cl
pH	1				
Ca	0.69	1			
Mg	0.65	0.94	1		
Ca/Cl	-0.06	-0.04	-0.04	1	
Mg/Cl	-0.17	-0.15	0.00	0.85	1

Table 5.10 Covariance matrix for the analyte ratios with pH for the 2013 data set and the historical data set containing Ca and Mg, by relative depth (overburden and underburden).

SUMMARY

Most well categories appear to be free of significant monotonic trends (increasing or decreasing pH over time). However, underburden pre-disturbance (UP) and underburden reclamation samples failed the runs test, indicating the presence of a monotonic trend that is present at the $\alpha = 0.05$ significance level. Close inspection of the time-series of pH for the historical data by well category (Figure 3.13) shows that the UP samples collected during the first baseline study in 1984-1986 have a higher pH range and median than subsequence samples. This pattern is attributed to a naturally higher pH in the southern portion of the Oak Hill Mine area, where the 1984-1986 baseline study was conducted for the Permit 22 study area. 1984-1986 UP wells have a pH range that resemble the pH of underburden downgradient (UG) wells, most of which are located in the same Permit 22 study area of Oak Hill Mine (Figure 3.5). (Similar for OG range and OP range for 1984-1986 samples)

Mining activities are associated with a decrease in groundwater pH for both overburden and underburden wells. The results from the Kruskal-Wallis *H*-test show that the pH distributions of overburden pre-disturbance and overburden reclamation samples are different and that the pH distributions of underburden pre-disturbance and underburden reclamation samples are different. The results from the median test show that the median pH of overburden pre-disturbance and overburden reclamation samples are different and that the median pH of underburden pre-disturbance and underburden reclamation samples are different. The 95% confidence interval for the median pH of overburden pre-disturbance (OP) samples is 4.7 to 4.8, indicating that groundwater at Oak Hill Mine was acidic (<6.0 pH) prior to mining activities. The 95% confidence interval for the median pH of overburden reclamation (OR) wells is 4.1 to 4.2, indicating that mining activities has changed the median groundwater pH by approximately -0.5 standard units. Underburden pre-disturbance (UP) groundwater has a median pH of 6.2 to 6.3 at the 95% confidence interval, and underburden reclamation (UR) groundwater has a median pH of 5.6 to 5.8 at the 95% confidence interval, indicating that mining activities also decrease the pH of underburden groundwater. Estimates of the median pH by well category are summarized in Table 5.4 for the combined historical and 2013 data set.

Multiple linear regression (MLR) modeling shows that Na/Cl is positively correlated with pH whereas SO_4/Cl is negatively correlated with pH. The positive correlation between Na/Cl may indicate that Ca derived from clay or bicarbonate weathering is displacing Na on cation exchange sites. Ca released to groundwater (from pH-buffering reactions) would thus result in an increase in Na and Na/Cl. SO_4/Cl is negatively correlated with pH due to the oxidative dissolution of pyrite, which increases SO_4/Cl and decreases pH.

Chapter 6: Conclusions and Discussion

CONCLUSIONS

1. Low pH (<6.0) groundwater observed prior to mining disturbance is not due to natural weathering of the Reklaw Formation. This conclusion is supported by Figure 3.14, in which the median pH for Reklaw wells (about 5.5) is higher than the median pH of samples from the undifferentiated Carrizo-Wilcox, the Carrizo Sand, and the overburden Wilcox Group. Though no Reklaw groundwater samples were collected in the 2013 data set, samples from undifferentiated Carrizo/Wilcox wells have a median pH of 5.0.
2. Low pH (<6.0) groundwater was not an isolated phenomenon within the mine. The cumulative distribution function of samples by well category for the historical data set (Figures 3.10 and 3.12) shows that the median pH for all overburden samples is below a pH 6. Indeed, the 95% confidence intervals for the median pH of overburden pre-disturbance, downgradient, and reclamation wells are 4.7 – 4.8, 5.0 – 5.3, and 4.1 – 4.2, respectively (Table 5.4).
3. Groundwater pH has changed as a result of mining. The cumulative distribution function of samples by well category for the historical data set (Figure 3.12) shows that overburden reclamation samples have lower pH for every quantile than overburden pre-disturbance samples. A similar pattern is observed in underburden samples. The 95% confidence intervals for overburden reclamation wells and overburden pre-disturbance wells do not overlap, nor do the intervals for underburden reclamation and underburden pre-disturbance wells (5.6 – 5.8 and 6.2 to 6.4, respectively) (Table 5.4). These results are confirmed by the results of the Kruskal-Wallis and medians tests.

4. Overburden and underburden downgradient (OG and UG) wells have a higher pH distribution than overburden and underburden pre-disturbance (OP and UP) wells, respectively because downgradient wells are located primarily in the original Permit 22 study area (southern portion of the present Oak Hill Mine, Figure 3.5). The 1984-1986 pre-disturbance samples were collected in the same Permit 22 study area as part of the baseline study the first Oak Hill Mine permit application. The strong similarity between the downgradient samples to the 1984-1986 pre-disturbance samples (Figure 3.13) provides further evidence that the higher pH distribution of the downgradient wells compared to pre-disturbance wells (Figures 3.12 and 4.9) is the result of the location of downgradient wells in the southern portion of the Oak Hill Mine.

DISCUSSION

Effect of overburden geology on water quality

Local geology plays a significant role in influencing groundwater pH. In the historical and 2013 data sets, the pH medians of Carrizo, undifferentiated Carrizo/Wilcox, and overburden Wilcox samples are low (4.25-5.0) (Figures 3.14 and 4.10). The median pH of Reklaw Formation samples is about 5.5 (Figure 3.14). The median pH of quaternary alluvium samples is 5.75 in the historical data set and 7.25 in the 2013 data set (Figures 3.14 and 4.10). From the Piper and Durov plots by geology (Figures 3.17 and 3.18), one sees that alluvium wells tend to have high pH and a high percentage of Ca cations compared to Mg and Na + K. Equation 3 in Chapter 5 shows that Ca/Cl (but also Ca) is positively correlated to pH. This pattern is attributed to higher $CaCO_3$ alkalinity in alluvium groundwater samples derived from the weathering of a combination of clay minerals and calcite in alluvium materials. (It is worth noting that the texture of the alluvium in the screened intervals is classified as mixed, a conglomerate category for silty sand, clayey sand, or sandy silt.)

Carrizo and Wilcox samples have higher SO_4/Cl ratios than Reklaw and Qal samples (Figure 3.17). Cl is a conservative anion; therefore, Cl concentrations must remain constant or increase as groundwater flows from recharge points on topographic highs (including Reklaw-capped hills) through the Carrizo and Wilcox to discharge point. In other words, the increase in the SO_4/Cl from the Reklaw to deeper formations is due not to a Cl sink but to SO_4 source. Specifically, SO_4/Cl increases are attributed to a gain in sulfate derived from the lower formations and not from leaching of the Reklaw Formation. Equations 3 and 4 in Chapter 5 show that the SO_4/Cl ratio is inversely correlated with pH, which is expected from the oxidative dissolution of pyrite (Chapter 2). Therefore, it is concluded that pyrite weathering within the Carrizo and Wilcox units is the mechanism that increases acidity and decreases pH in these units compared to the pH of Reklaw groundwater.

Extent of low pH groundwater

Although low pH pre—disturbance groundwater is not an isolated phenomenon within Oak Hill Mine, the systematic increase in pH for downgradient overburden and underburden wells in both the historical data set (Figures 3.11 and 3.12) and the 2013 data set (Figures 4.8 and 4.9) is noteworthy. These wells are located within the mine and are not closer to mine boundaries than pre-disturbance wells (Figure 3.5). The observations might suggest that acidic groundwater is naturally buffered along shallow and intermediate flowpaths. However, the downgradient wells are located in the southern portion of the mine only, between Oak Hill Mine and Henderson (Permit 22 study area; Figures 3.5 and 4.1). One should exercise caution in generalizing about donwgradient pH along shallow and intermediate flowpaths originating in the northern portion of the mine, which do not intersect the area monitored by the downgradient wells.

pH instability and measurements

Groundwater pH at Oak Hill Mine is not stable over time (Appendix H). Post collection, groundwater pH tends to decrease and the variance (spread) of the change tends to increase over time It is hypothesized that these changes are due to oxygen-driven redox reactions within the sample, resulting in a drop of pH over time as oxygen is consumed and H^+ released (e.g., Chapter 2, Equations 11-13). However, the repetition of pH distribution patterns in well categories between the historical data set and the 2013 data set indicates that the ensemble of pH data is sufficiently reliable so as to infer general patterns about pH distributions between well categories (OP, OG, OR, UP, UG, UR) and well geology (Qal, Reklaw, Carrizo, C/Wi, or overburden Wilcox). Though general patterns in pH distributions are preserved, the uncertainty of individual pH measurements and the variance of pH in sample groups is increased by this instability. It is hypothesized that this effect is at least partially responsible for the inability to model more than about 65% of the variation in pH (recall that the adjusted coefficient of determination is 0.65 for the final MLR model given in Equation 3 in Chapter 5).

ADDITIONAL RESEARCH

In many groundwater systems, the transition from oxidizing, recently recharged groundwater to reducing, aged groundwater corresponds to the decay organic matter along groundwater flowpaths. The quantity and reactivity of organic carbon plays a large role in the location of the subsurface redox boundary. In a groundwater system such as Oak Hill Mine, however, both lignite (organic carbon) and pyrite (reduced iron sulfides) are available to be oxidized (reducing materials). Organic carbon and pyrite could be viewed as “competitors” for dissolved oxygen in groundwater as the oxidization of either material consumes oxygen. However, the oxidative dissolution of pyrite also generates large amount of H^+ acidity and is therefore undesirable (Chapter 2). Future research could investigate the relative significance of pyrite and lignite as reducing materials in an undisturbed setting at Oak Hill Mine in comparison with a disturbed setting (spoil heap). Furthermore, the effect of incorporating varying amounts of organic material (e.g., lignite rider seams) in the shallow spoil could be tested in column experiments to investigate whether the increased availability of organic material for oxidation reduces the overall rate of pyrite oxidative dissolution.

Historical data sets similar to the one for Oak Hill Mine exist for all recent lignite mines in Texas. As Oak Hill Mine is the only mine categorized as “acid ferruginous” in the state (Chapter 2), it may well asked whether the conclusions of this study apply to other lignite mines in Texas. Therefore, it would be worthwhile for future research to investigate the pH distributions among well categories and well geology at multiple lignite mines in Texas to see if the same patterns exist at all mines. Of course, such an investigation should be sensitive to the significant differences in geology and lignite quality for mines that produce from Wilcox Group lignite as opposed to Jackson Group lignite.

Appendices

APPENDIX A: WELLS IN HISTORICAL DATA SET

The below table describes the 97 wells used for pH distribution descriptions in Chapter 3. With the exception of wells 89-2-OB (#96) and R-4(S) (#97), which contain no EC data, data from these wells are also used for multiple linear regression analysis in Chapter 5. "Well no." refers to the arbitrary well number assigned for this study. Completion date described the date that the well was originally installed. "Well category" contains information about the relative depth (overburden or underburden) and relative "age" (pre-disturbance, P, downgradient, G, or reclamation, R) of the well. "Well Geology" describes the geology and texture of the screened interval and the surface geology, where these data are known. For "Screen Interval Geology", Carrizo refers to Carrizo Sand, C/Wi refers to undifferentiated Carrizo/Wilcox, Wilcox means Wilcox Group, WUB means Wilcox Group underburden, Dist'd WUB means disturbed Wilcox Group underburden (for UR wells), Qal means Quaternary alluvium, and unk means that the geology is unknown. For "Screen Texture", SD2 is a clean channel sand unit (high conductivity), "mix" refers to silty sand, clayey sand, or sandy silt, "n/a" refers to spoil wells, which were not logged during installation, and "unk" stands for unknown texture. The location is given in northing and easting for the state plane coordinate system (Texas north-central zone).

Well ID		Completion Date	Well Category			Well Geology			Location	
Well Name	Well No.		O/U	P/G/R	W.C.	Screen Interval Geology	Screened Interval Texture	Surface Geology	Northing	Easting
89-1-OB	1	10/24/89	O	P	OP	Carrizo	SD2	unk	225,237	2,849,949
89-2-OB	2	10/19/89	O	P	OP	Carrizo	SD2	unk	226,791	2,853,116
89-3-OB	96	10/23/89	O	P	OP	Carrizo	SD2	unk	222,807	2,851,129
89-2-OB-R-03	3	09/25/03	O	R	OR	Spoil	n/a	Spoil	226,908	2,853,549
89-3-OB-R-99	4	08/31/99	O	R	OR	Spoil	n/a	Spoil	222,715	2,851,100
89-3-UB	5	10/23/89	U	P	UP	WUB	unk	unk	222,722	2,851,109
89-3-UB-R-99	6	08/31/99	U	R	UR	Dist'd WUB	unk	Spoil	222,700	2,851,100
89-4-OB	7	10/18/89	O	P	OP	Carrizo	SD2	unk	220,355	2,858,797
89-4-OB-R-99	8	09/02/99	O	R	OR	Spoil	n/a	Spoil	220,176	2,858,850
89-4-UB	9	10/17/89	U	P	UP	WUB	unk	unk	220,350	2,858,827
89-4-UB-R-99	10	09/02/99	U	R	UR	Dist'd WUB	unk	Spoil	220,170	2,858,850
D-1-(ALLUV)	11	02/01/84	O	P	OP	Qal	unk	Qal	208,100	2,837,600
D-14-OBa	12	01/16/84	O	P	OP	Wilcox	sand	Reklaw	215,050	2,855,820
D-14-OBb	13	01/12/84	O	P	OP	Carrizo	sand	Reklaw	215,050	2,855,820
D-14-OBc	14	01/16/84	O	P	OP	Reklaw	mix	Reklaw	215,050	2,855,820
D-14-OB-R-95	15	10/17/95	O	R	OR	Spoil	n/a	Spoil	215,538	2,855,943
D-14-UB	16	01/12/84	U	P	UP	WUB	mix	Reklaw	215,050	2,855,820
D-14-UB-R-95	17	12/11/95	U	R	UR	Dist'd WUB	unk	Spoil	215,538	2,855,932
D-16-Obal	18	02/01/84	O	P	OP	C/Wi	sand	Reklaw	214,400	2,859,260
D-16-UB	19	01/10/84	U	P	UP	WUB	clay/silt	Reklaw	214,400	2,859,260
D-17-OB	20	01/31/84	O	P	OP	Carrizo	sand	Carrizo	211,130	2,860,410
D-17-UB	21	01/30/84	U	P	UP	WUB	mix	C/Wi	211,130	2,860,410
D-19-OB	22	01/31/84	O	P	OP	C/Wi	sand	C/Wi	218,390	2,865,600
D-19-UB	23	01/31/84	U	P	UP	WUB	mix	C/Wi	218,390	2,865,600
D-2-(ALLUV)	24	01/25/84	O	P	OP	Qal	mix	Qal	220,960	2,843,900

D-2-(ALLUV)	25	01/25/84	O	G	OG	Qal	mix	Qal	220,960	2,843,900
D-21-OB	26	01/23/84	O	P	OP	Wilcox	mix	C/Wi	214,200	2,849,200
D-21-OB	27	01/23/84	O	G	OG	Wilcox	mix	C/Wi	214,200	2,849,200
D-22-OB	28	01/17/84	O	P	OP	C/Wi	sand	C/Wi	211,980	2,858,680
D-23-OBa	29	01/31/84	O	P	OP	Carrizo	mix	Reklaw	210,130	2,850,550
D-23-OBb	30	01/31/84	O	P	OP	Reklaw	mix	Reklaw	210,130	2,850,550
D-23-UB	31	01/31/84	U	P	UP	WUB	unk	Reklaw	210,130	2,850,550
D-24-OB	32	02/01/84	O	P	OP	Carrizo	sand	Reklaw	211,820	2,855,610
D-25-OB-test	33	02/08/84	O	P	OP	C/Wi	SD2	unk	212,280	2,860,500
D-26-OB	34	03/22/86	O	G	OG	unk	unk	unk	205,600	2,843,575
D-26-UB	35	03/22/86	U	G	UG	WUB	mix	Reklaw	205,600	2,843,600
D-27-D	36	03/19/86	U	P	UP	WUB	unk	unk	205,800	2,847,700
D-27-S	37	03/19/86	O	P	OP	unk	unk	unk	205,800	2,847,750
D-28-D	38	04/04/86	U	P	UP	WUB	unk	unk	208,400	2,852,900
D-28-S	39	04/06/86	O	P	OP	unk	unk	unk	208,425	2,852,900
D-29-D	40	03/24/86	U	P	UP	WUB	unk	unk	209,650	2,855,150
D-29-S	41	03/25/86	O	P	OP	unk	unk	unk	209,625	2,855,150
D-30-D	42	03/26/86	U	P	UP	WUB	unk	unk	209,700	2,857,000
D-30-S	43	03/27/86	O	P	OP	unk	unk	unk	209,700	2,857,025
D-31-OB	44	04/02/86	O	P	OP	unk	unk	unk	214,450	2,862,550
D-31-UB	45	04/02/86	U	P	UP	WUB	unk	unk	214,450	2,862,500
D-32-D	46	04/08/86	U	P	UP	WUB	unk	unk	215,425	2,850,450
D-32-S	47	04/08/86	O	P	OP	unk	unk	unk	215,400	2,850,450
D-35-OB	48	06/17/87	O	G	OG	unk	unk	unk	211,000	2,844,300
D-36-OB	49	06/12/87	O	G	OG	unk	unk	unk	213,800	2,846,800
D-37-OB	50	06/16/87	O	G	OG	unk	unk	unk	212,750	2,854,300
D-38-UB	51	04/04/86	U	G	UG	WUB	unk	unk	212,600	2,850,000
D-39-UB	52	03/20/86	U	G	UG	WUB	unk	unk	213,500	2,848,700
D-3-OB	53	01/19/84	O	G	OG	Wilcox	mix	Reklaw	208,600	2,842,400
D-41-UB	54	06/17/87	U	G	UG	WUB	unk	unk	211,000	2,844,300
D-42-UB	55	04/09/86	U	G	UG	WUB	unk	unk	211,500	2,854,500
D-43-UB	56	06/10/87	U	G	UG	WUB	unk	unk	212,900	2,857,300
D-44-S	57	11/03/94	O	P	OP	unk	unk	unk	211,801	2,842,770

D-45-S-95	58	10/18/95	O	P	OP	unk	unk	unk	217,794	2,841,643
D-4-UB	59	01/19/84	U	P	UP	WUB	mix	Reklaw	210,300	2,842,750
D-6-UB	60	01/24/84	U	P	UP	WUB	sand	unk	218,200	2,846,500
D-7-OBtest	61	02/02/84	O	P	OP	Carrizo	sand	Reklaw	207,420	2,848,600
D-7-UB	62	01/26/84	U	P	UP	WUB	mix	Reklaw	207,420	2,848,600
D-8-OB	63	01/25/84	O	P	OP	C/Wi	mix	Reklaw	214,200	2,844,200
D-9-OBa	64	02/01/84	O	P	OP	Wilcox	mix	Reklaw	211,700	2,846,750
D-9-OBb	65	02/01/84	O	P	OP	C/Wi	mix	Reklaw	211,700	2,846,750
D-9-UB	66	01/18/84	U	P	UP	WUB	mix	Reklaw	211,700	2,846,750
DII-14-R-08	67	01/05/08	O	R	OR	Spoil	n/a	Spoil	235,586	2,855,420
DII-37-R-91	68	11/08/91	O	R	OR	Spoil	n/a	Spoil	212,508	2,854,828
DII-4-OB	69	10/31/93	O	P	OP	C/Wi	SD2	unk	237,150	2,856,680
DII-4-UB	70	10/31/93	U	P	UP	WUB	unk	unk	237,666	2,856,985
DII-5-OB	71	11/10/93	O	P	OP	C/Wi	SD2	unk	240,400	2,857,974
DII-5-UB	72	11/10/93	U	P	UP	WUB	unk	unk	240,382	2,857,958
DII-6(ALLUV)-04	73	11/20/04	O	P	OP	Qal	unk	Qal	237,349	2,853,677
DIII-12-OB	74	10/30/93	O	P	OP	C/Wi	SD2	unk	241,878	2,851,206
DIII-13-OB-98	75	12/14/98	O	P	OP	unk	unk	unk	221,236	2,840,275
DIII-15(ALLUV)-04	76	11/19/04	O	P	OP	Qal	unk	Qal	237,693	2,851,978
DIII-1-OB2	77	10/26/93	O	P	OP	C/Wi	SD2	unk	219,833	2,838,132
DIII-1-OB2-R-99	78	09/01/99	O	R	OR	Spoil	n/a	Spoil	219,850	2,838,140
DIII-1-UB	79	10/25/93	U	P	UP	WUB	unk	unk	219,812	2,838,126
DIII-1-UB-R-99	80	09/01/99	U	R	UR	Dist'd WUB	n/a	Spoil	219,850	2,838,150
DIII-3-OB	81	11/09/93	O	P	OP	Reklaw	unk	Reklaw	227,800	2,843,352
DIII-3-UB	82	11/09/93	U	P	UP	WUB	unk	Reklaw	227,775	2,843,347
DIII-5-OB2	83	10/27/93	O	P	OP	C/Wi	SD2	unk	230,781	2,845,583
DIII-5-OB2-R-03	84	06/03/03	O	R	OR	Spoil	n/a	Spoil	230,777	2,845,585
DIII-6-OB	85	10/28/93	O	P	OP	Reklaw	unk	Reklaw	230,473	2,839,362
DIII-6-UB	86	10/28/93	U	P	UP	WUB	unk	Reklaw	230,502	2,839,367
DIII-7-UB	87	11/02/93	U	P	UP	WUB	unk	unk	231,610	2,835,756
R-16(S)	88	11/03/94	O	R	OR	Spoil	n/a	Spoil	210,868	2,842,710

R-18(S)-98	89	12/10/98	O	R	OR	Spoil	n/a	Spoil	220,888	2,845,915
R-2(S)	90	06/16/88	O	R	OR	Spoil	n/a	Spoil	207,300	2,849,030
R-4(S)	97	11/16/88	O	R	OR	Spoil	n/a	Spoil	208,600	2,846,600
R-5(S)	91	11/16/88	O	R	OR	Spoil	n/a	Spoil	210,400	2,847,200
R-6(S)	92	06/14/88	O	R	OR	Spoil	n/a	Spoil	212,600	2,850,000
TP-C5	93	unk	O	R	OR	Spoil	n/a	Spoil	219,280	2,855,380
TP-DG	94	unk	O	G	OG	unk	unk	unk	219,350	2,855,200
TP-UG	95	unk	O	P	OP	unk	unk	unk	219,350	2,855,650

APPENDIX B: SAMPLING EVENTS FOR WELLS IN HISTORICAL DATA SET

The below table describes the 97 wells used for pH distribution descriptions in Chapter 3. With the exception of wells 89-2-OB (#96) and R-4(S) (#97), which contain no EC data, data from these wells are also used for multiple linear regression analysis in Chapter 5. “Start Date” refers to the first sampling event for that well. “End Date” refers to the last sampling event for that well.

Well ID		Sampling Events (n)							
Well Name	Well No.	Start Date	End Date	Total	Dry	For "wet" wells: pH reported?		For pH measurements: EC reported?	
						yes	no	yes	no
89-1-OB	1	05/27/93	07/10/97	12	0	12	0	3	9
89-2-OB	2	05/27/93	02/18/02	30	0	30	0	19	11
89-3-OB	96	05/27/93	05/15/97	17	4	13	0	0	13
89-2-OB-R-03	3	12/12/03	05/16/12	35	0	35	0	35	0
89-3-OB-R-99	4	11/16/99	05/16/12	51	0	51	0	47	4
89-3-UB	5	05/27/93	05/14/97	17	0	17	0	2	15
89-3-UB-R-99	6	11/17/99	05/16/12	51	0	51	0	50	1
89-4-OB	7	05/26/93	07/09/97	16	0	16	0	3	13
89-4-OB-R-99	8	11/16/99	05/16/12	50	0	50	0	47	3
89-4-UB	9	05/26/93	07/09/97	18	0	18	0	3	15
89-4-UB-R-99	10	11/17/99	05/16/12	51	0	51	0	48	3
D-1-(ALLUV)	11	02/24/84	05/15/12	104	0	104	0	89	15
D-14-OBa	12	04/13/84	07/14/89	22	0	21	1	17	4
D-14-OBb	13	04/13/84	07/14/89	22	0	21	1	17	4
D-14-OBc	14	04/13/84	10/18/91	26	0	25	1	17	8
D-14-OB-R-95	15	12/26/95	01/13/04	34	0	34	0	33	1
D-14-UB	16	04/13/84	07/14/89	22	0	21	1	17	4
D-14-UB-R-95	17	12/26/95	07/16/10	35	0	35	0	34	1
D-16-Obal	18	02/17/84	05/15/12	107	16	91	0	89	2
D-16-UB	19	02/17/84	05/15/12	103	1	102	0	89	13
D-17-OB	20	02/20/84	05/12/88	17	0	17	0	16	1
D-17-UB	21	03/02/84	05/12/88	17	0	17	0	16	1
D-19-OB	22	08/10/09	05/15/12	12	0	12	0	12	0
D-19-UB	23	08/10/09	05/15/12	12	0	12	0	12	0
D-2-(ALLUV)*	24	02/18/84	11/15/88	19	0	19	0	18	1

D-2-(ALLUV)*	25	03/01/89	05/15/12	85	0	85	0	73	12
D-21-OB*	26	02/20/84	11/17/88	19	0	18	1	17	1
D-21-OB*	27	03/01/89	01/08/04	51	0	51	0	38	13
D-22-OB	28	04/14/84	02/16/88	16	0	16	0	15	1
D-23-OBa	29	02/22/84	01/23/86	8	0	8	0	8	0
D-23-OBb	30	03/02/84	01/23/86	8	1	7	0	7	0
D-23-UB	31	02/22/84	01/23/86	8	0	8	0	8	0
D-24-OB	32	02/18/84	07/14/89	22	0	22	0	18	4
D-25-OB-test	33	03/13/84	07/16/89	22	0	22	0	18	4
D-26-OB	34	07/08/86	05/16/12	48	0	48	0	44	4
D-26-UB	35	07/08/86	05/16/12	98	0	98	0	86	12
D-27-D	36	06/30/86	07/18/89	14	0	13	1	10	3
D-27-S	37	06/30/86	07/18/89	14	0	13	1	10	3
D-28-D	38	07/08/86	07/17/89	14	0	13	1	10	3
D-28-S	39	07/08/86	07/17/89	14	0	13	1	10	3
D-29-D	40	06/26/86	07/17/89	14	0	13	1	10	3
D-29-S	41	06/26/86	07/17/89	14	0	12	2	9	3
D-30-D	42	06/26/86	05/17/12	98	0	97	1	85	12
D-30-S	43	06/26/86	05/17/12	98	0	97	1	86	11
D-31-OB	44	06/30/86	07/16/89	14	0	14	0	10	4
D-31-UB	45	06/30/86	07/16/89	14	0	14	0	10	4
D-32-D	46	07/09/86	08/28/86	2	0	2	0	2	0
D-32-S	47	07/09/86	08/28/86	2	0	2	0	2	0
D-35-OB	48	09/19/87	07/16/10	61	4	57	0	48	9
D-36-OB	49	09/19/87	01/04/94	20	13	7	0	6	1
D-37-OB	50	09/19/87	01/10/92	10	1	9	0	6	3
D-38-UB	51	07/08/86	03/23/87	4	0	4	0	4	0
D-39-UB	52	07/08/86	09/19/87	6	0	6	0	5	1
D-3-OB	53	03/02/84	07/14/89	22	0	22	0	16	6
D-41-UB	54	09/19/87	07/16/10	61	0	61	0	50	11
D-42-UB	55	06/27/86	04/29/89	13	0	13	0	10	3
D-43-UB	56	09/19/87	07/16/89	9	0	9	0	6	3
D-44-S	57	08/09/95	05/15/12	68	12	56	0	55	1
D-45-S-95	58	12/26/95	07/19/10	35	0	35	0	34	1
D-4-UB	59	02/29/84	07/14/89	22	0	22	0	18	4
D-6-UB	60	01/17/91	08/14/95	19	1	18	0	10	8
D-7-OBtest	61	03/22/84	01/23/86	8	0	8	0	8	0
D-7-UB	62	03/21/84	01/23/86	8	0	8	0	8	0
D-8-OB	63	03/01/84	07/14/89	22	0	22	0	18	4
D-9-OBa	64	02/21/84	02/19/88	16	0	16	0	15	1
D-9-OBb	65	02/21/84	02/19/88	16	1	15	0	14	1
D-9-UB	66	02/22/84	02/19/88	16	0	16	0	15	1
DII-14-R-08	67	02/28/08	05/16/12	18	0	18	0	18	0
DII-37-R-91	68	02/22/93	05/17/12	75	2	73	0	72	1
DII-4-OB	69	03/25/04	02/22/06	10	0	10	0	10	0
DII-4-UB	70	05/04/04	02/22/06	8	0	8	0	8	0
DII-5-OB	71	06/02/06	05/16/12	25	0	25	0	25	0
DII-5-UB	72	06/02/06	05/16/12	25	0	25	0	25	0

DII-6(ALLUV)-04	73	03/10/05	05/16/12	30	0	30	0	30	0
DIII-12-OB	74	03/26/04	05/17/12	34	0	34	0	34	0
DIII-13-OB-98	75	02/15/99	05/17/12	54	1	53	0	51	2
DIII-15(ALLUV)-04	76	03/10/05	05/17/12	30	0	30	0	30	0
DIII-1-OB2	77	06/26/96	10/27/98	11	0	11	0	11	0
DIII-1-OB2-R-99	78	11/16/99	05/17/12	51	0	51	0	51	0
DIII-1-UB	79	06/26/96	10/28/98	11	0	11	0	11	0
DIII-1-UB-R-99	80	11/16/99	05/17/12	51	0	49	2	49	0
DIII-3-OB	81	06/26/96	11/16/99	15	0	15	0	15	0
DIII-3-UB	82	06/26/96	11/16/99	15	0	15	0	15	0
DIII-5-OB2	83	06/26/96	06/04/01	21	0	21	0	20	1
DIII-5-OB2-R-03	84	09/10/03	05/17/12	36	0	36	0	35	1
DIII-6-OB	85	01/20/00	11/30/06	28	1	27	0	27	0
DIII-6-UB	86	01/20/00	11/30/06	28	1	27	0	26	1
DIII-7-UB	87	03/26/04	10/11/07	16	0	16	0	16	0
R-16(S)	88	12/26/95	05/16/12	67	16	51	0	48	3
R-18(S)-98	89	02/15/99	05/16/12	54	1	53	0	49	4
R-2(S)	90	01/25/90	01/09/04	47	0	47	0	40	7
R-4(S)	97	11/21/88	07/15/89	4	1	3	0	0	3
R-5(S)	91	11/21/88	02/01/12	76	1	74	1	58	16
R-6(S)	92	06/16/88	05/15/12	94	12	79	3	69	10
TP-C5	93	03/23/84	07/19/89	22	1	20	1	18	2
TP-DG	94	03/21/84	07/19/89	22	0	21	1	18	3
TP-UG	95	03/22/84	07/19/89	22	0	21	1	18	3
		Total		**3033**	**91**	**2919**	**23**	**2562**	**357**
		Minimum		**2**	**0**	**2**	**0**	**0**	**0**
		Median		**22**	**0**	**21**	**0**	**17**	**2**
		Mean		**31**	**1**	**30**	**0**	**26**	**4**
		Maximum		**107**	**16**	**104**	**3**	**89**	**16**

*Wells split into P and M periods due to advance of mining pit and documentation in permits that wells are downgradient of mining activity.

**Outliers removed

APPENDIX C: HISTORICAL DATA SET OUTLIERS

No data for Mg, K, HCO3, F, SiO2, or Lab Charge Balance Error (CBE) were available for these measurements. All concentrations are in mg/L. For all categories, unk = unknown. For the “Well Category” column, O = overburden, U= underburden, P = pre-disturbance, R = reclamation, and G= downgradient (see Chapter 3 for further explanation). For the “Geology of Screen Interval” and “Surface Geology” columns, C/Wi = undifferentiated Carrizo/Wilcox, unk = unknown, and Qal = quaternary alluvium. For the “Screen Texture” column, SD2 is a clean channel sand unit (high conductivity) and n/a refers to spoil wells, which were not logged during installation.

Well Name	Date	Explanation (Outlier)	Well Cate-gory	Geology of Screen Interval	Screen Texture	Surface Geology	Temp (ºC)	Field pH	Water Depth (ft)	Water Elev (ft AMSL)
89-2-OB	11/29/00	Sulfate and EC deviate from general linear relationship by 2 orders of magnitude, but it is not clear which variable is mostly likely incorrect.	OP	Carrizo	SD2	unk	19	4.77	63.5	339.7
89-2-OB	09/06/01	Field EC outside of range for well and deviates from general relationship with Sulfate.	OP	Carrizo	SD2	unk	21	4.33	60.3	342.9
89-3-OB-R-99	07/19/00	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high.	OR	Spoil	n/a	Spoil	22	4.45	57.0	351.3
89-3-OB-R-99	02/07/01	Sulfate and EC deviate from general linear relationship by approx half an order of magnitude, but it cannot be determined which variable is most likely incorrect.	OR	Spoil	n/a	Spoil	20	4.85	54.0	354.3
89-3-OB-R-99	11/15/02	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high.	OR	Spoil	n/a	Spoil	19	4.16	47.9	360.4
89-3-OB-R-99	02/07/07	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high.	OR	Spoil	n/a	Spoil	20	4.20	47.5	360.8
89-3-UB-R-99	02/07/07	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high.	UR	disturbed WUB	n/a	Spoil	16	4.91	47.4	360.9
89-4-OB-R-99	02/08/01	Sulfate and EC deviate from general linear relationship by approx half an order of magnitude, but it cannot be determined which variable is most likely incorrect.	OR	Spoil	n/a	Spoil	19	4.06	74.5	370.0
89-4-OB-R-99	07/13/10	EC is an order of magnitude greater than 3rd largest value	OR	Spoil	n/a	Spoil	21.5	3.60	52.07	
89-4-OB-R-99	03/02/11	EC is an order of magnitude greater than 3rd largest value	OR	Spoil	n/a	Spoil	21	3.92	53.2	

Well Name	Field EC (umhos/cm)	TDS	SO$_4$	Cl	Diss Fe	Total Fe	Diss Mn	Total Mn	Ca	Na	Al	As	B	Cd	Cr	Cu
89-2-OB	76.2	1	210	3	3.09		0.10									
89-2-OB	760	12	26	5	0.39		0.02									
89-3-OB-R-99	1812	116	44	8	5.41		0.89									
89-3-OB-R-99	472	264	825	7	26.10		1.57				0.31	0.001	0.182	0.002	0.007	0.003
89-3-OB-R-99	3000	2700	352	235	9	57.10	57.10	1.96	1.96							
89-3-OB-R-99	1392	130	33	8	9.75		0.13				0.277	<0.005	<0.001	<0.001	<0.001	<0.004
89-3-UB-R-99	1180	142	36	10	0.89		0.19				0.085	<0.005	<0.001	<0.001	<0.001	<0.004
89-4-OB-R-99	1512	1688	1650	4	373.50		4.00				20.65	0.001	1.007	0.001	0.007	0.001
89-4-OB-R-99	28200	4396	1850	5	652	3.89	3.89									
89-4-OB-R-99	20600	2496	1540	6	8.545	0.229	0.229									

Well Name	Pb	Hg	Mo	Ni	Se	Zn	Lab pH	Lab EC (umhos/cm)
89-2-OB								
89-2-OB								
89-3-OB-R-99								
89-3-OB-R-99	0.01	2E-04	0.01	0.038	0.001	0.417		
89-3-OB-R-99								
89-3-OB-R-99	<0.001	<0.0002	<0.001	<0.001	<0.006	0.19		
89-3-UB-R-99	<0.001	<0.0002	<0.001	<0.001	<0.006	0.037		
89-4-OB-R-99	0.01	2E-04	0.01	0.887	0.001	5.39		
89-4-OB-R-99								
89-4-OB-R-99								

Well Name	Date	Explanation (Outlier)	Well Category	Geology of Screen Interval	Screen Texture	Surface Geology	Temp (ºC)	Field pH	Water Depth (ft)	Water Elev (ft AMSL)
89-4-UB-R-99	02/20/01	Both Cl is an order of magnitude outside the normal range for this well. EC and sulfate deviate from general linear relationship, but unclear which value is questionable.	UR	disturbed WUB	unk	Spoil	22	5.84	74.6	368.9
89-4-UB-R-99	07/24/02	Sulfate deviates from general relationship with EC, perhaps by as much as an order of magnitude too high	UR	disturbed WUB	unk	Spoil	20	5.46	69.5	374.0
89-4-UB-R-99	03/24/10	Sulfate deviates from general relationship with EC, perhaps by as much as an order of magnitude too high (or, EC is too low).	UR	disturbed WUB	unk	Spoil	21	5.79	52.5	391.0
D-1-(Alluv)	07/17/00	EC an order of magnitude outside range for this well.	OP	Qal	unk	Qal	21	5.23	14.4	352.9
D-1-(Alluv)	08/15/01	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high.	OP	Qal	unk	Qal	20	4.83	14.0	353.3
D-1-(Alluv)	02/28/11	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high. EC also an order of magnitude outside range for this well.	OP	Qal	unk	Qal	21	4.17	26	
D-14-OB-R-95	12/04/00	Sulfate deviates from general relationship with EC by an order of magnitude too high	OR	Spoil	n/a	Spoil	19	3.91	31.9	408.8
D-14-UB-R-95	08/24/01	EC is twice the upper range for this well. Transcription error most likely cause (849 vs. 489).	UR	disturbed WUB	n/a	Spoil	20	6.64	75.6	364.8
D-16-OBal	07/11/97	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high.	OP	C/Wi	sand	Reklaw	23	5.25	101.3	394.2

Well Name	Field EC (umhos/cm)	TDS	SO_4	Cl	Diss Fe	Total Fe	Diss Mn	Total Mn	Ca	Na	Al	As	B	Cd	Cr	Cu
89-4-UB-R-99	285	148	375	102	1.66		0.26				0.026	0.001	0.126	0.002	0.01	0.006
89-4-UB-R-99	463	328	975	6	10.48		0.98									
89-4-UB-R-99	213	660	358	8	4.39		1.56									
D-1-(Alluv)	574	42	75	8	1.15		0.06									
D-1-(Alluv)	1846	64	70	7	0.36		0.01									
D-1-(Alluv)	986	76	6	20	2.737		0.045									
D-14-OB-R-95	540	424	1350	9	44.80		1.89									
D-14-UB-R-95	849	240	66	11	3.93		0.15									
D-16-OBal	3920	3528	164	3	5	1.09	1.09	0.05	0.05							

Well Name	**Pb**	**Hg**	**Mo**	**Ni**	**Se**	**Zn**	**Lab pH**	**Lab EC (umhos/cm)**
89-4-UB-R-99	0.01	2E-04	0.01	0.006	0.001	0.039		
89-4-UB-R-99								
89-4-UB-R-99								
D-1-(Alluv)								
D-1-(Alluv)								
D-1-(Alluv)								
D-14-OB-R-95								
D-14-UB-R-95								
D-16-OBal								

Well Name	Date	Explanation (Outlier)	Well Category	Geology of Screen Interval	Screen Texture	Surface Geology	Temp (ºC)	Field pH	Water Depth (ft)	Water Elev (ft AMSL)
D-16-UB	07/11/97	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high. EC also an order of magnitude outside range for this well.	UP	Wilcox UB	Clay/ Silt	Reklaw	22	6.23	110.0	385.0
D-2-(Alluv)	02/05/01	Sulfate deviates from general relationship with EC by an order of magnitude of Sulfate too high. Sulfate also an order of magnitude outside range for this well.	OG	Qal	mix	Qal	14	7.43	2.8	329.0
D-21-OB	06/05/00	Sulfate deviates from general relationship with EC, perhaps by as much as an order of magnitude too high	OG	Wilcox	mix	C/Wi	19	4.85	9.4	385.9
D-30-D	10/30/98	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high. EC also an order of magnitude outside range for this well.	UP	Wilcox UB	unk	unk	23	3.21	6.4	420.3
D-3-OB	03/16/87	Sodium is .5 to 1 order of magnitude high of normal range for this well.	OG	Wilcox	mix	Reklaw	20.5	3.85		418
D-3-OB	02/18/88	Chloride is .5 to 1 order of magnitude high of normal range for this well.	OG	Wilcox	mix	Reklaw	20	3.86		417.0
D-44-S	06/12/01	Sulfate deviates from general relationship with EC by an order of magnitude too high	OP	unk	unk	unk	24	4.88	9.1	408.1
D-45-S	06/06/02	Field EC reported as "254 umhos/com," which is an outlier minimum for that well. Field EC may have been 524.	OP	unk	unk	unk	20	4.71	6.4	345.5
DII-37-R-91	07/09/97	EC deviates from general relationship with Sulfate by an order of magnitude of EC too low.	OR	Spoil	n/a	Spoil	21	3.73	6.2	426.9

Well Name	Field EC (umhos/cm)	TDS	SO_4	Cl	Diss Fe	Total Fe	Diss Mn	Total Mn	Ca	Na	Al	As	B	Cd	Cr	Cu
D-16-UB	1614	138	19	9	1		0.05									
D-2-(Alluv)	377	226	400	14	0.04		0.14									
D-21-OB	56.4	96	225	9	0.35		0.01									
D-30-D	1323	208	6.7	11.6	1.54		0.09									
D-3-OB	110	126	22	16	0.79	5.3	0.08	0.08		63						
D-3-OB	132	146	25	72	0.50		0.09			3.7						
D-44-S	192.2	48	1000	12	0.07		0.16									
D-45-S	254	366	350	21	9.78		0.33									
DII-37-R-91	185.9	1829	1137	9	105.00		11.90									

Well Name	Pb	Hg	Mo	Ni	Se	Zn	Lab pH	Lab EC (umhos/cm)
D-16-UB								
D-2-(Alluv)								
D-21-OB								
D-30-D								
D-3-OB							4.2	141
D-3-OB								
D-44-S								
D-45-S								
DII-37-R-91								

Well Name	Date	Explanation (Outlier)	Well Category	Geology of Screen Interval	Screen Texture	Surface Geology	Temp (ºC)	Field pH	Water Depth (ft)	Water Elev (ft AMSL)
DIII-12-OB	02/02/12	Cl is 1 order of magnitude high of normal range for this well.	OP	C/Wi	SD2	unk	21	4.01	61.2	
DIII-13-OB-98	07/25/02	Sulfate is an order of magnitude outside range for this well.	OG	unk	unk	unk	21	5.98	13.7	376.8
DIII-13-OB-98	05/30/03	Sulfate deviates from general relationship with EC, perhaps by as much as an order of magnitude too high.	OG	unk	unk	unk	20	5.13	12.3	378.2
DIII-5-OB2	10/29/97	EC deviates from general relationship with Sulfate by an order of magnitude of EC too high. EC also an order of magnitude outside range for this well.	OP	C/Wi	SD2	unk		4.06	70.0	358.6
DIII-5-OB2-R-03	05/04/04	EC deviates from general relationship with Sulfate by 2 orders of magnitude of EC too low.	OR	Spoil	n/a	Spoil	21	2.10	74.8	356.7
DIII-6-UB	03/10/05	EC and sulfate below range for this well by an order of magnitude.	UP	Wilcox UB	unk	Reklaw	21	7.00	77.9	351.6
R-16(S)	06/12/01	Sulfate deviates from general relationship with EC by an order of magnitude too high	OR	Spoil	n/a	Spoil	23	3.31	9.9	415.8
R-16(S)	07/19/02	EC deviates from general relationship with Sulfate by an order of magnitude of EC too low.	OR	Spoil	n/a	Spoil	21	2.84	12.3	413.4
R-16(S)	01/31/12	EC deviates from general relationship with Sulfate by an order of magnitude of EC too low.	OR	Spoil	n/a	Spoil	20	3.91	148.4	
R-18(S)-98	02/06/01	Sulfate deviates from general relationship with EC by an order of magnitude too high.	OR	Spoil	n/a	Spoil	20	5.05	45.3	361.6
R-18(S)-98	02/20/02	Sulfate deviates from general relationship with EC, perhaps by as much as an order of magnitude too high.	OR	Spoil	n/a	Spoil	18	2.98	38.6	368.3

Well Name	Field EC (umhos/cm)	TDS	SO_4	Cl	Diss Fe	Total Fe	Diss Mn	Total Mn	Ca	Na	Al	As	B	Cd	Cr	Cu
DIII-12-OB	460	284	15	114	0.22		0.07									
DIII-13-OB-98	135	180	425	7	0.73		0.06									
DIII-13-OB-98	127	480	450	15	0.34		0.16									
DIII-5-OB2	1804	112	14	5												
DIII-5-OB2-R-03	2.1	1698	1400	4	19.24		0.70									
DIII-6-UB	86	844	7	23	2.71		0.25									
R-16(S)	738	786	1525	4	10.33		3.41									
R-16(S)	214	2028	1600	8	154.3		11.05									
R-16(S)	103.4	864	540	11	73.83		5.13									
R-18(S)-98	556	376	1550	7	20.85		0.07				0.525	0.001	0.358	0.001	0.262	0.002
R-18(S)-98	2810	2908	3000	8	443.00		6.52				50.48	<0.001	1.936	<0.001	0.479	

Well Name	Pb	Hg	Mo	Ni	Se	Zn	Lab pH	Lab EC (umhos/cm)
DIII-12-OB								
DIII-13-OB-98								
DIII-13-OB-98								
DIII-5-OB2								
DIII-5-OB2-R-03								
DIII-6-UB								
R-16(S)								
R-16(S)								
R-16(S)								
R-18(S)-98	0.01	2E-04	0.01	0.107	0.001	0.271		
R-18(S)-98		<0.0002	0.01	1.018	<0.001	4.606		

Well Name	Date	Explanation (Outlier)	Well Category	Geology of Screen Interval	Screen Texture	Surface Geology	Temp (ºC)	Field pH	Water Depth (ft)	Water Elev (ft AMSL)
R-18(S)-98	11/05/04	EC deviates from general relationship with Sulfate by an order of magnitude of EC too low.	OR	Spoil	n/a	Spoil	19	3.83	27.7	379.2
R-18(S)-98	07/09/08	Cl is more than 4x the second highest value and is an order of magnitude greater than the median value. Sulfate and Cl values appear to have been switched.	OR	Spoil	n/a	Spoil		4.00	28.0	378.9
R-5(S)	06/11/01	Sulfate deviates from general relationship with EC, perhaps by as much as an order of magnitude too high	OR	Spoil	n/a	Spoil	20	4.81	4.7	413.3
R-5(S)	07/12/10	EC deviates from general relationship with Sulfate by 2 orders of magnitude of EC too low.	OR	Spoil	n/a	Spoil	20.5	4.12	9.1	
R-6(S)	05/08/01	EC deviates from general relationship with Sulfate by an order of magnitude of EC too low.	OR	Spoil	n/a	Spoil	20	4.84	25.0	374.7

Well Name	Field EC (umhos/cm)	TDS	SO_4	Cl	Diss Fe	Total Fe	Diss Mn	Total Mn
R-18(S)-98	339	926	825	13	65.70		5.42	
R-18(S)-98	1381	1324	5	900	189.00		3.01	
R-5(S)	893	514	1225	12	41.87		1.963	
R-5(S)	2.38	2620	1250	11	116.00		4.90	
R-6(S)	83	542	475	11	61.05		0.81	

No Ca, Na, Al, As, B, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Zn, Lab pH, or Lab EC measurements for wells R-18(S)-98 (11/05/04 and 07/09/08), R-5(S) (06/11/01 and 07/12/10), and R-6(S).

APPENDIX D: HISTORICAL DATA SET

No data for Mg, K, HCO3, F, SiO2, or Lab Charge Balance Error (CBE) were available for these measurements. All concentrations are in mg/L. For all categories, unk = unknown. For the “Well Category” column, O = overburden, U= underburden, P = pre-disturbance, R = reclamation, and M = mixing (see Chapter 3 for further explanation). For the “Geology of Screen Interval” and “Surface Geology” columns, C/Wi = undifferentiated Carrizo/Wilcox, unk = unknown, and Qal = quaternary alluvium. For the “Screen Texture” column, SD2 is a clean channel sand unit (high conductivity) and n/a refers to spoil wells, which were not logged during installation. Water Depth is reported in ft. Water Elevation is reported in ft above mean sea level (AMSL). Field EC and Lab EC are reported in μmhos/cm.

Data for As, Cd, Cr, Cu, Pb, Hg, Mo, Ni, and Se omitted from Appendix B for space considerations as this data was not analyzed, was infrequently measured, and was usually below detection limits.

For total Fe, total Mn, Ca, Mg, Na, K, HCO3, F, SiO2, Al, B, Zn, Lab pH, Lab EC, and Lab CBE%, well sampling events without any measurements in any of these categories are omitted

Well Name	Date	Temp (ºC)	Field pH	Water Depth	Water Elev	Field EC	TDS	SO_4	Cl	Diss Fe	Diss Mn
89-1-OB	03/03/97	21	6.09	51.9	337.8	222	88	2	6	1.36	0.06
89-1-OB	06/05/97	20	5.17	51.0	338.7	32	58	8	6	0.05	0.05
89-1-OB	07/10/97	23	5.13	51.0	338.7	38.3	52	1	7	0.05	0.05
89-2-OB	03/03/97	20	4.81	67.4	335.8	83	97	2	19	0.05	0.05
89-2-OB	05/22/97	18	4.83	56.2	347.0	84	70	3	14	0.09	0.05
89-2-OB	07/08/97	19	4.94	58.0	345.2	76.2	74	9	17	0.06	0.05
89-2-OB	10/31/97	20	4.73	60.4	342.8	125	81	2	21	0.38	0.05
89-2-OB	03/05/98	19	4.52	63.4	339.8	42	110	50	12	0.47	0.05
89-2-OB	05/20/98	20	4.36	63.6	339.6	50	112	2	7	0.43	0.05
89-2-OB	09/11/98	19	4.83	64.0	339.2	107	76	8	6	0.22	0.05
89-2-OB	10/29/98	21	3.85	64.1	339.1	48	61	3	7	0.05	0.05
89-2-OB	02/11/99	22	4.35	61.1	342.1	151	124	55	10	14.60	0.56
89-2-OB	04/23/99	20	4.52	61.1	342.1	60	71	6	11	0.67	0.05
89-2-OB	08/25/99	19	4.49	60.7	342.5	43	46	7	7	0.05	0.05
89-2-OB	11/15/99	19	5.12	59.6	343.6	44	66	19	8	0.06	0.05
89-2-OB	01/12/00	20	4.68	59.0	344.2	72	53	9	9	0.05	0.05
89-2-OB	06/08/00	19	4.93	60.5	342.7	44.4	16	33	8	1.38	0.04
89-2-OB	07/18/00	23	4.55	61.2	342.0	405	80	50	8	0.61	0.04
89-2-OB	02/06/01	20	4.54	63.4	339.8	47.4	52	31	5	0.05	0.01
89-2-OB	06/11/01	21	3.68	61.5	341.7	44.2	70	14	4	0.02	0.01
89-2-OB	12/11/01	20	4.38	59.8	343.4	23.8	2	3	4	0.03	0.01
89-2-OB	02/18/02	19	4.19	58.6	344.6	26.2	5	20	3	0.05	0.01
89-2-OB-R-03	12/12/03	19	6.52	104.3	346.6	1143	1300	400	38	1.27	0.36
89-2-OB-R-03	01/13/04	18	5.90	103.7	347.2	783	448	100	9	6.88	0.35
89-2-OB-R-03	04/30/04	22	5.10	102.3	348.6	1331	920	525	10	175.60	2.28
89-2-OB-R-03	08/03/04	23	5.54	101.5	349.4	327	196	75	12	4.50	0.20
89-2-OB-R-03	11/11/04	18	5.15	100.6	350.3	1326	1074	850	13	242.80	1.17
89-2-OB-R-03	03/03/05	20	5.06	99.0	351.9	1084	1006	800	10	177.50	1.86
89-2-OB-R-03	04/07/05	21.2	3.89	99.2	351.7	983	944	675	9	116.20	1.89
89-2-OB-R-03	08/31/05	22	4.52	98.3	352.6	764	534	360	12	62.40	1.97
89-2-OB-R-03	10/17/05	20	4.38	98.4	352.5	731	602	450	12	66.40	1.89
89-2-OB-R-03	02/23/06	21	4.15	98.3	352.6	599	574	345	12	56.50	1.78
89-2-OB-R-03	05/31/06	23	4.06	98.4	352.5	605	468	280	12	39.40	1.48
89-2-OB-R-03	09/07/06	22	3.30	98.5	352.4	525	478	255	12	37.90	1.68

89-2-OB-R-03	11/29/06	22	3.82	98.6	352.3	502	388	280	10	42.60	1.71
89-2-OB-R-03	01/30/07	21	7.45	98.9	352.0	374	378	260	7	39.70	1.58
89-2-OB-R-03	05/30/07	23	3.86	98.7	352.2	438	220	160	6	43.90	1.82
89-2-OB-R-03	08/22/07	23	3.85	98.5	352.4	434	378	180	5	35.60	1.57
89-2-OB-R-03	10/09/07	19	3.89	98.3	352.6	419	426	180	5	38.40	1.52
89-2-OB-R-03	02/20/08	22	3.49	97.6	353.3	438	392	225	8	32.40	1.62
89-2-OB-R-03	05/05/08	20	3.71	97.4	353.5	493	424	180	5	31.20	1.75
89-2-OB-R-03	07/08/08		4.39	97	353.9	704	610	48	8	73.50	1.69
89-2-OB-R-03	12/16/08	20	3.97	98.9	352.0	719	626	330	7	60.30	2.35
89-2-OB-R-03	02/02/09	22	3.84	12	438.9	687	654	300	5	54.30	2.18
89-2-OB-R-03	06/12/09	22	4.05	96.9	354.0	688	630	340	8	58.20	2.08
89-2-OB-R-03	08/10/09		3.92	96.9	354.0	674	624	360	9	51.00	1.65
89-2-OB-R-03	12/09/09	21	3.93	96.7	354.2	665	638	464	10	63.80	1.87
89-2-OB-R-03	03/24/10	20	4.01	95	355.9	714	184	120	6	6.18	0.162
89-2-OB-R-03	04/22/10	23	3.95	95.59		749	786	500	9	78	1.73
89-2-OB-R-03	07/14/10	23.5	3.55	95.22		766	770	320	11	74.1	1.62
89-2-OB-R-03	10/14/10	24.5	3.70	95.3		415	320	185	10	50.6	0.499
89-2-OB-R-03	03/02/11	21.5	3.90	95.6		727	622	420	8	66.97	1.75
89-2-OB-R-03	04/14/11	23	4.14	95.4		680	808	430	10	65.69	1.49
89-2-OB-R-03	09/07/11	24.5	4.61	97.2		479	424	230	8	48.19	0.792
89-2-OB-R-03	11/03/11	19.5	4.84	97.7		300	224	135	10	34.58	0.243
89-2-OB-R-03	01/31/12	22	4.03	96.9		755	672	420	9	91.22	1.6
89-2-OB-R-03	05/16/12	20	3.73	97.1		778	604	420	9	80	1.52
89-3-OB-R-99	11/16/99	18	5.41	59.4	348.9	333	191	67	6	3.47	2.26
89-3-OB-R-99	01/12/00	20	4.60	59.1	349.2	188	152	43	5	3.96	1.31
89-3-OB-R-99	06/07/00	20	5.15	57.9	350.4	111	96	26	7	3.20	0.52

89-3-OB-R-99	11/30/00	17	5.04	55.6	352.7	217	174	80	6	9.60	1.15
89-3-OB-R-99	06/11/01	22	3.88	50.5	357.8	478	338	210	7	58.60	1.63
89-3-OB-R-99	08/24/01	20	3.56	49.4	358.9	473	474	175	7	58.80	1.42
89-3-OB-R-99	12/10/01	20	3.11	47.6	360.7	403	260	185	7	41.28	0.64
89-3-OB-R-99	02/19/02	20	2.94	47.2	361.1	310	275	175	7	15.78	0.47
89-3-OB-R-99	06/07/02	20	3.71	47.0	361.3	456	340	280	8	71.90	0.64
89-3-OB-R-99	07/24/02	21	3.60	47.3	361.0	402	262	175	8	49.50	0.50
89-3-OB-R-99	01/09/03	20	3.90	47.8	360.5	748	636	475	8	153.10	1.14
89-3-OB-R-99	05/27/03	20	3.74	47.4	360.9	525	384	250	9	89.40	0.67
89-3-OB-R-99	09/09/03	20	3.90	46.9	361.4	527	348	69	7	93.70	0.73
89-3-OB-R-99	12/11/03	20	3.88	47.4	360.9	172	98	55	8	20.19	0.17
89-3-OB-R-99	01/09/04	20	3.74	47.6	360.7	225	176	75	8	23.49	0.02
89-3-OB-R-99	04/30/04	19	3.60	47.0	361.3	282	168	95	9	40.03	0.44
89-3-OB-R-99	08/02/04	20	3.90	46.3	362.0	305	182	100	10	59.50	0.43
89-3-OB-R-99	11/05/04	20	4.25	46.3	362.0	263	202	95	11	37.10	0.30
89-3-OB-R-99	03/03/05	19	4.01	45.0	363.3	431	348	195	9	86.50	0.50
89-3-OB-R-99	04/07/05	20.5	4.33	44.8	363.5	373	236	215	9	64.50	0.48
89-3-OB-R-99	09/01/05	21	5.53	44.8	363.5	142	88	75	11	19.80	0.12
89-3-OB-R-99	10/18/05	21	4.62	45.1	363.2	152	102	43	7	14.80	0.12
89-3-OB-R-99	02/22/06	19.5	4.49	45.6	362.7	117	108	39	10	7.41	0.09
89-3-OB-R-99	06/01/06	19	4.53	46.3	362.0	108	130	31	10	7.19	0.07
89-3-OB-R-99	09/08/06	21	4.14	46.9	361.4	126	116	102	15	12.00	0.09
89-3-OB-R-99	11/30/06	21	4.10	47.3	361.0	124	100	53	10	13.70	0.10
89-3-OB-R-99	05/31/07	20	4.11	47.4	360.9	168	132	45	8	18.40	0.12
89-3-OB-R-99	08/23/07	21	4.03	46.8	361.5	316	282	105	8	39.90	0.30
89-3-OB-R-99	10/10/07	21	4.11	46.6	361.7	199	176	77	7	27.60	0.23

89-3-OB-R-99	02/28/08	21	4.43	47	361.3	307	146	59	7	20.40	0.13
89-3-OB-R-99	05/06/08	20	4.04	47	361.3	196	134	48	8	19.80	0.11
89-3-OB-R-99	07/09/08		3.99	30	378.3	263	242	16	7	28.30	0.19
89-3-OB-R-99	12/16/08	20	4.18	47.4	360.9	262	224	75	8	31.90	0.23
89-3-OB-R-99	02/09/09	20	4.06	47.4	360.9	391	206	100	4	31.30	0.20
89-3-OB-R-99	06/12/09	21	4.29	47.5	360.8	199.3	144	70	5	18.00	0.13
89-3-OB-R-99	08/19/09	22	4.23	47.6	360.7	260	168	57	6	0.22	0.16
89-3-OB-R-99	12/09/09	21	3.91	47.1	361.2	300	256	183	6	37.80	0.24
89-3-OB-R-99	03/19/10		4.16	46.5	361.8	205	160	122	7	21.7	0.161
89-3-OB-R-99	04/21/10	22	4.00	46.25		280	276	114	7	33.3	0.237
89-3-OB-R-99	07/13/10	22	4.11	46.12		213	200	85	7	23.2	0.167
89-3-OB-R-99	10/14/10	22	3.84	46.7		403	316	180	8	74.08	0.331
89-3-OB-R-99	03/02/11	22	4.61	47.3		319	222	135	7	39.86	0.253
89-3-OB-R-99	04/14/11	22	4.84	47.3		229	186	110	8	29.34	0.175
89-3-OB-R-99	09/07/11	22.5	4.78	48.2		300	242	135	7	35.14	0.265
89-3-OB-R-99	11/03/11	20	4.85	48.3		201	152	75	8	19.67	0.134
89-3-OB-R-99	02/01/12	22	4.64	48.8		212	136	75	7	21.97	0.152
89-3-OB-R-99	05/16/12	22	3.98	48.8		231	156	90	8	21.77	0.14
89-3-UB	03/04/97	21	6.36	77.8	343.2	206	173	26	11	1.69	0.10
89-3-UB	05/14/97	22	6.35	82.6	338.4	211	165	29	11	0.45	0.08
89-3-UB-R-99	11/17/99	18	6.19	59.4	348.9	460	351	106	9	0.27	0.72
89-3-UB-R-99	01/12/00	19	6.05	59.0	349.3	441	291	64	7	1.12	0.72
89-3-UB-R-99	06/07/00	19	6.49	57.9	350.4	307	236	200	10	0.82	0.47
89-3-UB-R-99	07/19/00	22	5.91	57.0	351.3	297	274	34	13	0.09	0.45
89-3-UB-R-99	11/30/00	18	6.48	55.7	352.6	322	188	30	7	0.50	0.56
89-3-UB-R-99	02/07/01	20	6.20	54.2	354.1	214	208	63	8	1.34	0.54
89-3-UB-R-99	06/11/01	20	5.42	50.6	357.7	190.8	176	24	5	0.99	0.42

89-3-UB-R-99	08/24/01	19	5.48	48.9	359.4	193	112	175	6	0.15	0.44
89-3-UB-R-99	12/10/01	20	5.53	48.0	360.3	172.6	104	29	9	0.12	0.32
89-3-UB-R-99	02/19/02	20	5.17	47.8	360.5	145.7	115	26	8	0.11	0.28
89-3-UB-R-99	06/07/02	20	5.13	47.2	361.1	152.1	86	32	6	2.00	0.22
89-3-UB-R-99	07/24/02	21	5.50	47.6	360.7	180.4	138	95	8	3.64	0.24
89-3-UB-R-99	11/15/02	20	5.35	47.9	360.4	164.5	146	17	8	4.49	0.27
89-3-UB-R-99	01/09/03	20	5.31	48.0	360.3	153.3	102	35	8	1.48	0.25
89-3-UB-R-99	05/27/03	20	5.06	47.5	360.8	151.7	102	26	10	2.89	0.23
89-3-UB-R-99	09/09/03	21	4.82	46.9	361.4	130.9	94	21	7	0.87	0.22
89-3-UB-R-99	12/11/03	20	5.22	47.4	360.9	179.3	1	25	10	7.08	0.23
89-3-UB-R-99	01/09/04	20	5.17	47.5	360.8	152.4	144	22	8	1.47	0.21
89-3-UB-R-99	04/30/04	20	5.07	47	361.3	168.6	52	21	9	5.89	0.30
89-3-UB-R-99	08/02/04	20	5.01	46.3	362.0	153.1	90	34	11	6.15	0.28
89-3-UB-R-99	11/05/04	19	4.90	46.4	361.9	143	108	25	10	0.30	0.20
89-3-UB-R-99	03/03/05	19	5.39	45	363.3	168.6	150	31	8	24.93	0.35
89-3-UB-R-99	04/07/05	20.4	5.21	44.9	363.4	133.2	118	28	8	1.67	0.23
89-3-UB-R-99	09/01/05	21.5	6.15	44.8	363.5	119.8	40	22	11	1.01	0.19
89-3-UB-R-99	10/18/05	20.5	5.55	45	363.3	128.4	120	25	10	0.32	0.15
89-3-UB-R-99	02/22/06	20	5.81	45.6	362.7	152.4	176	27	11	3.47	0.18
89-3-UB-R-99	06/01/06	20	5.76	46.4	361.9	162	150	24	13	3.54	0.17
89-3-UB-R-99	09/08/06	20	5.06	46.8	361.5	223	200	77	14	10.90	0.39
89-3-UB-R-99	11/30/06	20	5.16	47.1	361.2	127.9	122	38	10	7.12	0.19
89-3-UB-R-99	05/31/07	21	5.00	47.3	361.0	132.6	94	13	6	4.70	0.17
89-3-UB-R-99	08/23/07	22	4.86	46.8	361.5	147.2	124	20	8	1.96	0.19
89-3-UB-R-99	10/10/07	23	4.75	46.4	361.9	113.9	96	20	6	1.42	0.22
89-3-UB-R-99	02/28/08	19	5.29	47	361.3	132.3	118	19	8	7.18	0.27

89-3-UB-R-99	05/06/08	18	4.71	47.1	361.2	138.5	98	23	8	0.53	0.16
89-3-UB-R-99	07/09/08		5.43	43	365.3	223	272	21	6	3.83	0.19
89-3-UB-R-99	12/16/08	20	5.37	47.4	360.9	185.7	144	18	8	3.95	0.26
89-3-UB-R-99	02/09/09	20	4.89	47.3	361.0	159.1	110	18	4	0.44	0.17
89-3-UB-R-99	06/12/09	22	5.28	47.4	360.9	136.7	130	20	6	5.04	0.18
89-3-UB-R-99	08/19/09	22	4.98	47.5	360.8	119.2	100	11	6	29.80	0.18
89-3-UB-R-99	12/09/09	20	4.79	47.1	361.2	128.1	130	24	5	1.46	0.20
89-3-UB-R-99	03/19/10		5.45	46.4	361.9	180	140	59.2	9	6.54	0.228
89-3-UB-R-99	04/21/10	22.5	5.19	42.29		187	116	34	12	5.777	0.189
89-3-UB-R-99	07/14/10	22.5	4.90	46.12		152.2	108	23	9	1.24	0.233
89-3-UB-R-99	10/14/10	22	4.56	46.7		113.6	98	20	7	2.33	0.221
89-3-UB-R-99	03/02/11	21.5	5.67	47.2		150.1	106	27	7	1.654	0.221
89-3-UB-R-99	04/14/11	22	5.68	47.2		129.5	114	33	6	0.784	0.206
89-3-UB-R-99	09/07/11	22.5	5.59	48.2		133.2	118	26	9	2.822	0.248
89-3-UB-R-99	11/02/11	21	5.59	48.3		137.5	122	32	8	0.763	0.222
89-3-UB-R-99	02/01/12	23	5.88	47.7		163.2	110	37	8	2.814	0.199
89-3-UB-R-99	05/16/12	22	5.02	48.7		144.9	114	28	8	137.9	0.218
89-4-OB	03/04/97	20	3.82	54.3	402.2	126	106	26	5	0.74	0.05
89-4-OB	05/22/97	18	4.15	54.3	402.2	91	84	21	4	1.04	0.05
89-4-OB	07/09/97	21	3.92	54.7	401.8	123	111	25	3	0.40	0.05
89-4-OB-R-99	11/16/99	19	4.01	74.8	369.7	1854	1760	1142	5	339.00	4.62
89-4-OB-R-99	01/24/00	17	3.61	74.9	369.6	644	532	308	6	79.80	1.45
89-4-OB-R-99	06/08/00	19	3.84	74.4	370.1	768	580	450	7	82.10	1.66
89-4-OB-R-99	07/20/00	19	3.70	74.9	369.6	1208	924	650	8	188.30	2.87
89-4-OB-R-99	12/04/00	19	3.63	75.0	369.5	1236	1242	550	5	191.50	3.38
89-4-OB-R-99	06/13/01	21	3.67	73.3	371.2	1330	1438	800	4	264.50	2.56
89-4-OB-R-99	08/24/01	20	3.63	72.4	372.1	1285	1250	600	3	267.00	2.47
89-4-OB-R-99	12/10/01	19	3.45	71.8	372.7	1097	1104	725	5	237.80	1.80

89-4-OB-R-99	02/20/02	19	3.20	71.7	372.8	1291	1212	600	5	218.10	2.37
89-4-OB-R-99	06/07/02	20	3.31	70.2	374.3	1473	1472	92	5	291.00	3.21
89-4-OB-R-99	07/24/02	20	3.64	69.7	374.8	1486	1546	1200	5	285.00	3.09
89-4-OB-R-99	11/18/02	18	3.59	68.8	375.7	1442	1460	1400	5	315.20	3.72
89-4-OB-R-99	01/16/03	19	4.01	68.3	376.2	1412	1450	1050	6	309.00	3.64
89-4-OB-R-99	05/29/03	20	3.36	66.5	378.0	1363	1384	1100	6	252.10	3.28
89-4-OB-R-99	09/09/03	20	3.63	65.3	379.2	1344	1172	1000	4	278.50	3.29
89-4-OB-R-99	12/11/03	19	3.44	64.6	379.9	1326	1290	950	5	247.50	3.17
89-4-OB-R-99	01/13/04	20	3.58	64.3	380.2	1390	1322	950	5	0.01	3.07
89-4-OB-R-99	05/03/04	20	3.48	63	381.5	1310	1256	825	5	253.00	3.59
89-4-OB-R-99	08/03/04	20	2.79	62.1	382.4	1289	1204	875	6	269.50	3.03
89-4-OB-R-99	11/09/04	16	3.70	60.8	383.7	1286	1210	1100	6	230.20	1.99
89-4-OB-R-99	03/08/05	18	3.69	58.3	386.2	1131	1076	900	8	231.40	2.41
89-4-OB-R-99	04/08/05	19.5	3.79	58.2	386.3	1153	1208	850	8	231.50	2.53
89-4-OB-R-99	09/01/05	20	4.73	56.6	387.9	1070	962	725	9	169.00	2.20
89-4-OB-R-99	10/19/05	19.5	4.09	56.2	388.3	1020	1000	675	6	175.00	2.43
89-4-OB-R-99	02/23/06	19	4.31	55.7	388.8	959	1088	650	7	152.00	2.52
89-4-OB-R-99	06/02/06	20	3.95	54.9	389.6	1136	1190	650	13	14.30	2.19
89-4-OB-R-99	11/29/06	21	3.78	55	389.5	1015	1034	700	7	188.00	2.39
89-4-OB-R-99	02/07/07	21	3.69	56.4	388.1	995	1074	550	7	147.00	2.58
89-4-OB-R-99	06/01/07	21	3.70	54.9	389.6	972	1026	540	3	207.00	2.20
89-4-OB-R-99	08/23/07	20	3.48	54.3	390.2	1021	1058	410	4	173.00	2.20
89-4-OB-R-99	10/10/07	20	3.58	54.2	390.3	892	1026	24	2	90.70	2.14
89-4-OB-R-99	02/28/08	20	5.81	54.8	389.7	234	198	61	5	11.80	0.31
89-4-OB-R-99	05/07/08	20	3.94	54	390.5	1011	1098	560	4	191.00	1.93
89-4-OB-R-99	07/10/08		3.92	53.7	390.8	1086	1124	700	2	197.00	2.18

89-4-OB-R-99	12/16/08	20	3.62	54	390.5	1106	1092	600	7	162.00	2.12
89-4-OB-R-99	02/09/09	20	3.68	54.1	390.4	1091	1014	600	4	143.00	1.83
89-4-OB-R-99	06/15/09	20	3.74	53.4	391.1	1056	1018	660	5	141.00	2.35
89-4-OB-R-99	08/18/09	21	3.72	53.3	391.2	2170	2648	1640	5	361.00	1.67
89-4-OB-R-99	12/10/09	21	3.83	53.2	391.3	2770	3984	2681	6	216.00	4.46
89-4-OB-R-99	03/23/10		3.80	52.2	392.3	3940	4172	3356	4	31.4	4.03
89-4-OB-R-99	04/26/10	20.5	3.72	52.16		2980	4702	2850	4	47	3.89
89-4-OB-R-99	10/15/10	21	3.72	52.5		2410	3386	2000	5	700	3.65
89-4-OB-R-99	04/15/11	21	3.59	53.2		1848	2468	1500	4	380.8	2.73
89-4-OB-R-99	09/08/11	22	3.44	54.1		1169	1038	720	6	161.4	2.5
89-4-OB-R-99	11/03/11	21	4.19	54.3		1456	1628	1120	4	354.4	2.38
89-4-OB-R-99	02/01/12	21	4.14	54.7		1355	1456	940	6	277.4	2.26
89-4-OB-R-99	05/16/12	22	4.05	54.4		1375	1402	880	5	248	1.8
89-4-UB	03/04/97	20	6.15	111.6	332.9	180	168	16	6	1.41	0.10
89-4-UB	05/22/97	20	6.38	113.2	331.3	152	140	16	6	0.97	0.07
89-4-UB	07/09/97	21	6.44	115.2	329.3	182	154	22	7	0.68	0.11
89-4-UB-R-99	11/17/99	18	5.93	74.6	368.9	228	164	45	7	2.02	0.43
89-4-UB-R-99	01/24/00	18	5.90	75.0	368.5	245	183	34	8	2.84	0.44
89-4-UB-R-99	06/08/00	19	6.14	75.2	368.3	219	171	27	9	1.59	0.34
89-4-UB-R-99	07/20/00	20	5.79	75.0	368.5	204	139	30	8	1.69	0.28
89-4-UB-R-99	12/04/00	20	6.11	75.3	368.2	191	172	23	6	0.90	0.20
89-4-UB-R-99	06/13/01	20	6.07	73.3	370.2	240	154	56	4	3.08	0.29
89-4-UB-R-99	08/24/01	21	5.37	72.6	370.9	370	166	62	6	6.12	0.29
89-4-UB-R-99	12/10/01	20	5.89	71.9	371.6	198	152	40	5	4.29	0.21
89-4-UB-R-99	02/20/02	20	5.68	71.5	372.0	205	154	35	5	0.14	0.22
89-4-UB-R-99	06/07/02	20	5.63	69.0	374.5	247	190	66	5	4.00	0.27
89-4-UB-R-99	11/18/02	19	5.31	68.6	374.9	532	390	375	4	21.63	1.26
89-4-UB-R-99	01/15/03	19	5.31	68.1	375.4	527	388	310	4	28.81	1.19

89-4-UB-R-99	05/29/03	20	5.39	66.2	377.3	338	226	145	7	10.21	0.64
89-4-UB-R-99	09/09/03	21	5.41	65.1	378.4	336	256	150	6	7.53	0.67
89-4-UB-R-99	12/11/03	19	5.40	64.2	379.3	396	260	50	5	14.17	0.74
89-4-UB-R-99	01/13/04	20	5.62	64.0	379.5	393	286	85	5	19.15	0.70
89-4-UB-R-99	05/04/04	20	5.31	62.2	381.3	435	344	130	16	21.43	0.96
89-4-UB-R-99	08/03/04	20	4.99	61.3	382.2	342	240	120	8	14.61	0.60
89-4-UB-R-99	11/09/04	16	5.64	60.5	383.0	246	174	70	8	1.30	0.29
89-4-UB-R-99	03/08/05	19	5.80	58.9	384.6	309	210	90	29	11.18	0.36
89-4-UB-R-99	04/08/05	19.4	5.72	57.9	385.6	359	266	130	10	15.31	0.48
89-4-UB-R-99	09/01/05	20	6.72	56.4	387.1	285	238	75	10	15.80	0.42
89-4-UB-R-99	10/19/05	19.5	6.11	55.9	387.6	274	244	30	7	12.30	0.35
89-4-UB-R-99	02/23/06	17	6.18	55.5	388.0	223	276	73	7	10.10	0.31
89-4-UB-R-99	06/02/06	20	5.72	54.9	388.6	432	346	140	9	19.90	0.56
89-4-UB-R-99	09/08/06	19	5.54	54.8	388.7	242	186	62	7	2.89	0.28
89-4-UB-R-99	11/29/06	20	5.89	55	388.5	201	154	46	10	4.78	0.22
89-4-UB-R-99	02/07/07	20	5.48	56.3	387.2	260	230	20	7	8.50	0.39
89-4-UB-R-99	06/01/07	20	5.74	54.5	389.0	236	218	64	3	11.90	0.30
89-4-UB-R-99	08/23/07	21	5.45	54.3	389.2	243	186	55	5	7.33	0.26
89-4-UB-R-99	10/10/07	22	5.59	54.4	389.1	198	158	38	4	9.60	0.20
89-4-UB-R-99	02/28/08	20	3.82	54.7	388.8	1039	1120	780	6	207.00	2.24
89-4-UB-R-99	05/07/08	21	5.82	53.9	389.6	173	148	28	5	0.09	0.15
89-4-UB-R-99	07/10/08		6.26	53.8	389.7	220	150	46	4	4.17	0.22
89-4-UB-R-99	12/16/08	20	5.63	54.2	389.3	239	180	44	5	4.54	0.23
89-4-UB-R-99	02/09/09	20	5.54	54.2	389.3	359	184	57	3	8.47	0.25
89-4-UB-R-99	06/15/09	21	5.74	53.5	390.0	232	170	38	5	5.41	0.17
89-4-UB-R-99	08/18/09	21	5.79	53.4	390.1	245	162	40	5	8.24	0.21

89-4-UB-R-99	12/10/09	18	5.87	53.2	390.3	493	202	67	5	10.30	0.26
89-4-UB-R-99	04/27/10	21	5.30	52.15		199	192	53	7	2.15	0.191
89-4-UB-R-99	07/14/10	21.5	5.35	52.11		242	174	52	6	8.3	0.235
89-4-UB-R-99	10/15/10	21.5	5.92	52.6		224	184	49	7	7.78	0.213
89-4-UB-R-99	03/02/11	21	6.02	53.3		289	176	50	7	486.1	3.91
89-4-UB-R-99	04/15/11	21.5	6.08	53		181	178	44	5	5.111	0.185
89-4-UB-R-99	09/07/11	22	6.20	54		190	186	36	6	0.387	0.148
89-4-UB-R-99	11/03/11	20.5	6.25	54.3		198	156	45	6	4.394	0.171
89-4-UB-R-99	02/01/12	21	6.04	54.7		221	150	51	6	4.211	0.202
89-4-UB-R-99	05/16/12	22	5.96	54.4		239	164	50	6	6.472	0.185
D-1-(Alluv)	02/24/84	16.5	5.60	10.3	357.0	70	59	6	10	0.05	
D-1-(Alluv)	06/23/84	20	4.59	12.2	355.1	58	28	8	14	0.07	0.03
D-1-(Alluv)	09/30/84	21	4.99	14.2	353.1	51	38	7	10	0.25	0.01
D-1-(Alluv)	01/07/85	19	4.30	9.9	357.4	65	43	6	10	0.19	0.03
D-1-(Alluv)	04/20/85	18	4.72	11.2	356.1	63	49	7	12	0.09	0.02
D-1-(Alluv)	07/22/85	22	4.75	13.1	354.2	63	58	7	11	0.08	0.01
D-1-(Alluv)	10/18/85	23	5.27	14.4	352.9	46	38	9	12	0.16	0.01
D-1-(Alluv)	01/23/86	18	5.45	10.4	357.0	55	12	8	12	0.20	0.02
D-1-(Alluv)	06/28/86	21	5.35	10.4	356.9	55	56	10	9	0.15	0.02
D-1-(Alluv)	09/05/86	22.5	5.48	12.7	354.6	50	56	8	9	0.25	0.02
D-1-(Alluv)	11/18/86	19	5.47	11.9	355.5	85	42	8	12	0.08	0.01
D-1-(Alluv)	03/16/87	18	5.42	9.3	358.0	65	40	10	11	0.17	0.01
D-1-(Alluv)	09/21/87	22	5.55	12.7	354.6	52	98	7.5	5.9	0.16	0.05
D-1-(Alluv)	11/16/87	20	5.51	12.2	355.1	60	82	7.8	7.5	0.11	0.05
D-1-(Alluv)	02/18/88	17	4.65	8.5	358.8	51	85	8.2	7.4	0.05	0.05
D-1-(Alluv)	05/13/88	17.5	5.38	11.3	356.0	55	85	9.0	6.0	0.09	0.05
D-1-(Alluv)	08/13/88	21	5.63	13.9	353.4	42	90	8.6	4.2	0.05	0.05
D-1-(Alluv)	11/15/88	22	5.65	14.1	353.2	48	101	6.6	5.0	0.11	0.05
D-1-(Alluv)	02/20/93	17.8	5.30	9.6	357.7	65	82	9	6	0.09	0.05
D-1-(Alluv)	04/15/93	20	4.80	10.2	357.1	66	72	17	5	0.20	0.05
D-1-(Alluv)	07/13/93	23.9	6.30	12.4	354.9	47	113	12	3	0.09	0.05
D-1-(Alluv)	10/26/93	24	5.10	15.0	352.3	72	105	16	3	0.07	0.05
D-1-(Alluv)	01/04/94	13.2	5.10	12.8	354.5	50	134	14	5	0.09	0.05
D-1-(Alluv)	06/27/94	12.8	5.06	12.9	354.4	57	90	29	5	0.25	0.05
D-1-(Alluv)	09/12/94	26.6	5.62	15.0	352.3	49	102	24	4	1.28	0.08
D-1-(Alluv)	10/04/94	21.3	5.63	13.7	353.6	43	116	12	3	0.48	0.05
D-1-(Alluv)	02/15/95	17.4	5.43	10.4	356.9	87	86	26	4	0.05	0.05
D-1-(Alluv)	05/15/95	19	5.37	9.0	358.3	42	69	18	3	0.05	0.05
D-1-(Alluv)	08/14/95	20	5.07	14.0	353.3	59	82	11	1	0.08	0.05
D-1-(Alluv)	10/04/95	22	5.27	14.9	352.4	41	82	26	1	0.08	0.05

D-1-(Alluv)	03/05/97	20	5.65	8.0	359.3	43.4	82	12	3	0.05	0.05
D-1-(Alluv)	06/04/97	18	5.09	11.8	355.5	48	162	14	3	0.14	0.05
D-1-(Alluv)	07/10/97	18	5.61	12.7	354.6	39.8	116	13	3	0.13	0.05
D-1-(Alluv)	10/31/97	20	5.01	13.6	353.7	121	158	61	6	0.70	0.09
D-1-(Alluv)	03/05/98	16	5.14	9.5	357.8	50	68	44	6	0.05	0.05
D-1-(Alluv)	05/21/98	17	4.80	12.7	354.6	56	101	18	3	0.06	0.05
D-1-(Alluv)	09/21/98	20	4.69	14.1	353.2	54	139	15	3	0.13	0.05
D-1-(Alluv)	10/29/98	21	4.34	12.6	354.7	82	263	39	10	0.19	0.13
D-1-(Alluv)	02/15/99	17	5.11	9.6	357.7	44	111	10	4	0.05	0.05
D-1-(Alluv)	04/16/99	16	4.84	9.3	358.0	51	84	7	5	0.06	0.05
D-1-(Alluv)	08/26/99	21	4.49	14.4	352.9	47	72	8	4	0.05	0.05
D-1-(Alluv)	11/15/99	20	5.14	15.3	352.0	44	97	35	4	0.05	0.05
D-1-(Alluv)	01/07/00	18	4.37	14.7	352.6	41	74	38	4	0.05	0.05
D-1-(Alluv)	06/05/00	18	5.08	13.2	354.1	61.1	430	175	7	0.11	0.01
D-1-(Alluv)	11/28/00	19	5.00	14.5	352.8	46.1	42	70	5	0.08	0.01
D-1-(Alluv)	02/05/01	16	5.06	9.3	358.0	51.7	32	80	6	0.05	0.01
D-1-(Alluv)	05/08/01	22	5.52	11.8	355.5	75.8	40	75	5	0.21	0.01
D-1-(Alluv)	12/04/01	20	4.29	11.4	355.9	45	42	13	3	0.03	0.00
D-1-(Alluv)	02/18/02	19	4.91	9.6	357.7	50.7	12	54	6	0.05	0.01
D-1-(Alluv)	06/05/02	18	4.90	13.1	354.2	61.3	50	105	6	0.05	0.00
D-1-(Alluv)	07/18/02	20	4.65	14.0	353.3	48.1	56	100	4	0.16	0.00
D-1-(Alluv)	11/14/02	20	4.68	15.3	352.0	52.6	76	7	5	0.25	0.03
D-1-(Alluv)	01/14/03	17	4.65	10.8	356.5	51.1	46	6	5	0.49	0.02
D-1-(Alluv)	05/22/03	18	4.63	13.1	354.2	56.9	62	9	7	0.26	0.05
D-1-(Alluv)	09/08/03	20	4.36	14.7	352.6	50.6	32	3	3	0.28	0.03
D-1-(Alluv)	12/02/03	19	4.67	15.0	352.3	48.8	76	1	4	0.32	0.01
D-1-(Alluv)	01/08/04	18	4.58	14.6	352.7	49.9	84	<1	6	0.16	0.02
D-1-(Alluv)	04/27/04	19	4.38	10.8	356.5	68.3	40	13	11	1.02	0.01
D-1-(Alluv)	07/28/04	19	4.56	14.2	353.1	54.7	44	12	9	0.10	0.04
D-1-(Alluv)	11/03/04	19	4.62	14.5	352.8	59.2	76	27	8	0.17	0.01
D-1-(Alluv)	03/01/05	18	5.32	9.3	358.0	70.6	116	9	8	<0.006	<0.004
D-1-(Alluv)	04/06/05	19	4.87	10.1	357.2	78.5	32	8	13	< 0.01	0.02
D-1-(Alluv)	08/31/05	20	5.83	15.2	352.1	236	126	14	49	0.29	0.03
D-1-(Alluv)	10/17/05	20	5.37	15.6	351.7	65.3	54	15	11	0.63	0.02
D-1-(Alluv)	02/21/06	15.5	5.50	14	353.3	132	22	10	13	0.70	0.03
D-1-(Alluv)	05/31/06	20	5.25	14.4	352.9	62	114	15	11	0.33	0.01
D-1-(Alluv)	09/06/06	20	4.40	16.4	350.9	88.8	68	27	16	0.31	0.05
D-1-(Alluv)	11/29/06	20	4.68	15.9	351.4	69.7	76	66	10	1.19	0.09
D-1-(Alluv)	01/30/07	17	4.84	13.3	354.0	76.6	42	<1	12	1.25	0.08
D-1-(Alluv)	05/30/07	17	4.40	12.1	355.2	59.5	66	<1	8	0.24	0.05
D-1-(Alluv)	08/22/07	20	4.38	13.1	354.2	83.1	60	2	14	0.61	0.04
D-1-(Alluv)	10/09/07	21	4.51	14.9	352.4	66.9	32	1	8	0.83	0.04
D-1-(Alluv)	02/20/08	18	4.60	14	353.3	70.7	16	4	8	1.42	0.05
D-1-(Alluv)	05/05/08	16	4.96	11.1	356.2	92.1	58	3	10	0.13	0.03
D-1-(Alluv)	07/08/08		5.06	14.4	352.9	98.1	74	6	7	0.89	0.04
D-1-(Alluv)	12/05/08	19	4.77	15.2	352.1	84.1	60	2	14	1.23	0.01
D-1-(Alluv)	02/02/09	17	5.26	14.5	352.8	132.5	114	<1	15	7.16	0.09
D-1-(Alluv)	06/09/09	18	4.86	13	354.3	104.5	82	5	15	0.63	0.03

D-1-(Alluv)	08/10/09	20	4.78	15.1	352.2	83.6	74	4	13	0.37	0.04
D-1-(Alluv)	12/08/09	20	5.45	11.7	355.6	90.8	48	33	14	1.12	0.04
D-1-(Alluv)	03/15/10		4.47	9.6	357.7	88.2	128	13.2	14	0.053	0.016
D-1-(Alluv)	04/20/10	16.5	4.71	11.61		107.2	84	12	16	0.029	0.019
D-1-(Alluv)	07/09/10	19.5	4.67	14.4		119.5	84	13	23	0.085	0.016
D-1-(Alluv)	10/14/10	18	4.59	16.8		123.7	104	22	29	0.505	0.022
D-1-(Alluv)	04/06/11	17.5	5.17	14.2		117.2	80	10	20	4.541	0.058
D-1-(Alluv)	08/31/11	22.5	5.75	17.3		108.6	80	15	16	1.653	0.056
D-1-(Alluv)	11/01/11	21.5	5.27	17.3		106.9	52	17	15	1.118	0.027
D-1-(Alluv)	01/31/12	19	5.82	14.7		167.7	112	18	20	3.836	0.163
D-1-(Alluv)	05/15/12	19	5.31	12.8		154.3	108	5	27	5.532	0.248
D-14-OBa	06/20/84	19	3.42		409	175	174	67	10	5.39	0.15
D-14-OBa	09/28/84	18	3.65		407	223	168	65	6	4.34	0.08
D-14-OBa	01/05/85	18	2.87		412	250	152	65	9	4.86	0.12
D-14-OBa	04/23/85	19	3.30		411	195	182	48	5	4.34	0.08
D-14-OBa	07/24/85	20	3.24		409	205	102	29	8	3.49	0.09
D-14-OBa	10/14/85	19	3.72		408	200	162	64	10	4.04	0.12
D-14-OBa	01/23/86	18	3.90		411	182	98	82	10	4.03	0.13
D-14-OBa	06/24/86	20	3.69		413	170	156	58	6	4	0.09
D-14-OBa	09/03/86	19.5	3.93		409	185	136	65	8	3.26	0.08
D-14-OBa	11/18/86	19	3.96		409	178	142	61	10	4.14	0.09
D-14-OBa	03/22/87	18	3.81		415	158	152	48	7	3.62	0.08
D-14-OBa	09/20/87	20	3.72		409	160	164	58.6	3.1	3.69	0.1
D-14-OBa	11/17/87	18	3.74		409	172	157	60.8	3.4	2.91	0.09
D-14-OBa	02/16/88	19	3.66		413	168	156	56.1	3.3	3.48	0.11
D-14-OBa	05/11/88	19	3.78		412	154	149	53	4	3.82	0.11
D-14-OBa	08/12/88	22	3.76		409	169	156	52.2	3.4	2.98	0.09
D-14-OBa	11/18/88	19	3.92		408	140	139	49.9	1.9	2.53	0.07
D-14-OBb	06/20/84	19	3.41		428	305	216	108	12	7.85	0.24
D-14-OBb	09/28/84	18	3.31		427	423	332	116	8	7.6	0.2
D-14-OBb	01/05/85	18	2.76		428	450	182	129	16	5.2	0.23
D-14-OBb	04/23/85	19	3.75		431	260	248	77	9	10.7	0.13
D-14-OBb	07/24/85	19.5	3.07		430	390	252	91	8	2.92	0.17
D-14-OBb	10/14/85	19	3.43		428	410	298	137	14	3.29	0.26
D-14-OBb	01/23/86	18	3.60		431	373	174	102	14	5.01	0.19
D-14-OBb	06/24/86	20	3.49		432	309	254	114	8	4.4	0.18
D-14-OBb	09/03/86	19	3.41		430	327	300	149	11	3.35	0.22
D-14-OBb	11/18/86	19	3.68		429	362	284	143	18	3.74	0.21
D-14-OBb	03/22/87	19.5	3.55		437	290	248	98	10	4.9	0.17
D-14-OBb	09/20/87	20	3.49		429	345	312	143	3.9	2.31	0.25
D-14-OBb	11/17/87	18	3.39		429	340	314	146	4.8	1.94	0.23
D-14-OBb	02/16/88	19	3.46		432	319	265	126	5.4	7.82	0.24
D-14-OBb	05/12/88	19.5	3.49		433	325	286	127	4	2.14	0.25
D-14-OBb	08/12/88	21	3.40		430	330	284	132	3.6	2.33	0.22
D-14-OBb	11/18/88	19	3.48		428	315	268	129	4.6	2.36	0.19
D-14-OBc	06/20/84	19	5.46	24.15	467.9	85.0	78	17	8	8.03	0.68
D-14-OBc	09/28/84	17	5.17	27.37	464.7	114.0	54	13	6	5.26	0.30
D-14-OBc	01/05/85	18	4.80	22.32	469.7	82.0	49	15	7	7.40	0.34

D-14-OBc	04/23/85	20	5.01	22.02	470.0	78.0	76	17	6	9.96	0.27
D-14-OBc	07/24/85	20	5.00	24.69	467.4	89.0	52	19	5	11.30	0.26
D-14-OBc	10/16/85	19	5.70	26.79	465.3	75.0	80	12	7	6.84	0.18
D-14-OBc	01/23/86	19	5.76	21.60	470.5	80.0	56	11	8	2.35	0.20
D-14-OBc	06/23/86	20	5.91	23.14	468.9	62.0	56		5	7.84	0.31
D-14-OBc	09/03/86	19.5	5.91	25.22	466.8	72.0	48	16	7	2.30	0.06
D-14-OBc	11/18/86	20	6.21	25.43	466.6	63.0	54	14	6	1.88	0.06
D-14-OBc	03/22/87	18	6.06	19.15	472.9	60.0	62	16	6	6.00	0.11
D-14-OBc	09/20/87	20	6.20	25.87	466.2	68.0	85	18.5	2.8	6.43	0.13
D-14-OBc	11/17/87	19	5.64	25.75	466.3	73.0	88	15.9	2.2	7.83	0.11
D-14-OBc	02/16/88	20	5.98	20.71	471.3	68.0	89	18.2	2.3	8.56	0.14
D-14-OBc	05/12/88	20	5.88	22.33	469.7	69.0	89	18.2	3.0	6.25	0.14
D-14-OBc	08/12/88	21	5.85	25.27	466.8	60.0	97	15.5	2.0	5.08	0.13
D-14-OBc	11/18/88	20	6.12	27.11	464.9	65.0	91	16.1	2.8	7.74	0.12
D-14-OB-R-95	12/26/95	17	4.64	37.7	403.0	156	197	53	6	4.73	2.04
D-14-OB-R-95	01/08/96	17	4.25	37.6	403.1	161	141	55	6	2.64	1.71
D-14-OB-R-95	05/02/96	19	4.43	36.5	404.2	144	126	53	6	7.30	1.22
D-14-OB-R-95	07/10/96	20	4.68	36.4	404.3	114	114	36	6	3.83	0.79
D-14-OB-R-95	10/29/96	20	4.25	36.4	404.3	163	136	65	6	6.81	1.00
D-14-OB-R-95	03/05/97	20	4.43	36.0	404.7	158.3	150	48	6	6.95	0.82
D-14-OB-R-95	05/23/97	19	4.81	35.4	405.3	172.7	143	60	6	13.20	0.88
D-14-OB-R-95	07/09/97	20	4.56	35.2	405.5	152.2	135	49	7	8.31	0.73
D-14-OB-R-95	10/30/97	20	4.08	34.9	405.8	224	160	61	7	11.10	0.94
D-14-OB-R-95	03/05/98	20	4.62	34.5	406.2	187	132	62	7	14.60	0.81
D-14-OB-R-95	05/20/98	19	4.12	34.5	406.2	160	123	43	7	9.83	0.62
D-14-OB-R-95	09/21/98	21	4.37	34.1	406.6	186	160	62	7	16.00	0.78
D-14-OB-R-95	10/30/98	20	3.99	34.3	406.4	218	140	53	7	14.10	0.70
D-14-OB-R-95	02/11/99	20	4.03	32.8	407.9	154	119	58	9	12.10	0.58
D-14-OB-R-95	04/23/99	20	4.10	32.3	408.4	166	113	46	8	10.60	0.55
D-14-OB-R-95	08/25/99	19	4.24	31.7	409.0	149	111	42	8	9.77	0.46
D-14-OB-R-95	11/12/99	20	3.77	31.8	408.9	161	107	47	9	8.84	0.45
D-14-OB-R-95	01/24/00	18	3.60	32.0	408.7	174	136	53	8	8.09	0.55

D-14-OB-R-95	06/08/00	20	4.47	31.4	409.3	192	188	150	13	14.12	0.66
D-14-OB-R-95	07/20/00	21	4.12	31.0	409.7	272	176	175	11	14.05	0.86
D-14-OB-R-95	02/20/01	23	3.46	29.5	411.2	753	502	325	11	49.73	2.19
D-14-OB-R-95	06/13/01	23	4.12	26.5	414.2	1302	1232	725	8	148.00	9.78
D-14-OB-R-95	08/24/01	19	3.59	26.0	414.7	1452	1382	500	7	191.00	10.23
D-14-OB-R-95	12/10/01	20	3.58	26.3	414.4	1252	1210	850	9	182.50	8.51
D-14-OB-R-95	02/20/02	19	3.54	25.8	414.9	1517	1453	600	11	221.10	9.22
D-14-OB-R-95	06/10/02	20	3.44	24.4	416.3	1229	1026	1050	12	201.40	7.59
D-14-OB-R-95	07/24/02	20	4.67	24.7	416.0	1040	876	625	11	138.00	4.26
D-14-OB-R-95	11/15/02	19	4.00	25.2	415.5	465	248	150	7	45.60	0.40
D-14-OB-R-95	01/15/03	19	3.81	24.8	415.9	626	478	450	10	95.80	3.07
D-14-OB-R-95	05/29/03	20	3.75	23.6	417.1	1083	982	950	13	172.30	4.93
D-14-OB-R-95	09/09/03	20	3.86	23.8	416.9	489	342	310	10	67.00	2.01
D-14-OB-R-95	12/11/03	20	3.79	24.4	416.3	295	168	125	10	33.33	0.02
D-14-OB-R-95	01/13/04	20	4.10	24.6	416.1	296	172	105	11	31.94	1.00
D-14-UB	06/21/84	19	6.52		396	530	368	113	22	0.62	0.17
D-14-UB	09/28/84	18.5	6.25		395	517	382	73	15	0.55	0.1
D-14-UB	01/06/85	19	5.74		396	400	270	52	17	0.32	0.11
D-14-UB	04/23/85	20	6.10		398	355	236	50	16	0.06	0.08
D-14-UB	07/25/85	20.5	6.20		398	440	276	57	21	0.11	0.07
D-14-UB	10/16/85	19	6.58		397	400	258	62	18	0.06	0.13
D-14-UB	01/25/86	18	6.90		401	450	210	69	14	0.31	0.12
D-14-UB	06/24/86	20.5	6.85		397	350	244	58	16	0.56	0.14
D-14-UB	09/04/86	19.5	6.94		396	342	228	54	16	0.13	0.13
D-14-UB	11/19/86	19	6.66		396	392	220	57	18	0.17	0.13
D-14-UB	03/23/87	19	7.05		398	347	206	51	18	0.22	0.13
D-14-UB	09/21/87	21	6.63		396	318	276	51.5	13	0.05	0.13
D-14-UB	11/17/87	18.5	6.56		395	302	269	55.7	15	0.05	0.14
D-14-UB	02/17/88	19	6.83		397	324	274	55.3	18	1.02	0.13
D-14-UB	05/12/88	20	6.66		398	340	282	52	17	0.27	0.14
D-14-UB	08/12/88	24	6.87		396	350	318	51.2	15	0.18	0.08
D-14-UB	11/15/88	20	6.67		394	297	241	54.8	16	0.7	0.15
D-14-UB-R-95	12/26/95	18	6.65	79.8	360.6	360	334	68	13	0.05	0.16
D-14-UB-R-95	01/08/96	19	6.71	78.6	361.8	395	297	71	11	0.06	0.18

D-14-UB-R-95	05/02/96	20	6.89	74.7	365.7	416	269	76	12	0.98	0.08
D-14-UB-R-95	07/10/96	20	6.89	80.2	360.2	429	309	81	12	0.06	0.06
D-14-UB-R-95	10/29/96	20	6.98	79.9	360.5	422	288	84	12	0.05	0.06
D-14-UB-R-95	03/05/97	18	7.03	79.0	361.4	412	292	73	11	0.10	0.06
D-14-UB-R-95	06/25/97	19	6.75	78.9	361.5	427	281	78	12	2.20	0.06
D-14-UB-R-95	07/11/97	20	7.11	78.7	361.7	419	281	74	12	0.33	0.06
D-14-UB-R-95	11/03/97	17	6.68	78.9	361.5	428	280	71	12	0.10	0.06
D-14-UB-R-95	03/06/98	17	6.59	78.1	362.3	420	275	76	11	0.54	0.06
D-14-UB-R-95	05/22/98	18	6.76	78.0	362.4	468	320	71	12	0.13	0.05
D-14-UB-R-95	09/21/98	19	6.36	78.3	362.1	388	289	72	11	0.30	0.08
D-14-UB-R-95	10/30/98	20	5.99	78.4	362.0	413	290	71	11	1.65	0.06
D-14-UB-R-95	02/11/99	20	6.43	77.3	363.1	428	282	82	12	1.27	0.05
D-14-UB-R-95	04/23/99	19	6.59	77.0	363.4	468	271	74	11	1.39	0.06
D-14-UB-R-95	08/25/99	19	6.65	76.9	363.5	474	280	72	11	1.64	0.06
D-14-UB-R-95	11/12/99	23	6.61	77.2	363.2	438	272	76	12	1.81	0.06
D-14-UB-R-95	01/24/00	17	6.20	77.1	363.3	463	285	75	11	1.55	0.06
D-14-UB-R-95	06/08/00	20	6.90	77.3	363.1	456	312	65	13	1.73	0.09
D-14-UB-R-95	07/20/00	20	6.84	77.2	363.2	440	241	85	13	1.70	0.06
D-14-UB-R-95	12/04/00	19	6.65	76.6	363.8	413	268	85	12	2.17	0.08
D-14-UB-R-95	02/20/01	25	6.83	76.7	363.7	450	276	110	11	1.77	0.06
D-14-UB-R-95	06/13/01	22	6.68	75.6	364.8	413	240	90	15	1.66	0.06
D-14-UB-R-95	12/10/01	20	6.63	75.2	365.2	423	244	95	11	2.04	0.06
D-14-UB-R-95	02/20/02	20	6.35	74.9	365.5	443	271	75	11	1.89	0.07
D-14-UB-R-95	06/10/02	20	6.56	74.0	366.4	434	234	90	11	2.05	0.07
D-14-UB-R-95	07/24/02	20	6.33	74.2	366.2	410	324	170	11	21.45	0.67
D-14-UB-R-95	11/15/02	19	6.53	74.4	366.0	443	276	90	10	1.99	0.06

D-14-UB-R-95	01/15/03	19	6.46	74.2	366.2	430	254	100	11	1.82	0.08
D-14-UB-R-95	05/29/03	20	6.50	73.8	366.6	432	254	105	11	2.01	0.11
D-14-UB-R-95	09/09/03	21	6.51	73.9	366.5	410	246	90	10	4.38	0.08
D-14-UB-R-95	12/11/03	20	6.51	74.4	366.0	419	236	55	10	1.69	0.06
D-14-UB-R-95	01/13/04	20	6.49	74.2	366.2	436	228	80	10	2.02	0.07
D-14-UB-R-95	07/16/10	23	6.49	75.42		432	290	55	11	0.038	0.064
D-16-OBal	02/17/84	19	4.00	80.16	415.3	78.0	31	14	4	0.41	
D-16-OBal	06/22/84	21	3.73	80.44	415.1	67.0	70	10	12	0.55	0.03
D-16-OBal	09/28/84	19	3.80	81.58	413.9	63.0	36	10	7	0.21	0.01
D-16-OBal	01/06/85	20	4.27	81.48	414.0	59.0	35	6	9	1.27	0.05
D-16-OBal	04/23/85	21	3.25	80.80	414.7	64.0	56	8	10	0.21	0.01
D-16-OBal	07/24/85	21.5	3.31	80.87	414.6	67.0	54	9	10	0.27	0.01
D-16-OBal	10/16/85	20	4.28	82.04	413.5	68.0	62	7	8	0.23	0.02
D-16-OBal	01/23/86	19.5	4.23	81.30	414.2	65.0	48	10	11	0.40	0.02
D-16-OBal	06/23/86	21	4.39	81.20	414.3	58.0	50	11	9	1.40	0.02
D-16-OBal	09/03/86	20	4.10	81.54	414.0	70.0	54	10	9	0.32	0.01
D-16-OBal	11/18/86	20	4.36	81.93	413.6	62.0	44	9	8	0.43	0.01
D-16-OBal	03/22/87	19.5	4.18	80.97	414.5	62.0	44	8	10	0.59	0.02
D-16-OBal	09/20/87	21	4.26	81.88	413.6	65.0	72	10.6	5.7	0.24	0.05
D-16-OBal	11/17/87	20	4.08	81.73	413.8	80.0	62	10.5	5.4	0.15	0.05
D-16-OBal	02/16/88	20	4.02	80.90	414.6	72.0	73	10.70	7.17	0.43	0.05
D-16-OBal	05/12/88	20.5	3.97	80.81	414.7	70.0	82	9	7	0.48	0.05
D-16-OBal	08/12/88	21	4.21	82.92	412.6	70.0	73	10.5	5.8	0.65	0.05
D-16-OBal	11/19/88	21	5.53	90.80	404.7	38.0	66	6.2	4.3	3.75	0.05
D-16-OBal	04/15/93	19.4	5.40	106.6	388.9	202	124	17	52	13.00	0.07
D-16-OBal	06/28/94	20.6	5.30	104.0	391.5	292	256	23	77	7.83	0.08
D-16-OBal	09/13/94	26.5	5.45	105.0	390.5	306	204	13	80	6.20	0.09
D-16-OBal	10/05/94	21.4	5.08	104.9	390.6	309	208	5	84	3.83	0.07
D-16-OBal	02/17/95	17.5	5.61	106.0	389.5	235	167	18	47	3.80	0.42
D-16-OBal	10/04/95	20	4.51	102.8	392.7	61	80	9	11	0.09	0.05
D-16-OBal	01/08/96	20	4.41	106.9	388.6	54	78	8	7	0.05	0.05
D-16-OBal	05/06/96	21	5.12	101.8	393.7	47	150	7	6	0.13	0.05
D-16-OBal	07/16/96	22	5.20	102.0	393.5	44	110	9	6	0.05	0.05
D-16-OBal	10/29/96	20	5.27	102.3	393.2	45	82	14	7	0.05	0.05
D-16-OBal	03/05/97	20	5.39	102.1	393.4	42	89	8	5	0.07	0.05
D-16-OBal	06/05/97	22	4.46	101.4	394.1	36	131	7	6	0.06	0.05
D-16-OBal	10/31/97	22	4.86	101.0	394.5	52	102	77	11	0.38	0.05
D-16-OBal	03/06/98	19	4.61	99.4	396.1	39	146	6	6	0.28	0.05
D-16-OBal	05/21/98	21	4.60	98.8	396.7	51	130	2	6	0.74	0.05
D-16-OBal	09/21/98	21	3.86	98.0	397.5	42	162	6	6	0.23	0.05
D-16-OBal	10/30/98	20	4.69	98.0	397.5	36	143	4	7	0.21	0.05
D-16-OBal	02/15/99	20	4.10	97.1	398.4	35	122	5	5	0.41	0.05
D-16-OBal	04/16/99	20	4.47	96.9	398.7	34	146	3	5	0.55	0.05

D-16-OBal	08/26/99	20	4.55	95.6	399.9	35	84	5	5	3.08	0.05
D-16-OBal	11/15/99	20	4.53	95.1	400.4	35	94	28	6	0.32	0.05
D-16-OBal	01/07/00	19	3.98	95.3	400.2	32	63	37	6	0.58	0.05
D-16-OBal	06/05/00	22	4.60	94.7	400.8	36.5	12	175	6	0.95	0.01
D-16-OBal	07/17/00	21	4.66	94.5	401.0	458	72	43	9	1.85	0.13
D-16-OBal	11/28/00	20	4.28	94.3	401.2	41.2	26	45	6	0.43	0.01
D-16-OBal	02/05/01	20	4.41	94.1	401.4	32.9	100	95	5	0.20	0.01
D-16-OBal	05/08/01	21	5.21	93.4	402.1	84	26	65	4	2.47	0.03
D-16-OBal	08/15/01	21	4.42	92.4	403.1	360	60	150	5	0.37	0.02
D-16-OBal	12/04/01	20	4.93	81.8	413.7	42	48	45	6	2.79	0.01
D-16-OBal	02/18/02	20	4.47	91.5	404.0	32.4	22	28	4	0.43	0.01
D-16-OBal	06/05/02	20	4.03	90.3	405.2	42.6	68	100	5	0.12	0.00
D-16-OBal	07/18/02	20	4.25	94.1	401.4	46.5	74	72	5	0.72	0.00
D-16-OBal	11/13/02	19	4.64	90.0	405.5	44.4	72	1	6	3.36	0.01
D-16-OBal	01/14/03	18	4.30	89.7	405.8	36.8	56	1	5	1.30	0.01
D-16-OBal	05/22/03	20	3.94	89.0	406.5	50.3	40	8	5	1.04	0.02
D-16-OBal	07/17/03	21	4.40	88.4	407.1	55.5	84	1	6	2.25	0.01
D-16-OBal	12/02/03	19	4.06	88.5	407.0	44.5	48	1	6	0.10	0.01
D-16-OBal	01/08/04	19	3.80	88.2	407.3	44.8	80	3	5	0.03	0.02
D-16-OBal	04/27/04	19	3.87	88	407.5	60.8	126	14	6	1.40	0.06
D-16-OBal	07/28/04	20	3.91	87.4	408.1	63.8	80	7	10	1.40	0.03
D-16-OBal	11/03/04	20	3.71	87.3	408.2	87.9	108	54	11	0.71	0.02
D-16-OBal	03/01/05	19	3.80	86.7	408.8	88.3	94	21	18	<0.006	<0.004
D-16-OBal	04/06/05	20.1	4.07	86.3	409.2	67	74	14	10	0.04	0.02
D-16-OBal	08/31/05	20	4.76	85.9	409.6	79.7	84	16	14	0.59	0.02
D-16-OBal	10/17/05	19	4.39	36.6	458.9	70.5	70	8	7	0.27	0.01
D-16-OBal	02/21/06	18	4.47	86.1	409.4	78.8	78	15	10	0.11	0.00
D-16-OBal	05/31/06	20	4.16	89.9	405.6	80	98	14	12	0.04	0.01
D-16-OBal	09/06/06	20	3.35	91.4	404.1	113.1	88	13	16	0.10	0.01
D-16-OBal	11/28/06	19	4.35	93.3	402.2	55.3	62	45	8	0.21	0.00
D-16-OBal	01/30/07	18	4.32	94	401.5	89.6	26	4	5	1.07	0.02
D-16-OBal	05/30/07	20	4.32	95.7	399.8	36	52	<1	4	1.49	0.01
D-16-OBal	08/22/07	20	4.49	96.4	399.1	49.3	52	<1	5	1.41	0.01
D-16-OBal	10/09/07	20	4.61	96.3	399.2	37.7	44	<1	7	1.88	0.01
D-16-OBal	02/20/08	20	4.65	95.7	399.8	45	46	<1	5	1.88	0.01
D-16-OBal	05/05/08	20	4.76	95.2	400.3	75.9	56	<1	5	0.22	0.01
D-16-OBal	07/08/08		4.97	95	400.5	86.7	94	<1	3	1.72	0.01
D-16-OBal	12/05/08	19	4.49	97.1	398.4	48.7	52	<1	4	0.67	0.01
D-16-OBal	02/02/09	19	4.46	93.8	401.7	61.1	80	6	7	0.15	0.02
D-16-OBal	06/09/09	20	4.58	93.1	402.4	46.2	54	28	5	0.58	0.01
D-16-OBal	08/10/09	22	4.35	92.9	402.6	62.8	136	10	7	0.46	0.05
D-16-OBal	12/08/09	20	5.19	92.3	403.2	56.6	58	15	6	0.76	0.01
D-16-OBal	03/15/10		3.95	91.9	403.6	51.3	84	6.8	6	0.372	0.012
D-16-OBal	04/20/10	20.5	4.24	91.35		52.4	48	11	6	0.116	0.013
D-16-OBal	07/08/10	22	3.97	90.95		54.9	66	15	9	<0.01	0.013
D-16-OBal	10/13/10	21	4.81	90.4		73.2	122	7	9	0.618	<0.01
D-16-OBal	02/28/11	21	4.93	89.8		46.4	80	7	6	0.932	<0.01
D-16-OBal	04/06/11	21.5	4.61	89.9		88.4	62	6	7	0.391	<0.01

D-16-OBal	08/31/11	22	4.68	92.9		56.9	68	16	7	0.053	0.012
D-16-OBal	11/01/11	22	4.57	93.5		56.2	34	11	6	0.271	<0.01
D-16-OBal	01/31/12	21	4.72	95.6		52.6	60	10	8	0.198	0.011
D-16-OBal	05/15/12	22.5	4.55	96.7		51.1	52	5	8	0.066	< 0.01
D-16-UB	02/17/84	19	6.10	91.0	404.0	170	147	22	8	0.04	
D-16-UB	06/22/84	21	5.54	90.9	404.1	175	152	26	14	1.72	0.06
D-16-UB	09/28/84	19	5.18	91.6	403.4	170	126	17	10	1.70	0.06
D-16-UB	01/06/85	20	5.96	92.0	403.0	167	142	15	11	2.03	0.11
D-16-UB	04/24/85	20	5.51	92.1	402.9	163	110	13	12	2.43	0.05
D-16-UB	07/24/85	22	5.70	92.0	403.0	160	66	16	20	0.38	0.05
D-16-UB	10/16/85	20	6.18	92.7	402.3	155	126	15	12	0.59	0.06
D-16-UB	01/26/86	18	6.23	92.4	402.6	145	76	13	8	0.10	0.03
D-16-UB	06/24/86	21	6.33	92.1	402.9	140	150	16	10	0.21	0.05
D-16-UB	09/04/86	20	6.23	92.3	402.7	140	110	13	10	0.10	0.04
D-16-UB	11/19/86	20	6.10	92.7	402.3	149	102	12	9	0.40	0.04
D-16-UB	03/23/87	19	6.12	92.0	403.1	123	94	11	11	0.12	0.04
D-16-UB	09/21/87	21	6.38	92.5	402.5	128	141	12	7	0.05	0.07
D-16-UB	11/17/87	19.5	6.43	92.6	402.4	133	125	10.5	6.9	0.13	0.05
D-16-UB	02/17/88	20	6.42	91.9	403.1	134	128	11.30	9.34	0.12	0.06
D-16-UB	05/13/88	21	6.27	91.5	403.5	149	143	12	8	0.82	0.05
D-16-UB	08/13/88	21	6.26	92.5	402.5	130	132	11.4	7.3	0.29	0.07
D-16-UB	11/19/88	21	6.46	97.6	397.4	125	126	9.7	6	0.15	0.06
D-16-UB	02/20/93	19.5	6.10	107.0	388.0	174	131	16	10	0.93	0.07
D-16-UB	04/15/93	19.5	5.80	107.6	387.4	152	120	27	9	1.49	0.05
D-16-UB	07/14/93	25.1	6.20	107.3	387.7	158	133	18	9	0.06	0.05
D-16-UB	01/04/94		5.90	107.1	387.9	149	132	0	8	0.67	0.05
D-16-UB	06/28/94	23.1	6.10	106.8	388.2	153	149	32	9	0.17	0.05
D-16-UB	09/13/94	26.1	5.51	108.0	387.0	157	139	21	9	0.05	0.05
D-16-UB	10/05/94	21.1	5.65	118.0	377.0	152	167	20	8	0.16	0.05
D-16-UB	02/17/95	18	5.92	108.0	387.0	158	152	19	8	0.13	0.05
D-16-UB	05/15/95	22	6.27	106.7	388.3	163	138	15	8	0.07	0.05
D-16-UB	08/14/95	21	6.03	103.2	391.8	167	145	16	9	0.67	0.05
D-16-UB	03/05/97	20	6.12	105.2	389.8	153	148	38	8	0.24	0.06
D-16-UB	06/05/97	21	5.87	104.5	390.5	138	131	21	9	0.16	0.05
D-16-UB	10/31/97	22	5.75	103.8	391.2	149	191	107	15	0.54	0.07
D-16-UB	03/06/98	18	5.78	102.4	392.6	140	154	68	12	0.49	0.06
D-16-UB	05/21/98	21	5.34	102.9	392.1	166	143	12	8	0.27	0.05
D-16-UB	09/21/98	21	5.34	102.0	393.0	142	142	15	9	1.34	0.05
D-16-UB	10/30/98	19	5.93	101.9	393.1	139	158	47	11	0.21	0.06
D-16-UB	02/15/99	19	5.37	101.0	394.0	181	169	29	11	0.40	0.05
D-16-UB	04/16/99	19	5.68	100.9	394.2	153	260	20	12	6.76	0.16
D-16-UB	08/26/99	20	5.56	108.0	387.0	159	141	32	10	1.11	0.05
D-16-UB	11/15/99	20	5.42	107.0	388.0	163	147	24	9	0.75	0.05
D-16-UB	01/07/00	19	5.80	106.0	389.0	146	117	13	8	2.08	0.05
D-16-UB	06/05/00	21	5.78	100.7	394.3	164.9	104	20	10	1.13	0.04
D-16-UB	07/17/00	21	6.06	107.0	388.0	348	143	34	12	0.12	0.01
D-16-UB	11/28/00	20	5.64	100.2	394.8	148.2	108	20	8	1.91	0.04
D-16-UB	02/05/01	19	5.84	100.0	395.0	155	136	21	8	1.65	0.05

D-16-UB	05/08/01	21	6.03	98.8	396.2	204	132	11	11	1.22	0.05
D-16-UB	08/15/01	20	5.78	98.5	396.5	153	120	25	10	0.60	0.04
D-16-UB	12/04/01	20	5.71	97.7	397.3	147	98	14	8	2.04	0.05
D-16-UB	02/18/02	19	5.79	97.5	397.5	142	118	12	8	2.25	0.05
D-16-UB	06/05/02	20	5.73	97.0	398.0	337	146	19	11	2.48	0.04
D-16-UB	07/18/02	20	5.53	97.0	398.0	150.5	118	18	8	2.24	0.02
D-16-UB	11/13/02	19	5.53	97.0	398.0	152.3	124	15	8	1.75	0.04
D-16-UB	01/14/03	18	5.65	97.0	398.0	149.5	122	21	10	1.10	0.01
D-16-UB	05/22/03	20	5.55	96.5	398.5	155.3	78	20	8	1.65	0.04
D-16-UB	07/17/03	21	5.67	96.0	399.0	162	144	20	10	1.98	0.05
D-16-UB	12/02/03	19	5.70	96.4	398.6	155.1	138	7	8	1.93	0.04
D-16-UB	01/08/04	19	5.64	96.4	398.6	155.8	156	10	9	1.75	0.06
D-16-UB	04/27/04	20	5.45	95.6	399.4	161.3	54	8	6	0.50	0.02
D-16-UB	07/28/04	20	5.38	95.7	399.3	155.2	106	8	9	2.34	0.07
D-16-UB	11/03/04	20	5.61	95.4	399.6	166.3	156	21	12	1.53	0.05
D-16-UB	03/01/05	19	5.32	95.0	400.0	156.6	152	14	11	<0.006	<0.004
D-16-UB	04/06/05	20	5.66	94.4	400.6	147.5	108	12	12	1.43	0.06
D-16-UB	08/31/05	19	6.47	94.6	400.4	130.9	118	13	13	2.33	0.05
D-16-UB	10/17/05	19	6.10	34.9	460.1	118.9	98	59	9	1.19	0.03
D-16-UB	02/21/06	18	6.07	95	400.0	136.1	108	10	11	1.79	0.02
D-16-UB	05/31/06	20	5.88	98.3	396.7	145	126	13	13	1.57	0.03
D-16-UB	09/06/06	20	5.30	100.2	394.8	158.2	134	27	17	1.46	0.05
D-16-UB	11/28/06	18	5.51	96	399.0	133.6	90	12	10	1.67	0.03
D-16-UB	01/30/07	19	5.51	101.7	393.3	141.5	82	12	6	1.89	0.03
D-16-UB	05/30/07	21	5.38	103.3	391.7	130.2	112	7	7	1.95	0.03
D-16-UB	08/22/07	21	5.45	103.4	391.6	131.5	110	<1	8	1.68	0.03
D-16-UB	10/09/07	21	5.60	103	392.0	121	104	<1	5	1.86	0.03
D-16-UB	02/20/08	19	5.43	102.5	392.5	135	96	7	5	1.49	0.05
D-16-UB	05/05/08	20	5.83	102.1	392.9	161.7	124	7	5	0.62	0.06
D-16-UB	07/08/08		5.75	101.8	393.2	148.7	190	8	6	0.13	0.04
D-16-UB	12/05/08	20	5.81	109.2	385.8	152.9	120	8	8	0.89	0.04
D-16-UB	02/02/09	20	5.35	101.2	393.8	131.2	130	5	8	0.95	0.04
D-16-UB	06/09/09	20	5.70	100.8	394.2	143	110	7	7	16.80	1.33
D-16-UB	08/10/09	23	5.68	105.2	389.8	143.9	82	<1	5	0.93	0.51
D-16-UB	12/08/09	20	6.07	100	395.0	140.7	120	14	7	1.04	0.04
D-16-UB	03/18/10		5.20	99.1	395.9	127.3	116	19.4	7	<0.01	0.019
D-16-UB	04/21/10	20.5	5.23	98.75		134	122	19	9	0.023	0.039
D-16-UB	07/09/10	21.5	5.44	98.28		146.8	124	16	9	<0.01	0.036
D-16-UB	10/13/10	20.5	5.73	98.7		155.4	138	13	16	1.16	0.042
D-16-UB	02/28/11	20.5	5.99	98.2		156.7	144	19	11	0.854	0.039
D-16-UB	04/06/11	19	5.62	98.3		125.7	112	15	9	0.472	0.034
D-16-UB	08/31/11	22	6.24	100.8		170.7	130	19	11	0.342	0.043
D-16-UB	11/01/11	21.5	6.09	101.4		146	128	18	9	0.806	0.042
D-16-UB	01/31/12	21	6.19	104.1		157.3	134	20	7	0.916	0.049
D-16-UB	05/15/12	21	5.93	104.1		146.3	100	11	7	0.584	0.037
D-17-OB	02/20/84	18	4.00		407	115	97	10	16	0.37	
D-17-OB	06/21/84	20	3.59		405	107	88	14	24	0.61	0.04
D-17-OB	09/29/84	18	4.96		404	115	40	10	20	0.63	0.02

D-17-OB	01/04/85	19	3.15		403	120	73	9	25	0.79	0.01
D-17-OB	04/23/85	18	4.01		407	118	88	10	24	0.79	0.02
D-17-OB	07/23/85	21	3.54		405	105	68	10	24	0.75	0.01
D-17-OB	10/21/85	20	4.26		405	110	60	12	24	0.64	0.01
D-17-OB	01/23/86	18	4.22		407	110	40	9	23	0.83	0.02
D-17-OB	07/09/86	20	4.27		406	99	50	11	20	0.79	0.02
D-17-OB	09/03/86	19.5	4.33		404	100	84	11	19	0.72	0.01
D-17-OB	11/19/86	20	4.33		406	110	68	10	23	0.77	<0.01
D-17-OB	03/16/87	19.5	4.26		408	90	62	10	18	0.76	0.01
D-17-OB	09/17/87	21	4.02		406	100	88	10.3	20.6	0.5	0.05
D-17-OB	11/16/87	20.5	4.30		406	110	87	10.4	19.8	0.48	0.05
D-17-OB	02/17/88	19	4.25		407	95	82	10.8	18.4	0.61	0.05
D-17-OB	05/12/88	19	4.16		406	99	84	8	13.0	0.47	0.05
D-17-UB	03/02/84	18.5	6.30		398	260	209	22	10	0.18	
D-17-UB	06/21/84	21	6.50		397	290	174	8	16	0.94	0.12
D-17-UB	09/29/84	19	6.28		395	340	156	9	12	1.84	0.08
D-17-UB	01/04/85	19	6.12		396	350	216	8	16	1.07	0.07
D-17-UB	04/23/85	19	6.61		397	315	176	8	19	0.84	0.08
D-17-UB	07/23/85	20	6.55		396	350	168	9	16	0.33	0.07
D-17-UB	10/21/85	20	7.01		395	330	172	10	16	0.1	0.06
D-17-UB	01/23/86	19	7.12		396	340	170	9	17	0.12	0.06
D-17-UB	07/09/86	21.5	7.01		396	297	178	11	13	0.08	0.06
D-17-UB	09/03/86	20	7.11		395	305	216	10	13	0.19	0.05
D-17-UB	11/19/86	20	7.47		395	290	184	9	16	0.66	0.04
D-17-UB	03/16/87	20	7.23		397	285	196	8	16	1.04	0.05
D-17-UB	09/17/87	21	7.02		396	298	216	7.8	12.5	0.58	0.08
D-17-UB	11/16/87	20.5	7.03		395	295	223	7.8	12.8	0.08	0.05
D-17-UB	02/17/88	20	6.94		396	287	212	7.5	13	0.85	0.07
D-17-UB	05/12/88	21	7.04		397	296	210	11	19	0.57	0.05
D-19-OB	08/10/09	20	4.18	20.2	383.0	72	64	<1	10	0.10	0.02
D-19-OB	12/09/09	18	4.67	19.4	383.8	78.4	116	55	11	0.03	0.01
D-19-OB	03/15/10		3.63	18.4	384.8	83.2	120	<1	7	0.081	0.016
D-19-OB	04/20/10	17.5	3.81	18.4		72.3	32	5	9	<0.01	0.012
D-19-OB	07/08/10	20	3.54	18.9		65.8	60	5	8	<0.01	0.012
D-19-OB	10/13/10	20	3.99	19.7		63	60	6	10	0.033	<0.01
D-19-OB	02/28/11	18.5	4.44	19.6		66.2	48	6	10	0.11	0.01
D-19-OB	04/06/11	18	4.48	19.6		57.8	60	6	9	0.03	0.012
D-19-OB	08/31/11	21.5	4.69	20.7		55.9	44	6	10	0.053	0.012
D-19-OB	11/01/11	22	4.72	20.5		60.3	52	8	10	0.109	0.012
D-19-OB	01/31/12	19	4.63	20.2		67.4	68	6	11	0.032	0.017
D-19-OB	05/15/12	19	4.21	20.2		63.5	32	5	9	0.233	0.017
D-19-UB	08/10/09	19	5.76	21.1	381.9	153.9	144	<1	6	1.90	0.14
D-19-UB	12/09/09	19	5.40	19.9	383.1	74.1	90	10	8	1.32	0.08
D-19-UB	03/26/10	19	5.52	19.2	383.8	132.2	108	16	8	1.87	0.124
D-19-UB	04/20/10	19	5.77	19.2		153.4	140	32	8	0.089	0.139
D-19-UB	07/08/10	20.5	5.74	19.64		145.3	144	22	9	0.062	0.133
D-19-UB	10/13/10	20	5.64	20.7		162.5	136	1	15	0.283	0.135
D-19-UB	02/28/11	19	5.98	21.3		146.7	124	10	9	1.765	0.155

D-19-UB	04/06/11	19.5	6.14	20.5		137.9	144	17	8	0.148	0.146
D-19-UB	08/31/11	20	6.21	21.9		88.6	60	7	22	1.109	0.111
D-19-UB	11/01/11	21	5.86	22		89.4	78	13	9	0.205	0.095
D-19-UB	01/31/12	20	5.97	21.3		99.5	92	7	10	0.972	0.103
D-19-UB	05/15/12	20	6.19	21.2		115.9	60	39	10	0.311	0.121
D-2-(Alluv)	02/18/84	17	7.50	3.6	328.2	380.0	181	40	12	0.18	
D-2-(Alluv)	06/23/84	19	7.42	6.1	325.7	390.0	220	51	18	0.17	0.11
D-2-(Alluv)	09/30/84	18.5	7.35	10.4	321.4	400.0	220	42	16	0.19	0.12
D-2-(Alluv)	01/08/85	18.5	6.85	3.4	328.4	450.0	232	40	16	0.20	0.22
D-2-(Alluv)	04/20/85	19	7.12	5.0	326.8	400.0	288	43	16	0.08	0.12
D-2-(Alluv)	07/23/85	20	7.63	8.1	323.7	430.0	242	43	16	0.08	0.07
D-2-(Alluv)	10/14/85	20.5	8.09	11.4	320.4	390.0	232	45	16	0.10	0.07
D-2-(Alluv)	01/23/86	18	7.87	3.7	328.1	420.0	204	44	12	0.13	0.14
D-2-(Alluv)	06/28/86	20.5	7.87	4.8	327.1	349.0	274	42	13	0.06	0.12
D-2-(Alluv)	09/05/86	21	8.18	7.7	324.1	348.0	222	42	12	0.11	0.09
D-2-(Alluv)	11/19/86	20	8.24	5.5	326.4	345.0	226	40	16	0.07	0.10
D-2-(Alluv)	03/16/87	19.5	8.08	3.9	327.9	320.0	208	39	16	0.18	0.11
D-2-(Alluv)	09/20/87	21	8.09	12.1	319.7	350.0	261	40.7	10.7	0.05	0.10
D-2-(Alluv)	11/16/87	20	7.72	4.3	327.6	332.0	247	40.9	12.3	0.05	0.09
D-2-(Alluv)	02/15/88	18	7.95	3.4	328.4	320.0	238	42.5	12.9	0.05	0.13
D-2-(Alluv)	05/11/88	19	8.06	5.2	326.6	338.0	255	43.0	13.0	0.11	0.12
D-2-(Alluv)	08/13/88	20	7.99	10.5	321.3	350.0	253	41.5	11.7	0.06	0.12
D-2-(Alluv)	11/15/88	21	8.33	9.8	322.0	344.0	252	45.5	13.3	0.05	0.05
D-2-(Alluv)	02/20/93	17.8	7.00	2.2	329.6	436.0	239	71	16	0.06	0.16
D-2-(Alluv)	07/14/93	24.7	7.70	6.0	325.8	399	256	43	13	0.05	0.11
D-2-(Alluv)	10/26/93	22.8	7.90	9.7	322.1	438	265	48	13	0.07	0.06
D-2-(Alluv)	01/04/94	12.8	7.80	4.4	327.4	385	248	60	14	0.05	0.08
D-2-(Alluv)	06/27/94	13.2	6.90	5.1	326.7	402	282	46	13	0.05	0.13
D-2-(Alluv)	09/13/94	20.6	7.05	9.3	322.5	401	272	49	14	0.15	0.32
D-2-(Alluv)	10/04/94	20.1	7.34	20.5	311.3	393	337	55	14	0.08	0.06
D-2-(Alluv)	02/17/95	16.4	6.98	2.5	329.3	411	277	48	14	0.05	0.20
D-2-(Alluv)	05/16/95	18	7.26	3.5	328.4	399	239	43	13	0.05	0.14
D-2-(Alluv)	08/14/95	19	7.57	7.3	324.5	391	265	46	13	0.20	0.14
D-2-(Alluv)	10/04/95	20	7.59	10.1	321.7	383	254	42	13	0.06	0.10
D-2-(Alluv)	01/08/96	19	7.52	7.7	324.1	391	250	54	13	0.05	0.12
D-2-(Alluv)	03/06/97	19	7.01	2.4	329.4	403	253	42	13	0.14	0.17
D-2-(Alluv)	06/05/97	17	7.76	4.7	327.1	367	252	44	13	0.15	0.14
D-2-(Alluv)	07/10/97	18	8.09	6.0	325.8	370	254	44	14	0.05	0.14
D-2-(Alluv)	11/03/97	18	7.43	8.2	323.6	399	250	59	14	0.06	0.13
D-2-(Alluv)	03/05/98	17	7.68	2.7	329.1	336	242	45	14	0.06	0.14
D-2-(Alluv)	05/21/98	17	7.08	6.7	325.1	179	261	41	13	0.05	0.12
D-2-(Alluv)	09/21/98	21	6.84	30.6	301.2	478	258	49	14	0.06	0.11
D-2-(Alluv)	10/29/98	20	6.94	30.6	301.2	448	109	38	6	0.94	0.05
D-2-(Alluv)	02/15/99	17	7.08	3.6	328.2	400	246	44	14	0.34	0.12
D-2-(Alluv)	04/16/99	17	7.28	2.8	329.0	393	247	44	14	0.29	0.14
D-2-(Alluv)	08/26/99	21	7.42	9.2	322.6	432	271	51	14	0.05	0.12
D-2-(Alluv)	11/15/99	18	7.20	10.5	321.3	418	278	55	14	0.05	0.09
D-2-(Alluv)	01/07/00	17	7.50	9.2	322.6	386	237	45	14	0.05	0.10

D-2-(Alluv)	06/05/00	18	7.69	5.0	326.8	428	202	65	14	0.01	0.12
D-2-(Alluv)	07/17/00	21	7.84	8.3	323.5	406	222	45	14	0.03	0.09
D-2-(Alluv)	11/28/00	19	7.00	5.7	326.1	336	222	51	9	0.46	0.09
D-2-(Alluv)	05/08/01	19	7.24	4.3	327.5	414	216	19	15	0.08	0.14
D-2-(Alluv)	08/15/01	20	7.57	8.8	323.0	414	242	40	14	0.05	0.13
D-2-(Alluv)	12/04/01	19	7.21	3.9	327.9	387	222	53	13	0.06	0.05
D-2-(Alluv)	02/18/02	19	7.15	2.4	329.4	385	218	55	14	0.29	0.14
D-2-(Alluv)	06/05/02	19	7.36	6.4	325.4	396	236	58	15	0.02	0.11
D-2-(Alluv)	07/18/02	20	7.42	7.3	324.5	382	232	48	14	0.07	0.08
D-2-(Alluv)	11/13/02	19	7.66	9.4	322.4	397	222	17	14	0.19	0.12
D-2-(Alluv)	01/14/03	18	7.26	3.1	328.7	404	222	80	13	0.27	0.14
D-2-(Alluv)	05/22/03	17	7.35	7.0	324.8	399	178	59	13	0.32	0.11
D-2-(Alluv)	09/08/03	19	7.30	10.2	321.6	417	200	68	13	0.18	0.13
D-2-(Alluv)	12/02/03	19	7.37	9.6	322.2	398	258	51	15	0.36	0.12
D-2-(Alluv)	01/08/04	18	7.39	9.2	322.6	388	264	25	13	0.23	0.16
D-2-(Alluv)	04/27/04	20	6.96	2.5	329.3	360	220	40	2	0.09	0.15
D-2-(Alluv)	07/28/04	20	7.37	8.3	323.5	404	212	40	17	0.14	0.15
D-2-(Alluv)	11/03/04	19	7.33	7.0	324.8	413	240	60	17	0.04	0.12
D-2-(Alluv)	03/01/05	15	7.45	2.4	329.4	383	230	57	15	<0.006	0.06
D-2-(Alluv)	04/06/05	17	7.61	2.0	329.8	364	236	57	16	< 0.01	0.14
D-2-(Alluv)	08/31/05	20	8.23	11.1	320.7	395	254	46	22	0.68	0.13
D-2-(Alluv)	10/17/05	20.5	7.93	11.1	320.7	373	224	43	16	0.04	0.12
D-2-(Alluv)	02/21/06	16	7.91	9.6	322.2	375	214	53	15	0.53	0.11
D-2-(Alluv)	05/31/06	17	7.51	10.3	321.5	391	248	52	20	0.00	0.09
D-2-(Alluv)	09/06/06	18	7.15	13.4	318.4	385	220	56	19	0.05	0.12
D-2-(Alluv)	11/29/06	18	7.59	12.9	318.9	377	230	85	15	0.16	0.11
D-2-(Alluv)	01/30/07	17	7.30	8.7	323.1	359	180	58	18	0.32	0.11
D-2-(Alluv)	05/30/07	18	7.24	5	326.8	360	224	31	10	0.04	0.14
D-2-(Alluv)	08/22/07	20	7.15	7.4	324.4	346	218	41	12	0.46	0.13
D-2-(Alluv)	10/09/07	19	7.57	10.7	321.1	345	220	35	11	<0.006	0.10
D-2-(Alluv)	02/20/08	17	7.33	9.3	322.5	371	204	44	11	0.03	0.10
D-2-(Alluv)	05/05/08	16	7.08	5.2	326.6	418	222	38	14	0.18	0.13
D-2-(Alluv)	07/08/08		7.12	9.6	322.2	395	270	43	13	0.08	0.11
D-2-(Alluv)	12/05/08	19	7.39	11.3	320.5	386	220	36	15	0.05	0.07
D-2-(Alluv)	02/02/09	18	7.08	9.7	322.1	397	258	37	15	0.06	0.11
D-2-(Alluv)	06/09/09	18	7.32	7.5	324.3	395	232	44	13	0.12	0.12
D-2-(Alluv)	08/10/09	20	7.35	12.3	319.5	375	230	35	15	0.09	0.09
D-2-(Alluv)	12/08/09	18	7.67	3.8	328.0	371	230	39	12	<0.01	0.11
D-2-(Alluv)	03/01/10		6.65	2.6	329.2	398	254	130	17	0.168	0.152
D-2-(Alluv)	04/20/10	17	7.09	4.55		391	232	50	16	0.022	0.124
D-2-(Alluv)	07/09/10	19	7.18	10.94		404	240	51	15	<0.01	0.098
D-2-(Alluv)	10/13/10	20	7.52	14		385	240	44	16	0.034	0.095
D-2-(Alluv)	02/28/11	17.5	5.21	14.6		127.3	232	55	17	0.09	0.093
D-2-(Alluv)	04/06/11	18.5	7.65	11.7		383	236	56	13	0.052	0.112
D-2-(Alluv)	08/31/11	21.5	7.90	15.3		370	244	48	17	0.055	0.123
D-2-(Alluv)	11/01/11	20	7.80	15.5		412	256	61	16	0.07	0.116
D-2-(Alluv)	01/31/12	19	8.01	14.1		400	258	50	16	0.224	0.13
D-2-(Alluv)	05/15/12	19	7.84	9.3		388	228	45	14	0.019	0.109

D-21-OB	02/20/84	14.0	5.10	9.4	385.9	34.0	40	9	4	0.04	
D-21-OB	06/27/84	20.0	3.74	10.3	385.0	32.0	20	3	10	0.26	0.02
D-21-OB	09/29/84	20.0	4.93	11.2	384.1	30.0	21	<5	10	0.26	0.01
D-21-OB	01/07/85	18.0	5.00	6.9	388.4	44.0	26	<2	10	0.19	0.04
D-21-OB	04/22/85	17.0	4.26	4.0	391.4	35.0	30	4	9	0.54	<0.01
D-21-OB	07/23/85	21.5	4.06	10.3	385.0	36.0	<5	3	8	0.41	0.01
D-21-OB	10/13/85	22.0	4.92	11.3	384.0	26.0	16	<2	9	0.10	0.01
D-21-OB	01/24/86	16.0	4.82	11.7	383.6	34.0	24	7	6.00	0.26	<0.01
D-21-OB	06/29/86	20.5	5.01	8.4	386.9	27.0	28	8	8.00	0.22	0.01
D-21-OB	09/04/86	22.0	5.07	10.4	385.0	23.0	16	6	8.00	0.18	0.01
D-21-OB	11/19/86	20.0	5.08	10.1	385.3	40.0	14	8	6.00	0.22	<0.01
D-21-OB	03/24/87	20.0	5.01	8.2	387.2	25.0	26	6	9.00	0.19	0.01
D-21-OB	09/21/87	21.0	5.23	11.5	383.8	22.0	202	4.4	3.80	0.49	0.05
D-21-OB	11/16/87	20.5	4.99	11.5	383.9	38.0	200	4.3	3.70	0.10	0.05
D-21-OB	05/12/88	17.0	4.90	10.0	385.3	29.0	79	3	5.00	0.15	0.05
D-21-OB	08/13/88	21.0	4.99	10.8	384.5	22.0	144	4.3	3.40	0.21	0.05
D-21-OB	11/17/88	20.0	5.16	11.0	384.3	22.0	75	2.3	3.70	0.09	0.05
D-21-OB	04/15/93	18.9	4.50	9.5	385.8	40	228	3	5	0.08	0.05
D-21-OB	07/13/93	23.6	5.00	10.4	384.9	37	296	4	5	0.09	0.05
D-21-OB	10/26/93	25.4	4.40	11.5	383.8	47	267	16	7	0.12	0.05
D-21-OB	01/04/94	13	4.70	11.3	384.0	38	166	19	7	0.05	0.05
D-21-OB	06/27/94	13.1	4.50	13.1	382.2	40	139	14	11	0.05	0.05
D-21-OB	09/12/94	26.8	5.04	12.5	382.8	34	240	37	6	0.05	0.05
D-21-OB	10/04/94	19	5.15	14.3	381.0	35	167	6	5	0.12	0.05
D-21-OB	02/15/95	16.7	4.67	9.6	385.7	39	154	26	4	0.21	0.05
D-21-OB	05/15/95	20	4.78	8.3	387.0	41	68	9	5	0.05	0.05
D-21-OB	08/14/95	21	4.64	10.7	384.6	34	109	21	7	0.12	0.05
D-21-OB	03/05/97	20	5.14	5.7	389.6	42.7	62	11	5	0.05	0.05
D-21-OB	06/04/97	19	4.80	9.3	386.0	33	93	17	7	0.55	0.05
D-21-OB	07/10/97	20	5.06	10.2	385.1	37.1	110	5	7	0.42	0.05
D-21-OB	10/31/97	20	4.60	10.5	384.8	60	112	20	9	0.05	0.05
D-21-OB	03/05/98	15	4.80	7.5	387.8	36	57	40	8	0.07	0.05
D-21-OB	05/21/98	18	4.42	6.9	388.4	45	123	16	6	0.05	0.05
D-21-OB	09/21/98	22	4.34	10.0	385.3	90	119	6	7	0.07	0.05
D-21-OB	10/29/98	21	4.03	10.0	385.3	50	88	3	6	0.10	0.05
D-21-OB	02/15/99	16	4.41	7.8	387.5	42	107	6	6	0.07	0.05
D-21-OB	04/16/99	16	4.32	7.9	387.4	41	99	5	6	0.33	0.05
D-21-OB	08/26/99	21	4.35	11.0	384.3	38	131	6	6	0.05	0.05
D-21-OB	11/15/99	19	4.77	11.5	383.8	41	139	7	6	0.05	0.05
D-21-OB	01/07/00	17	4.27	10.4	384.9	42	71	38	8	0.30	0.05
D-21-OB	07/17/00	20	5.19	10.4	384.9	441	22	450	40	0.31	0.01
D-21-OB	11/28/00	20	4.40	8.3	387.0	44	28	90	8	0.03	0.01
D-21-OB	02/05/01	14	4.49	6.9	388.4	52.8	96	20	10	0.05	0.01
D-21-OB	05/08/01	18	4.78	7.2	388.1	51.2	30	90	6	0.15	0.01
D-21-OB	08/15/01	19	4.28	9.5	385.8	390	44	200	6	0.15	0.01
D-21-OB	12/04/01	20	4.50	8.2	387.1	65.3	36	12	7	0.18	0.01
D-21-OB	02/18/02	17	4.36	8.4	386.9	49	9	95	9	0.09	0.03
D-21-OB	06/05/02	18.5	4.21	5.7	389.6	42.8	32	90	7	0.32	0.01

D-21-OB	07/18/02	21	4.82	6.6	388.7	104.1	86	39	7	0.54	0.01
D-21-OB	11/13/02	20	4.51	10.2	385.1	126.2	92	12	9	1.41	0.02
D-21-OB	01/14/03	18	4.27	8.4	386.9	67.2	56	10	8	0.42	0.01
D-21-OB	05/22/03	18	4.21	10.2	385.1	69.2	22	1	7	0.20	0.01
D-21-OB	09/08/03	21	4.07	10.7	384.6	76.1	30	8	7	0.38	0.03
D-21-OB	12/02/03	19	4.29	11.5	383.8	71.3	88	1	10	0.15	0.01
D-21-OB	01/08/04	18	4.24	11.4	383.9	69.9	132	1	10	0.18	0.03
D-22-OB	04/14/84	16	6.20		418	50	13	10	6	1.6	
D-22-OB	06/22/84	19	4.79		415	60	58	10	12	1.95	0.06
D-22-OB	09/29/84	19	5.29		413	60	58	9	6	1.57	0.03
D-22-OB	01/06/85	18	4.77		418	63	76	8	10	1.8	0.08
D-22-OB	04/22/85	18.5	4.53		417	56	42	10	11	1.74	0.03
D-22-OB	07/25/85	19	4.54		414	64	20	9	8	1.64	0.03
D-22-OB	10/19/85	19	5.42		413	58	50	9	10	2.03	0.03
D-22-OB	01/23/86	17	5.50		417	62	24	9	10	1.87	0.04
D-22-OB	06/26/86	19	5.65		416	49	70	12	8	4.36	0.04
D-22-OB	09/04/86	18	5.73		413	48	54	10	8	1.8	0.02
D-22-OB	11/18/86	19	5.28		415	57	46	9	10	2.12	0.03
D-22-OB	03/23/87	17	5.75		418	48	62	9	8	1.97	0.02
D-22-OB	09/20/87	19	5.68		414	51	67	11.4	5	1.7	0.06
D-22-OB	11/16/87	19	5.49		417	62	69	8.9	4.9	1.47	0.05
D-22-OB	02/16/88	18	5.71		419	49.9	81	8.2	5.3	1.92	0.05
D-23-OBa	02/22/84	19	5.74		424	360	297	60	10	0.61	
D-23-OBa	06/22/84	20	5.94		422	390	268	71	16	4.51	0.14
D-23-OBa	09/29/84	18	6.27		420	390	954	177	196	2.5	0.1
D-23-OBa	01/08/85	18.5	5.77		422	410	196	78	12	8.15	0.22
D-23-OBa	04/24/85	19	6.14		424	365	226	54	14	8.86	0.14
D-23-OBa	07/21/85	20.5	6.05		421	390	306	71	12	4.95	0.12
D-23-OBa	10/20/85	19.5	6.33		420	350	226	68	14	2.29	0.14
D-23-OBa	01/23/86	18	6.33		424	360	204	73	15	3.5	0.14
D-23-OBb	03/02/84	19	4.80		426	36	32	5	6	0.04	
D-23-OBb	06/22/84	20.5	3.81		424	37	27	<5	10	0.31	0.03
D-23-OBb	01/08/85	20	3.63		425	42	88	28	10	0.16	0.06
D-23-OBb	04/24/85	20	4.52		426	40	14	2	8	0.14	<0.01
D-23-OBb	07/21/85	20.5	4.00		424	43	42	2	6	1.88	0.06
D-23-OBb	10/20/85	20	4.31		422	42	30	2	9	0.05	<0.01
D-23-OBb	01/23/86	19	4.28		426	44	10	6	9	0.14	0.01
D-23-UB	02/22/84	19	7.30		391	1150	816	250	206	<0.01	
D-23-UB	06/22/84	20.5	7.26		390	1230	874	230	206	0.09	0.05
D-23-UB	09/29/84	19	7.34		389	1320	870	185	188	3.5	0.11
D-23-UB	01/08/85	20	7.00		390	1350	798	191	209	0.15	0.13
D-23-UB	04/24/85	19	7.64		390	1250	836	178	204	0.11	0.05
D-23-UB	07/21/85	20.5	7.28		390	1400	876	238	200	0.17	0.04
D-23-UB	10/20/85	20	7.64		389	1300	820	236	204	0.08	0.04
D-23-UB	01/23/86	19	7.76		391	1400	776	216	214	0.19	0.05
D-24-OB	02/18/84	16	4.40		447	30	12	7	4	0.02	
D-24-OB	06/22/84	19	4.37		439	40	32	7	10	0.2	0.01
D-24-OB	09/29/84	19	4.20		436	35	27	<5	10	0.2	0.01

D-24-OB	01/06/85	18	4.32		447	33	23	4	8	0.29	0.05
D-24-OB	04/22/85	18	3.86		443	36	19	6	8	0.05	<0.01
D-24-OB	07/25/85	20	3.95		437	37	42	4	8	0.13	0.01
D-24-OB	10/19/85	20	4.48		435	30	24	3	10	0.07	0.01
D-24-OB	01/23/86	17	5.25		444	39	18	8	9	0.22	0.02
D-24-OB	06/27/86	19	5.16		443	24	22	9	5	0.17	0.03
D-24-OB	09/04/86	19	5.22		437	23	30	7	6	0.14	<0.01
D-24-OB	11/19/86	20	5.16		436	45	38	7	7	0.1	<0.01
D-24-OB	03/23/87	15.5	5.43		447	17	24	7	6	0.14	0.01
D-24-OB	09/17/87	21.5	4.92		436	28	75	6.3	3.1		
D-24-OB	11/16/87	19	5.10		436	38	59	7	2.1		
D-24-OB	02/15/88	16	5.37		444	22	46	5.4	1.5		
D-24-OB	05/12/88	17.5	5.01		439	25	66	5	2		
D-24-OB	08/13/88	19	5.19		436	20	98	5.3	2.7	0.13	0.05
D-24-OB	11/17/88	19	5.23		436	25	63	7.2	1.8	0.06	0.05
D-25-OB-T	03/13/84	20	4.10		414	100	59	8	8	0.1	
D-25-OB-T	06/21/84	20	3.32		412	70	49	7	10	0.38	0.03
D-25-OB-T	09/29/84	18	4.03		410	100	90	13	10	0.33	0.01
D-25-OB-T	01/04/85	19	2.92		415	70	42	6	9	0.17	0.02
D-25-OB-T	04/18/85	19.5	3.08		413	70	24	9	12	0.13	<0.01
D-25-OB-T	07/23/85	20	3.03		411	93	24	9	9	0.18	0.01
D-25-OB-T	10/20/85	20	3.73		410	100	60	12	11	0.23	0.01
D-25-OB-T	01/23/86	19	4.08		413	65	24	8	11	0.24	<0.01
D-25-OB-T	06/30/86	20	3.99		414	60	64			0.22	<0.01
D-25-OB-T	08/27/86	20	4.15		411	73	36	9	10	0.29	0.01
D-25-OB-T	11/18/86	21	3.80		411	103	74	11	8	0.32	<0.01
D-25-OB-T	03/15/87	20.5	4.11		417	55	48	9	10	0.28	0.01
D-25-OB-T	09/17/87	21	3.96		411	73	70	9.6	5.8	0.2	0.05
D-25-OB-T	11/17/87	19.5	3.98		412	105	72	12.2	7.4	0.21	0.05
D-25-OB-T	02/17/88	20	4.11		414	60	60	6.1	6.21	0.06	0.05
D-25-OB-T	05/12/88	20	4.01		413	64	74	7	7	0.13	0.05
D-25-OB-T	08/13/88	21	3.67		410	75	62	10	5.4	0.16	0.05
D-25-OB-T	11/17/88	19	3.99		408	71	69	9.6	6	0.1	0.05
D-26-OB	07/08/86	20	5.54	20.10	430.0	46.0	60	7.0	8.0	0.17	0.03
D-26-OB	08/28/86	19.5	5.36	21.10	429.0	40.0	50	7.0	6.0	0.14	0.02
D-26-OB	11/17/86	20.5	4.76	23.10	427.0	48.0	30	8.0	8.0	0.20	0.01
D-26-OB	03/15/87	20.5	5.56	17.10	433.0	42.0	42	9.0	7.0	0.18	0.02
D-26-OB	09/18/87	21	5.29	22.10	428.0	48.0	76	3.2	3.5	0.05	0.05
D-26-OB	11/19/87	20	5.98	23.10	427.0	70.0	104	2.2	3.3	0.05	0.05
D-26-OB	02/18/88	20	5.60	20.10	430.0	40.0	67	2.3	5.1	0.05	0.05
D-26-OB	05/14/88	20	5.54	20.10	430.0	182.0	79	3.0	3.0	0.10	0.05
D-26-OB	08/15/88	21	5.58	23.10	427.0	45.0	74	3.9	3.5	0.05	0.05
D-26-OB	11/20/88	18	5.80	25.10	425.0	40.0	66	2.7	3.4	0.05	0.05
D-26-OB	04/29/04	19	4.44	18.9	431.2	44.6	1	10	6	0.14	0.02
D-26-OB	07/29/04	21	4.73	19.1	431.0	44.1	60	5	5	0.09	0.01
D-26-OB	11/05/04	19	5.29	20.6	429.5	43.2	78	12	6	0.19	0.01
D-26-OB	03/03/05	19	4.96	16.7	433.4	43	88	7	5	<0.006	<0.006
D-26-OB	04/07/05	20	5.40	16.4	433.7	58.2	82	8	5	0.04	0.02

D-26-OB	09/01/05	20	6.23	20.2	429.9	45.7	72	7	9	0.14	0.01
D-26-OB	09/01/05	20	6.23	20.2	429.9	45.7	72	7	9	0.14	0.01
D-26-OB	10/18/05	20	5.52	21.3	428.8	42.4	30	7	7	0.98	0.06
D-26-OB	02/22/06	19	5.85	23.1	427.0	43.3	106	13	5	0.04	0.00
D-26-OB	06/01/06	19	5.66	22.5	427.6	51	92	2	9	0.03	0.01
D-26-OB	09/07/06	22	4.75	24	426.1	49.5	114	12	10	0.10	0.01
D-26-OB	11/30/06	21	4.77	24.7	425.4	40.3	60	14	7	0.08	0.01
D-26-OB	01/31/07	19	4.86	23.4	426.7	45.5	52	32	2	0.15	0.01
D-26-OB	05/31/07	20	4.81	21.7	428.4	42.9	78	<1	2	0.01	0.01
D-26-OB	08/23/07	20	7.51	20.6	429.5	53.7	88	1	3	0.05	0.01
D-26-OB	10/10/07	20	4.95	21.9	428.2	40.2	62	1	1	0.12	0.01
D-26-OB	02/28/08	19	5.23	22.6	427.5	55.6	82	5	<1	0.08	0.01
D-26-OB	05/06/08	19	5.23	19.4	430.7	49.3	68	<1	3	0.22	0.01
D-26-OB	07/09/08		5.20	20.8	429.3	47.3	68	<1	2	0.09	0.00
D-26-OB	12/15/08	20	5.17	25.4	424.7	68.7	86	1	4	0.03	0.01
D-26-OB	02/06/09	19	4.88	22.8	427.3	42.1	98	4	5	<0.006	0.02
D-26-OB	06/10/09	20	5.28	20.7	429.4	51.7	78	1	3	0.15	0.01
D-26-OB	08/18/09	20.5	5.59	22.1	428.0	448	84	<1	4	0.07	0.00
D-26-OB	12/09/09	20	5.34	20.4	429.7	47.3	96	8	3	0.62	0.02
D-26-OB	03/18/10		4.77	18.3	431.8	44.9	78	8.8	3	<0.01	0.018
D-26-OB	04/21/10	20.5	4.71	18.05		43.7	64	14	3	0.048	0.014
D-26-OB	07/19/10	21	4.41	10.47		106.8	92	2	12	0.158	0.011
D-26-OB	10/14/10	20.5	5.43	22.5		45.9	76	7	2	0.07	<0.01
D-26-OB	03/01/11	19.5	5.27	23.4		46.8	80	4	3	0.076	<0.01
D-26-OB	04/14/11	21	5.84	23.6		123.8	80	6	2	0.082	<0.01
D-26-OB	09/07/11	21	5.54	25.6		47.6	92	6	3	0.091	<0.01
D-26-OB	11/02/11	21.5	6.12	26.2		48.5	84	5	4	0.048	<0.01
D-26-OB	02/01/12	21	5.87	26		45.9	84	11	2	0.065	<0.01
D-26-OB	05/16/12	21	5.31	22.8		49.9	74	7	3	0.06	<0.01
D-26-UB	07/08/86	21	7.72	66.1	383.7	385	218	62	27	0.32	0.16
D-26-UB	08/28/86	20.5	8.03	69.5	380.3	399	234	65	27	0.39	0.15
D-26-UB	11/17/86	20.5	7.54	67.5	382.3	431	234	65	26	0.12	0.11
D-26-UB	03/15/87	21	7.67	63.7	386.2	370	298	62	25	0.38	0.11
D-26-UB	09/18/87	22	7.67	69.9	379.9	386	261	63.8	26.0	0.17	0.14
D-26-UB	11/19/87	20.5	7.03	69.9	380.0	370	254	62.3	25.6	0.12	0.11
D-26-UB	02/18/88	21	7.33	68.0	381.8	365	271	39.9	17.9	0.17	0.13
D-26-UB	05/14/88	21	7.53	68.9	380.9	386	256	64	26	0.18	0.11
D-26-UB	08/15/88	22	7.74	76.0	373.8	399	259	62.4	25.6	0.05	0.06
D-26-UB	11/20/88	21	8.24	80.4	369.5	370	258	60.6	29.1	0.05	0.11
D-26-UB	03/05/93	23.8	7.2	60.2	389.6	435	242	60	29	0.07	0.11
D-26-UB	04/20/93	22	7.6	59.7	390.1	426	252	64	27	0.11	0.11
D-26-UB	07/23/93	23.3	7.2	58.8	391.0	431	261	63	27	0.07	0.10
D-26-UB	11/02/93	18.5	6.6	59.0	390.8	420	257	63	26	0.05	0.10
D-26-UB	01/06/94	21	7.3	58.2	391.6	431	266	56	26	0.08	0.10
D-26-UB	06/23/94	15.3	7.0	56.9	392.9	425	274	70	26	0.08	0.10
D-26-UB	09/09/94	17.8	7.0	121.8	328.0	433	275	64	27	1.85	0.13
D-26-UB	10/04/94	23.7	7.1	57.5	392.3	444	276	61	27	0.06	0.10
D-26-UB	02/14/95	15	7.3	56.1	393.7	419	274	67	27	0.12	0.10

D-26-UB	05/11/95	20.5	7.7	55.3	394.5	434	290	65	26	0.34	0.11
D-26-UB	08/09/95	21	7.6	55.3	394.5	435	280	70	26	0.05	0.08
D-26-UB	10/03/95	20	7.3	55.5	394.3	427	274	70	26	0.05	0.09
D-26-UB	01/08/96	20	7.6	55.7	394.1	428	281	67	27	0.05	0.08
D-26-UB	04/30/96	21	7.8	55.8	394.0	434	272	74	27	0.05	0.09
D-26-UB	03/03/97	20	7.32	54.9	394.9	399	280	66	27	0.05	0.09
D-26-UB	05/19/97	21	7.60	54.2	395.6	419	279	78	27	0.05	0.11
D-26-UB	07/08/97	22	7.70	54.0	395.8	422	268	82	27	0.05	0.09
D-26-UB	10/30/97	20	6.88	54.1	395.7	417	296	76	27	0.23	0.12
D-26-UB	03/03/98	19	7.47	53.3	396.5	407	272	96	29	0.45	0.10
D-26-UB	05/19/98	21	7.03	53.2	396.6	908	294	68	26	0.05	0.09
D-26-UB	09/18/98	21	6.48	53.8	396.0	455	287	68	26	0.07	0.10
D-26-UB	10/28/98	21	7.33	54.1	395.7	446	280	68	26	0.05	0.09
D-26-UB	02/03/99	20	7.05	53.2	396.7	442	287	118	31	0.06	0.08
D-26-UB	04/19/99	21	6.97	52.7	397.2	468	277	75	27	0.05	0.08
D-26-UB	08/23/99	20	7.05	53.9	396.0	481	274	72	27	0.05	0.10
D-26-UB	11/08/99	20	7.31	53.4	396.4	461	273	87	28	0.05	0.09
D-26-UB	01/10/00	20	7.19	53.6	396.2	450	324	75	27	0.05	0.10
D-26-UB	06/07/00	20	7.85	53.6	396.2	455	275	250	28	0.04	0.08
D-26-UB	07/18/00	21	7.34	54.1	395.7	438	276	90	30	0.02	0.10
D-26-UB	11/29/00	20	7.59	54.8	395.0	392	244	70	27	0.02	0.14
D-26-UB	02/06/01	20	7.18	54.3	395.5	413	268	80	26	0.15	0.13
D-26-UB	06/11/01	20	7.42	53.9	395.9	427	290	95	25	0.05	0.09
D-26-UB	08/21/01	20	7.53	54.1	395.7	442	270	90	30	0.10	0.09
D-26-UB	12/06/01	20	7.62	53.4	396.4	411	258	100	24	0.43	0.10
D-26-UB	02/19/02	20	7.10	53.4	396.4	426	249	75	27	0.24	0.11
D-26-UB	06/06/02	21	7.50	53.1	396.7	420	266	105	25	0.15	0.14
D-26-UB	07/19/02	21	7.49	53.3	396.5	435	274	70	26	0.51	0.14
D-26-UB	11/14/02	20	7.31	53.6	396.2	430	262	85	26	0.01	0.10
D-26-UB	01/09/03	20.5	7.40	53.8	396.0	436	228	90	25	0.02	0.11
D-26-UB	05/23/03	21	7.48	53.6	396.2	450	220	105	27	0.06	0.06
D-26-UB	09/03/03	21	7.31	53.2	396.6	436	262	90	25	0.12	0.09
D-26-UB	12/12/03	20	7.35	54.0	395.8	428	218	60	27	0.03	0.03
D-26-UB	01/09/04	19	7.22	54.7	395.1	419	272	70	26	0.03	0.01
D-26-UB	04/29/04	20	7.4	53.4	396.4	450	228	55	26	0.15	0.12
D-26-UB	07/29/04	21	7.42	53.3	396.5	436	230	50	28	0.19	0.11
D-26-UB	11/05/04	18	7.37	53.7	396.1	438	278	80	27	0.86	0.09
D-26-UB	03/03/05	20	7.49	52.9	396.9	411	264	100	30	<0.006	0.01
D-26-UB	04/07/05	20.3	6.98	52.5	397.3	399	278	85	26	0.02	0.10
D-26-UB	09/01/05	20.5	8.27	53.6	396.2	399	266	62	29	0.07	0.10
D-26-UB	10/17/05	20	7.3	44.7	405.1	418	248	66	37	0.11	0.08
D-26-UB	02/22/06	19	7.31	53.8	396.0	396	302	60	25	0.07	0.09
D-26-UB	06/01/06	19	7.15	54	395.8	482	161	65	50	0.02	0.07
D-26-UB	09/07/06	20	6.82	55.5	394.3	411	292	225	34	0.09	0.10
D-26-UB	11/30/06	20	6.9	55.9	393.9	383	278	85	30	0.09	0.09
D-26-UB	01/31/07	20	6.73	55.6	394.2	398	234	70	28	0.08	0.08
D-26-UB	05/31/07	21	7.27	55.1	394.7	398	660	65	22	0.02	0.08
D-26-UB	08/23/07	21	7.22	55.3	394.5	388	270	73	27	0.05	0.08

D-26-UB	10/10/07	21	6.87	55.3	394.5	365	244	78	23	0.05	0.09
D-26-UB	02/28/08	20	7.35	56.2	393.6	399	296	25	64	0.07	0.08
D-26-UB	05/06/08	20	7.32	55.3	394.5	427	266	61	24	0.05	0.07
D-26-UB	07/09/08		6.89	55.4	394.4	442	288	80	23	0.05	0.10
D-26-UB	12/15/08	18	6.59	55.7	394.1	433	272	68	26	0.02	0.07
D-26-UB	02/06/09	20	6.7	55.5	394.3	399	298	71	25	<0.006	0.10
D-26-UB	06/10/09	20	7.32	55.1	394.7	454	264	65	25	0.04	0.08
D-26-UB	08/18/09	22	7.6	55.2	394.6	446	248	55	25	<0.003	0.08
D-26-UB	12/09/09	20	6.92	56.2	393.6	398	284	75	27	0.04	0.09
D-26-UB	03/19/10		6.99	56.1	393.7	439	308	115	26	<0.01	0.097
D-26-UB	04/21/10	21	6.96	55.68		453	248	84	27	0.015	0.092
D-26-UB	07/12/10	21.5	7.06	55.02		442	258	80	26	0.057	0.085
D-26-UB	10/14/10	21	7.45	55.7		428	260	70	28	0.083	0.081
D-26-UB	03/02/11	20.5	7.43	57.9		428	268	80	26	0.02	0.08
D-26-UB	04/14/11	21.5	7.31	57.2		394	270	90	27	0.011	0.095
D-26-UB	09/07/11	21.5	7.56	57.2		440	272	205	26	0.025	0.083
D-26-UB	11/02/11	21.5	7.72	57.4		435	262	85	26	0.017	0.084
D-26-UB	02/01/12	22	7.97	57.2		429	270	79	26	<0.01	0.09
D-26-UB	05/16/12	21	7.57	53.5		442	248	80	27	<0.01	0.082
D-27-D	06/30/86	20.5	7.24		385	325	260	54	17	0.54	0.04
D-27-D	08/28/86	20.5	7.55		383	338	208	60	17	0.37	0.05
D-27-D	11/17/86	20.5	7.08		381	371	190	53	20	0.28	0.04
D-27-D	03/16/87	21	7.54		382	315	276	58	20	0.32	0.04
D-27-D	09/18/87	22	7.29		374	335	238	53.9	16	0.17	0.06
D-27-D	11/19/87	21	7.11		373	331	233	58.6	17	0.15	0.05
D-27-D	02/19/88	21	7.05		374	325	237	60.8	19	0.19	0.05
D-27-D	05/14/88	21.5	7.24		373	363	244	57	13	0.24	0.05
D-27-D	08/15/88	22	7.26		371	340	236	51.9	16	0.17	0.05
D-27-D	11/20/88	21	7.79		373	314	233	50.9	17	0.16	0.05
D-27-S	06/30/86	21	4.21		435	102	104	30	8	4.16	0.04
D-27-S	08/28/86	20	4.25		435	110	106	33	10	3.47	0.04
D-27-S	11/27/86	20.5	3.90		428	131	80	32	14	3.46	0.02
D-27-S	03/16/87	21	4.03		438	110	112	30	12	3.85	0.03
D-27-S	09/18/87	21	3.91		428	115	130	30.4	6.9	3.34	0.05
D-27-S	11/19/87	20	4.08		427	128	113	32.8	6.4	2.79	0.05
D-27-S	02/19/88	20	3.25		435	115	113	32.7	8	3.09	0.05
D-27-S	05/14/88	20.5	3.82		432	129	118	35	7	2.65	0.05
D-27-S	08/15/88	21	3.92		427	120	114	30.5	6.6	2.44	0.05
D-27-S	11/20/88	20	4.15		425	109	117	33.7	6.7	3.4	0.06
D-28-D	07/08/86	21	8.25		403	391	240	50	14	0.23	0.03
D-28-D	08/28/86	20	8.09		402	390	222	52	14	0.17	0.03
D-28-D	11/17/86	20.5	7.95		401	427	218	44	17	0.17	0.04
D-28-D	03/24/87	20.5	8.25		406	365	258	39	17	0.14	0.03
D-28-D	09/18/87	21	8.21		403	387	279	40.6	13	0.05	0.06
D-28-D	11/18/87	20	7.78		403	370	249	42.8	14	0.05	0.05
D-28-D	02/17/88	21	7.92		405	388	257	39.6	14	0.06	0.05
D-28-D	05/14/88	21	8.02		406	418	253	42	13	0.11	0.05
D-28-D	08/15/88	21	8.00		403	390	248	40.7	14	0.07	0.05

D-28-D	11/20/88	20	8.41		402	371	255	44.2	15	0.05	0.05
D-28-S	07/08/86	21.5	5.10		419	55	24	15	10	5.09	0.12
D-28-S	08/28/86	20	5.29		417	55	38	17	8	4.96	0.05
D-28-S	11/17/86	20	5.19		417	96	48	13	14	3.81	0.07
D-28-S	03/24/87	19.5	4.57		421	60	40	18	11	3.03	0.06
D-28-S	09/18/87	21.5	5.20		417	56	60	9.9	5.4	3.43	0.09
D-28-S	11/18/87	20	4.70		418	70	57	12.8	5.6	3.42	0.05
D-28-S	02/17/88	20	5.04		420	53	57	11.6	5.1	2.04	0.06
D-28-S	05/14/88	20	4.99		419	49	53	8	6	1.96	0.05
D-28-S	08/15/88	21	5.04		416	48	51	5.3	10	1.74	0.05
D-28-S	11/20/88	19	5.30		415	50	57	10.5	5.5	2.52	0.07
D-29-D	06/26/86	21	7.30		346	432	324	26	26	1.58	0.14
D-29-D	08/27/86	21	7.50		330	460	252	29	27	0.87	0.11
D-29-D	11/17/86	20	7.28		330	430	284	26	28	0.22	0.15
D-29-D	03/15/87	21	7.48		332	420	320	26	26	0.63	0.1
D-29-D	09/19/87	23	7.74		329	408	270	22.1	26	0.2	0.12
D-29-D	11/18/87	21	7.48		328	387	253	22	27	0.23	0.08
D-29-D	02/19/88	21	7.50		329	365	246	24.1	29	0.22	0.07
D-29-D	05/14/88	21	7.86		328	380	228	21	25	0.28	0.06
D-29-D	08/14/88	22	8.11		327	325	220	21.2	24	<0.05	0.05
D-29-D	11/20/88	20	6.28		327	397	269	22.1	25	0.14	0.1
D-29-S	06/26/86	20	6.38		429	102	112	11	12	12.1	0.28
D-29-S	08/27/86	21	6.34		426	110	44	11	11	9.6	0.3
D-29-S	01/17/87	19.5	6.57		425	110	68	8	9	7.04	0.27
D-29-S	03/15/87	20.5	6.17		430	100	88	7	12	11.9	0.28
D-29-S	09/19/87	21	6.06		425	95	99	4.7	10.2	8.15	0.32
D-29-S	11/18/87	20.5	6.36		425	102	80	5.8	8.5	7.12	0.278
D-29-S	02/19/88	19	5.60		429	90	95	32	14	9.53	0.3
D-29-S	05/14/88	21	6.17		428	106	93	5	11	8.63	0.3
D-29-S	08/14/88	21	7.99		425	95	92	5.2	9.8	7.87	0.29
D-30-D	06/26/86	21.0	6.75	18.70	408.0	248	202	12	11	2.20	0.10
D-30-D	08/27/86	21.0	6.77	21.75	405.0	247	180	20	13	2.12	0.10
D-30-D	11/17/86	20.0	6.91	23.20	403.5	275	182	10	17	0.80	0.10
D-30-D	03/15/87	21.0	6.77	19.68	407.0	250	186	10	16	2.09	0.07
D-30-D	09/18/87	22.0	6.76	23.50	403.2	265	195	8	12	2.07	0.08
D-30-D	11/18/87	20.5	6.70	24.19	402.5	253	187	8	13	1.70	0.07
D-30-D	02/19/88	21.0	6.23	20.95	405.8	248	189	8	15	1.34	0.07
D-30-D	05/14/88	21.0	6.74	21.34	405.4	287	192	8	13	1.92	0.07
D-30-D	08/15/88	21.0	6.83	24.31	402.4	260	190	8	13	1.10	0.06
D-30-D	11/17/88	20.0	6.88	26.20	400.5	255	194	8	10	1.18	0.08
D-30-D	02/18/93	21.6	6.80	22.6	404.1	275	172	9	13	0.21	0.07
D-30-D	04/20/93	23.3	7.00	21.5	405.2	283	194	14	14	0.08	0.06
D-30-D	07/15/93	25	7.00	22.2	404.5	285	186	11	13	0.08	0.07
D-30-D	11/03/93	17.4	6.00	24.8	401.9	286	192	7	13	2.22	0.06
D-30-D	01/05/94	18.4	6.50	23.4	403.3	300	201	16	14	2.28	0.07
D-30-D	06/24/94	14.2	6.20	21.7	405.0	284	197	9	13	0.21	0.06
D-30-D	09/13/94	26.7	6.09	25.0	401.7	287	198	11	12	0.05	0.06
D-30-D	10/05/94	21.4	6.34	20.5	406.2	289	205	8	13	0.35	0.07

D-30-D	02/16/95	19.4	6.60	22.5	404.2	284	213	26	13	0.05	0.10
D-30-D	05/30/95	20	6.60	20.6	406.1	279	198	9	12	0.09	0.08
D-30-D	08/10/95	21	6.46	22.6	404.1	278	204	9	12	1.59	0.11
D-30-D	10/04/95	20	6.47	24.8	401.9	269	191	8	12	0.08	0.08
D-30-D	01/04/96	21	6.64	25.3	401.4	275	199	11	12	0.41	0.09
D-30-D	05/01/96	21	6.78	25.7	401.0	281	192	12	13	0.07	0.08
D-30-D	03/05/97	20	6.65	21.6	405.1	261	198	26	12	0.34	0.07
D-30-D	05/22/97	20	6.69	21.4	405.3	251	177	8	11	0.89	0.07
D-30-D	07/09/97	20	6.57	22.4	404.3	279	201	12	13	1.32	0.08
D-30-D	10/31/97	20	6.36	24.7	402.0	114	204	8	12	0.96	0.08
D-30-D	03/04/98	20	6.01	21.2	405.5	266	186	9	12	1.37	0.08
D-30-D	05/20/98	21	6.12	22.1	404.6	318	197	9	12	1.00	0.09
D-30-D	09/18/98	21	6.62	25.0	401.7	276	204	8	12	1.77	0.09
D-30-D	02/10/99	21	6.34	20.9	405.9	421	182	12	12	0.72	0.07
D-30-D	04/23/99	21	6.45	20.5	406.2	296	192	9	12	1.34	0.07
D-30-D	08/25/99	20	6.24	23.0	403.7	288	194	10	12	1.21	0.08
D-30-D	11/09/99	21	5.98	24.8	401.9	296	105	15	12	1.90	0.08
D-30-D	01/24/00	19	6.37	25.2	401.5	267	202	8	12	1.69	0.08
D-30-D	06/08/00	22	6.70	23.1	403.6	276	192	25	12	0.73	0.09
D-30-D	07/20/00	22	6.75	23.7	403.0	286	179	15	13	2.03	0.08
D-30-D	12/01/00	20	6.30	25.7	401.0	270	156	16	12	2.60	0.09
D-30-D	02/07/01	21	6.41	22.5	404.2	264	194	16	7	4.08	0.16
D-30-D	06/13/01	23	6.37	21.5	405.2	257	124	17	8	2.68	0.10
D-30-D	08/24/01	21	6.07	22.5	404.2	284	122	40	9	1.71	0.11
D-30-D	12/10/01	20	6.38	23.0	403.7	268	158	23	12	2.62	0.10
D-30-D	02/20/02	20	6.20	21.5	405.2	271	163	22	11	1.00	0.08
D-30-D	06/10/02	20.5	6.28	21.4	405.3	267	140	14	10	1.48	0.11
D-30-D	07/24/02	20.5	6.38	22.4	404.3	265	176	28	12	2.08	0.09
D-30-D	11/18/02	20	6.20	24.1	402.6	278	196	20	11	1.15	0.08
D-30-D	01/15/03	20	6.20	22.1	404.6	283	180	20	12	2.84	0.10
D-30-D	05/29/03	20	6.20	22.0	404.7	279	182	14	13	3.76	0.11
D-30-D	09/09/03	21	6.30	23.1	403.6	260	162	14	10	3.39	0.11
D-30-D	12/11/03	20	6.29	24.7	402.0	273	140	6	13	2.20	0.08
D-30-D	01/13/04	20	6.33	24.7	402.0	282	140	5	12	2.50	0.09
D-30-D	05/04/04	20	6.17	20.3	406.4	285	194	4	10	1.02	0.12
D-30-D	08/03/04	20	6.02	22.6	404.1	295	150	11	16	1.29	0.08
D-30-D	11/09/04	18	6.24	23.4	403.3	271	172	14	14	1.52	0.08
D-30-D	03/08/05	18	5.71	20.2	406.5	450	304	19	72	22.21	1.20
D-30-D	04/08/05	20.2	6.25	20.2	406.5	289	186	6	13	2.34	0.09
D-30-D	09/02/05	20.5	6.93	23.7	403.0	247	186	31	16	1.30	0.07
D-30-D	10/19/05	20.5	6.60	24.7	402.0	237	208	6	13	2.74	0.10
D-30-D	02/23/06	19.5	6.65	30.2	396.5	220	224	13	11	3.07	0.07
D-30-D	06/05/06	21	7.00	87.5	339.2	266	180	8	16	1.55	0.06
D-30-D	09/08/06	20	6.08	29.6	397.1	263	196	14	21	2.65	0.09
D-30-D	11/29/06	20	6.28	30.3	396.4	249	186	15	15	2.41	0.08
D-30-D	02/07/07	21	6.14	29.4	397.3	264	180	24	11	2.58	0.11
D-30-D	06/01/07	22	6.19	24.6	402.1	241	194	<1	8	2.33	0.09
D-30-D	08/24/07	21	6.29	26.1	400.6	253	206	2	9	1.72	0.07

D-30-D	10/11/07	20	6.13	27.5	399.2	225	202	<1	8	2.52	0.07
D-30-D	02/29/08	20	6.42	27.9	398.8	272	180	15	17	1.60	0.08
D-30-D	05/07/08	20	6.48	25.5	401.2	252	168	4	10	1.14	0.06
D-30-D	07/10/08		6.57	26.6	400.1	271	174	10	3	2.37	0.08
D-30-D	12/16/08	20	5.79	27.9	398.8	269	186	4	9	3.21	0.10
D-30-D	02/05/09	19	6.18	27	399.7	280	204	3	11	2.01	0.10
D-30-D	06/15/09	20	6.21	25.8	400.9	263	176	2	10	0.61	0.09
D-30-D	08/18/09	20.5	6.42	27.2	399.5	275	166	2	10	1.05	0.07
D-30-D	12/10/09	21	6.42	25.9	400.8	289	160	24	10	7.34	0.10
D-30-D	03/22/10		5.44	22.5	404.2	729	168	13	12	1.47	0.042
D-30-D	04/22/10	21	6.00	24.69		260	156	16	11	2.31	0.097
D-30-D	07/14/10	21	5.97	26.43		265	182	10	12	0.834	0.236
D-30-D	10/15/10	20.5	6.44	28.9		219	168	12	10	3.34	0.094
D-30-D	03/02/11	20.5	6.53	29.2		275	186	6	11	1.818	0.06
D-30-D	04/15/11	21	6.45	29.2		221	224	7	14	1.048	0.067
D-30-D	09/08/11	21.5	6.86	31.6		256	188	12	10	1.843	0.083
D-30-D	11/03/11	20.5	6.80	32.3		259	176	14	12	2.566	0.111
D-30-D	02/02/12	21	6.67	32		275	152	8	11	2.315	0.092
D-30-D	05/17/12	21	6.57	30.1		263	194	32	11	4.603	0.116
D-30-S	06/26/86	20.0	6.19	12.5	414.4	149.0	160	17	10	8.88	0.26
D-30-S	08/27/86	20.0	6.40	12.7	414.2	155.0	124	15	9	8.08	0.24
D-30-S	11/17/86	20.0	6.56	12.3	414.6	170.0	108	10	10	6.70	0.25
D-30-S	03/15/87	20.5	6.31	8.0	418.9	140.0	92	11	11	9.35	0.25
D-30-S	09/18/87	21.0	6.22	12.6	414.3	149.0	145	8	7	7.36	0.29
D-30-S	11/18/87	20.0	6.49	11.9	415.0	154.0	137	8	9	6.95	0.23
D-30-S	02/19/88	20.0	5.68	9.7	417.3	142.0	136	48	10	7.52	0.26
D-30-S	05/14/88	20.0	5.13	10.3	416.6	156.0	133	8	6	6.97	0.25
D-30-S	08/15/88	21.0	6.44	13.3	413.6	150.0	139	9	7	6.08	0.19
D-30-S	11/17/88	20.0	6.27	14.5	412.4	145.0	134	8	14	7.68	0.25
D-30-S	02/17/93	19.6	6.20	8.2	418.7	260	200	47	17	0.84	0.33
D-30-S	04/20/93	23.6	6.30	8.2	418.7	236	182	50	17	5.60	0.45
D-30-S	07/15/93	21.7	5.90	9.4	417.5	149	142	37	9	5.62	0.28
D-30-S	11/03/93	14.6	5.70	12.4	414.5	178	152	10	7	7.68	0.28
D-30-S	01/06/94	20.8	6.00	10.8	416.1	190	167	26	9	8.76	0.34
D-30-S	06/24/94	12.7	5.80	9.5	417.4	170	152	15	7	6.95	0.23
D-30-S	09/13/94	14.5	6.70	10.0	416.9	163	151	15	7	8.32	0.30
D-30-S	10/04/94	25.2	5.90			196	152	26	11	7.81	0.36
D-30-S	02/15/95	21.1	6.01	8.4	418.5	284	219	41	20	14.00	0.57
D-30-S	05/30/95	20	6.03	6.9	420.0	206	169	29	14	9.04	0.37
D-30-S	08/10/95	20	5.99	10.7	416.2	163	148	14	7	6.89	0.29
D-30-S	10/03/95	20	5.86	12.0	414.9	160	136	15	7	5.41	0.27
D-30-S	01/04/96	20	6.05	12.6	414.3	227	180	28	16	9.71	0.45
D-30-S	05/01/96	21	6.25	12.7	414.2	307	237	44	28	6.52	0.63
D-30-S	03/05/97	20	5.94	6.7	420.2	356	266	52	36	18.70	0.89
D-30-S	05/22/97	19	6.07	8.2	418.7	350	280	54	39	17.10	0.82
D-30-S	07/09/97	21	6.05	9.4	417.5	299	227	40	30	14.80	0.70
D-30-S	10/31/97	19	6.14	11.9	415.0	332	256	47	44	18.30	0.90
D-30-S	03/04/98	20	5.60	6.8	420.1	389	277	56	44	20.50	0.90

D-30-S	05/20/98	21	5.90	9.7	417.2	347	241	46	33	16.40	0.85
D-30-S	09/18/98	21	6.13	12.0	414.9	319	230	38	37	15.50	0.72
D-30-S	10/30/98	20	5.71	10.5	416.4	335	252	42	38	17.00	0.86
D-30-S	02/10/99	21	5.68	6.6	420.3	360	294	63	49	21.40	0.90
D-30-S	04/23/99	20	5.82	7.1	419.8	437	273	61	48	19.50	1.01
D-30-S	08/25/99	20	6.01	11.0	415.9	167	139	15	8	7.29	0.30
D-30-S	11/09/99	21	6.22			214	169	33	14	9.93	0.43
D-30-S	01/24/00	15	5.58	12.4	414.5	402	286	57	54	20.90	1.01
D-30-S	06/08/00	21	6.02	9.6	417.3	463	166	70	63	15.27	0.93
D-30-S	07/20/00	21	5.97	11.0	415.9	409	254	71	53	17.42	1.09
D-30-S	12/01/00	20	5.87	11.7	415.2	444	292	95	62	25.20	1.28
D-30-S	02/07/01	21	5.73	4.8	422.1	450	322	85	59	23.33	1.16
D-30-S	06/13/01	21	5.79	7.2	419.7	498	292	60	76	24.83	1.31
D-30-S	08/24/01	19	5.42	10.5	416.4	221	160	28	14	9.76	0.45
D-30-S	12/10/01	20	5.91	9.7	417.2	272	140	41	17	10.08	0.44
D-30-S	02/20/02	19	5.67	7.9	419.0	434	274	70	56	16.76	1.09
D-30-S	06/10/02	20	5.90	9.0	417.9	231	156	42	20	10.92	0.61
D-30-S	07/24/02	20	5.89	10.5	416.4	180	142	19	10	8.37	0.67
D-30-S	11/18/02	20	5.83	11.6	415.3	177	170	24	8	8.72	0.38
D-30-S	01/15/03	20	5.67	8.4	418.5	353	224	34	42	16.96	0.85
D-30-S	05/29/03	20	5.69	10.0	416.9	297	198	38	29	13.26	0.67
D-30-S	09/09/03	20	5.92	11.4	415.5	173	138	15	8	7.95	0.36
D-30-S	12/11/03	20	5.82	12.3	414.6	279	144	34	31	12.71	0.71
D-30-S	01/13/04	20	5.75	12.2	414.7	393	200	61	53	19.84	1.06
D-30-S	05/04/04	20	5.57	7.4	419.5	551	368	50	175	25.96	1.51
D-30-S	08/03/04	20	5.34	10.6	416.3	205	138	17	15	9.36	0.45
D-30-S	11/09/04	17	5.85	10	416.9	161	104	17	9	6.80	0.26
D-30-S	03/08/05	19	5.58	6.6	420.3	519	368	110	91	27.86	1.51
D-30-S	04/08/05	19.8	5.66	7.1	419.8	490	320	80	74	18.59	1.24
D-30-S	09/02/05	20	6.47	12.2	414.7	159	146	10	9	7.14	0.30
D-30-S	10/19/05	20	6.26	13	413.9	162	192	11	11	7.26	0.36
D-30-S	02/23/06	19	6.35	13.1	413.8	151	172	26	11	7.04	0.29
D-30-S	06/05/06	21	6.17	12.5	414.4	328	238	42	50	13.60	0.68
D-30-S	09/08/06	20	5.66	14.8	412.1	517	366	75	107	26.40	1.59
D-30-S	11/29/06	20	5.81	15	411.9	467	334	100	90	26.90	1.39
D-30-S	02/07/07	20	5.60	12.8	414.1	524	380	19	95	28.70	2.17
D-30-S	06/01/07	21	5.73	10.6	416.3	539	434	80	92	29.40	1.56
D-30-S	08/24/07	20	6.09	10.4	416.5	578	428	60	11	27.90	1.57
D-30-S	10/11/07	20	5.74	12.6	414.3	498	410	75	94	30.00	1.36
D-30-S	02/29/08	20	6.16	11.8	415.1	566	382	110	95	25.40	1.51
D-30-S	05/07/08	20	5.72	9.6	417.3	543	386	70	96	25.10	1.33
D-30-S	07/10/08		6.08	11.9	415.0	637	386	75	100	29.60	1.61
D-30-S	12/16/08	20	5.46	12.1	414.8	597	408	74	98	26.40	1.49
D-30-S	02/05/09	19	5.61	11.1	415.8	554	412	79	100	26.60	1.38
D-30-S	06/15/09	20	5.62	10.5	416.4	608	434	80	104	25.30	1.48
D-30-S	08/18/09	20.5	5.74	12.2	414.7	600	418	78	103	28.30	1.58
D-30-S	12/10/09	20	5.76	8.9	418.0	630	336	61	97	27.50	1.50
D-30-S	03/19/10		5.81	7.7	419.2	603	416	301	103	25.5	1.61

D-30-S	04/22/10	21	5.60	8.94		607	402	90	100	27.7	1.53
D-30-S	07/13/10	20.5	5.75	10.73		528	326	77	88	25.6	1.32
D-30-S	10/15/10	20.5	5.90	14.1		506	332	68	87	22.4	1.31
D-30-S	03/02/11	20.5	5.91	13.1		573	380	80	107	27.57	1.46
D-30-S	04/15/11	20.5	5.73	13.4		668	464	80	110	25.37	0.154
D-30-S	09/08/11	21	6.27	16.6		299	238	56	41	15.36	0.814
D-30-S	11/03/11	21	6.27	17.2		567	380	78	109	31.27	1.5
D-30-S	02/02/12	21	6.13	15.3		579	382	70	103	29.7	1.65
D-30-S	05/17/12	21	5.86	13.7		626	200	75	113	18.61	1.41
D-31-OB	06/30/86	20	5.85		415	49	48	10	9	3.48	0.06
D-31-OB	09/27/86	20	5.47		414	30	40	7	8	1	0.03
D-31-OB	11/17/86	20	5.61		414	55	30	8	8	0.74	0.01
D-31-OB	03/15/87	20.5	5.08		416	20	16	6	8	0.2	0.01
D-31-OB	09/18/87	21	4.79		415	23	45	2.5	3.9	0.05	0.05
D-31-OB	11/17/87	19.5	5.05		414	35	41	2.2	3.6	0.05	0.05
D-31-OB	02/17/88	20.5	4.93		416	21	29	3	3.6	0.05	0.05
D-31-OB	05/13/88	20	4.47		416	25	40	2	4	0.08	0.05
D-31-OB	08/15/88	21	4.85		415	20	39	2.6	3.7	0.08	0.05
D-31-OB	11/17/88	19.5	5.04		414	22	40	1.4	7.5	0.05	0.05
D-31-UB	06/30/86	22	6.52		374	137	136	16	8	7.42	0.18
D-31-UB	08/27/86	21	6.49		373	130	108	11	9	6.24	0.15
D-31-UB	11/17/86	19.5	6.49		373	142	98	11	10	4.03	0.15
D-31-UB	03/15/87	20.5	6.44		376	110	98	9	9	5.18	0.15
D-31-UB	09/18/87	22	6.18		373	110	132	5	5.7	5.63	0.2
D-31-UB	11/17/87	20	6.57		373	102	116	4.3	6.2	4.26	0.13
D-31-UB	02/17/88	19.5	6.26		374	105	111	3.4	5.58	4.65	0.15
D-31-UB	05/13/88	21	6.41		374	118	126	4	7	4.25	0.14
D-31-UB	08/15/88	21	6.18		373	110	124	5.1	8.1	4	0.11
D-31-UB	11/17/88	20	6.57		372	102	126	3.6	5.9	4.63	0.14
D-32-D	07/09/86	20.5	7.23		363	605	354	128	33	2.06	0.16
D-32-D	08/28/86	18.5	7.16		360	550	366	106	34	1.76	0.15
D-32-S	07/09/86	21	7.01		362	550	376	96	33	0.16	0.14
D-32-S	08/28/86	19	7.09		359	525	360	97	31	0.6	0.13
D-35-OB	09/19/87	22.5	5.16	10.5	403.1	55	56	4	9	2.20	0.28
D-35-OB	11/19/87	21	4.31	7.7	405.9	82	88	6	13	0.11	0.09
D-35-OB	02/18/88	17	4.74	2.7	410.9	58	85	8	8	0.14	0.05
D-35-OB	05/13/88	19	4.82	7.8	405.8	78	87	9	9	0.20	0.05
D-35-OB	08/14/88	24	4.89	11.4	402.2	55	84	4	10	0.15	0.05
D-35-OB	11/19/88	20	5.29	11.4	402.2	48	93	4	8	1.54	0.05
D-35-OB	02/22/93	21.2	3.30	10.4	403.3	597	392	329	9	24.00	2.19
D-35-OB	04/17/93	18.7	3.60	10.6	403.1	518	340	224	8	22.30	1.87
D-35-OB	07/20/93	26.8	3.90	10.2	403.5	407	278	172	8	6.79	1.09
D-35-OB	11/01/93	20.2	3.80	15.6	398.1	168	149	52	6	0.67	0.49
D-35-OB	01/05/94	18.3	4.20	14.5	399.2	90	98	22	7	0.06	0.10
D-35-OB	06/27/94	17.8	3.90	13.0	400.7	99	104	27	6	0.08	0.16
D-35-OB	09/07/94	17.7	4.05	15.4	398.3	82	100	17	6	0.05	0.11
D-35-OB	10/03/94	22.7	5.48	15.8	397.9	83	101	18	6	0.86	0.12
D-35-OB	02/16/95	18.4	3.88	6.8	406.9	321	239	122	5	0.31	0.81

D-35-OB	05/11/95	19	4.11	4.5	409.2	218	195	75	4	0.08	0.49
D-35-OB	08/09/95	26	6.85	13.7	400.0	414	291	52	10	0.05	0.05
D-35-OB	10/03/95	21	3.86	14.7	399.0	108.0	109	29	5	0.05	0.18
D-35-OB	01/05/96	19	4.30	15.8	397.9	121.0	122	38	4	0.13	0.24
D-35-OB	05/02/96	18.0	4.99	15.7	398.0	63.0	92	18	5	0.05	0.08
D-35-OB	03/04/97	18	3.74	3.2	410.5	395	303	169	4	0.05	1.11
D-35-OB	05/21/97	19	4.21	4.1	409.6	229	188	92	4	0.07	0.60
D-35-OB	07/08/97	21	4.65	12.0	401.7	87	114	59	6	0.20	0.15
D-35-OB	10/30/97	20	6.60	14.5	399.2	357	294	75	27	0.26	0.14
D-35-OB	03/04/98	15	3.41	5.0	408.7	290	232	130	4	0.07	0.91
D-35-OB	05/19/98	24	4.32	12.3	401.4	195	156	51	4	0.18	0.40
D-35-OB	09/11/98	20	3.61	14.8	398.9	154	153	53	4	0.06	0.41
D-35-OB	10/29/98	23	3.94	12.5	401.2	191	163	59	4	0.05	0.51
D-35-OB	02/10/99	20	3.73	4.3	409.4	260	213	107	5	1.00	0.77
D-35-OB	04/19/99	20	4.01	6.6	407.1	195	185	66	4	0.12	0.56
D-35-OB	08/24/99	22	6.33	13.5	400.2	483	291	55	11	0.23	0.06
D-35-OB	11/09/99	17	4.69	14.0	399.7	1598	1230	773	68	0.55	0.98
D-35-OB	06/07/00	20	7.00	12.3	401.4	464	277	50	11	0.56	0.06
D-35-OB	07/18/00	20	6.46	13.4	400.3	339	222	200	13	0.11	0.16
D-35-OB	11/29/00	21	4.02	11.1	402.6	195.2	148	165	5	0.22	0.69
D-35-OB	02/06/01	17	4.11	4.4	409.3	397	346	160	3	0.54	1.36
D-35-OB	06/12/01	19	3.90	3.2	410.5	197.2	90	48	2	0.62	0.55
D-35-OB	08/21/01	25	3.60	11.6	402.1	446	332	275	3	88.10	7.39
D-35-OB	12/06/01	20	4.41	7.9	405.8	73.9	50	43	4	0.68	0.16
D-35-OB	02/19/02	18	4.15	4.5	409.2	457	314	240	4	0.05	1.71
D-35-OB	06/06/02	21	6.55	11.5	402.2	458	284	80	10	0.14	0.07
D-35-OB	07/25/02	21	6.65	12.9	400.8	465	292	64	10	0.26	0.14
D-35-OB	11/14/02	20	6.27	14.3	399.4	461	286	67	9	0.26	0.10
D-35-OB	01/15/03	18	3.43	6.8	406.9	196.8	152	105	3	0.12	0.45
D-35-OB	05/27/03	129	6.58	11.9	401.8	513	284	35	11	1.13	0.08
D-35-OB	09/08/03	22	6.30	13.3	400.4	476	272	69	8	0.24	0.14
D-35-OB	12/17/03	20	6.44	14.8	398.9	459	306	55	10	0.47	0.13
D-35-OB	01/09/04	18	3.70	14.7	399.0	122.5	152	49	4	0.77	0.33
D-36-OB	09/19/87	23	6.07	14.78	400.2	165.0	137	10	26	5.03	0.36
D-36-OB	11/16/87	21	5.95	14.71	400.3	120.0	108	5	18	3.20	0.25
D-36-OB	02/19/88	15	5.05	5.25	409.8	48.0	94	7	9	0.29	0.07
D-36-OB	05/11/88	19	6.23	15.21	399.8	128.0	133	13	12	0.34	0.18
D-36-OB	08/14/88	24	6.00	15.16	399.8	108.0	111	8	14	0.19	0.10
D-36-OB	11/17/88	22	5.50	15.66	399.3	90.0	119	6	17	0.28	0.12
D-37-OB	09/19/87	20.5	5.22	24.7	407.0	71.0	91	19	6	3.03	0.19
D-37-OB	11/18/87	20	5.55	23.7	408.0	85.0	77	19	5	3.45	0.15
D-37-OB	02/15/88	20.5	5.17	19.7	412.0	77.0	73	19	6	3.67	0.11
D-37-OB	05/13/88	20.5	4.63	20.7	411.0	79.0	79	19	6	2.19	0.08
D-37-OB	08/13/88	21	4.86	23.7	408.0	70.0	80	19	6	3.06	0.06
D-37-OB	11/19/88	22	5.32	24.7	407.0	48.0	72	22	5	3.08	0.08
D-38-UB	07/08/86	22	7.30		364	454	282	68	31	1.1	0.1
D-38-UB	08/27/86	21	7.62		362	484	306	64	32	0.68	0.06
D-38-UB	11/18/86	21	7.35		363	512	346	67	35	0.31	0.06

D-38-UB	03/23/87	21	7.68		366	440	316	59	34	0.26	0.04
D-39-UB	07/08/86	22	8.49		335	442	258	55	11	0.2	0.03
D-39-UB	08/29/86	21	8.58		334	455	292	49	11	0.19	0.02
D-39-UB	11/18/86	20.5	8.40		333	495	330	52	14	0.27	0.03
D-39-UB	03/24/87	21	8.39		337	400	292	43	13	0.16	0.01
D-39-UB	09/19/87	21.5	8.66		332	448	320	48.1	8	0.05	0.05
D-3-OB	03/02/84	19	4.70		418	90	80	36	8	2.9	
D-3-OB	06/23/84	20	3.30		412	135	95	33	18	1.54	0.09
D-3-OB	09/29/84	19	4.62		405	132	88	36	10	4.88	0.1
D-3-OB	01/08/85	19	3.52		418	143	70	29	12	1.29	0.09
D-3-OB	04/22/85	19	3.50		416	134	130	22	13	1.65	0.06
D-3-OB	07/23/85	20	3.14		409	115	60	28	12	1.37	0.08
D-3-OB	10/17/85	20	4.20		404	120	118	35	11	6.34	0.16
D-3-OB	01/23/86	19	3.87		417	125	48	24	15	1.67	0.1
D-3-OB	06/28/86	20.5	3.86		416	130	156	26	12	1.5	0.09
D-3-OB	09/05/86	20	3.89		408	132	140	29	10	1.36	0.09
D-3-OB	11/18/86	19	3.87		409	145	100	29	12	1.68	0.08
D-3-OB	09/21/87	20.5	4.00		406	118	147	27.5	9.6	0.62	0.11
D-3-OB	11/16/87	20.5	3.78		406	135	138	30.1	8.1	1.34	0.11
D-3-OB	05/12/88	21	3.69		414	132	140	24	12	0.23	0.08
D-3-OB	08/13/88	21	3.75		407	130	142	22.9	12	0.19	0.11
D-3-OB	11/05/88	19	4.20		402	129	164	44.5	7.8	4.81	0.16
D-41-UB	09/19/87	22.5	6.91	18.5	395.2	486	360	88	9	0.75	0.41
D-41-UB	11/19/87	21.0	6.90	18.1	395.6	410	293	69	11	1.29	0.30
D-41-UB	02/18/88	20.5	7.18	16.6	397.0	448	318	87	13	1.16	0.15
D-41-UB	05/13/88	25.0	6.97	19.1	394.6	489	320	80	9	0.23	0.14
D-41-UB	08/14/88	23.0	7.00	21.4	392.3	450	316	62	11	0.40	0.10
D-41-UB	11/19/88	21.0	7.47	22.1	391.5	400	309	70	13	0.83	0.10
D-41-UB	02/22/93	21.5	6.40	29.5	384.2	426	277	73	13	0.05	0.14
D-41-UB	04/17/93	20.9	7.30	27.2	386.5	442	265	58	11	0.14	0.09
D-41-UB	07/20/93	27.2	7.00	26.0	387.7	448	273	58	11	0.05	0.06
D-41-UB	11/01/93	20.1	6.40	25.9	387.8	454	297	52	11	0.07	0.05
D-41-UB	01/05/94	18.3	6.80	25.0	388.7	447	285	58	12	0.12	0.09
D-41-UB	06/27/94	18.6	7.10	23.3	390.4	438	290	54	10	0.29	0.06
D-41-UB	09/07/94	17.5	6.25	24.7	389.0	435	286	55	11	0.21	0.06
D-41-UB	10/03/94	23.4	6.34	25.0	388.7	433	281	55	11	0.09	0.07
D-41-UB	02/14/95	12.1	6.81	31.7	382.0	426	279	56	11	0.84	0.08
D-41-UB	05/11/95	20	7.01	18.6	395.1	433	284	52	10	0.07	0.05
D-41-UB	08/09/95	21	6.87	20.5	393.2	426	291	53	11	0.08	0.05
D-41-UB	10/03/95	20	6.83			417.0	277	50	11	0.05	0.08
D-41-UB	01/04/96	20	6.81			424.0	294	52	10	0.33	0.11
D-41-UB	04/30/96	19.0	7.00			426.0	288	53	11	0.18	0.05
D-41-UB	03/04/97	20	6.75	16.3	397.4	425	284	51	10	0.32	0.05
D-41-UB	05/21/97	20	6.70	16.4	397.3	397	280	53	11	0.35	0.05
D-41-UB	07/08/97	22	6.80	17.4	396.3	415	278	54	11	0.34	0.05
D-41-UB	10/30/97	20	6.79	28.5	385.2	417	281	52	11	0.41	0.13
D-41-UB	03/04/98	19	6.43	15.5	398.2	411	286	55	10	0.16	0.05
D-41-UB	05/19/98	21	6.59	17.0	396.7	457	284	50	11	0.12	0.05

D-41-UB	09/11/98	20	6.91	18.3	395.4	408	281	57	10	0.11	0.10
D-41-UB	10/29/98	21	6.59	17.3	396.4	354	297	53	11	0.45	0.07
D-41-UB	02/10/99	19	6.33	14.2	399.4	393	278	51	11	1.01	0.08
D-41-UB	04/19/99	20	6.37	14.2	399.5	434	279	53	10	0.42	0.05
D-41-UB	08/24/99	20	6.38	15.9	397.8	453	256	50	10	0.05	0.06
D-41-UB	11/09/99		6.30			474	153	56	11	0.45	0.09
D-41-UB	01/12/00	20	6.63	16.8	396.9	426	280	53	10	0.51	0.08
D-41-UB	06/07/00	20	6.78	15.7	398.0	452	278	55	12	0.17	0.02
D-41-UB	07/18/00	20	6.53	15.9	397.8	466	291	65	13	0.11	0.11
D-41-UB	11/29/00	20	6.58	16.0	397.7	435	248	53	11	2.17	0.21
D-41-UB	02/06/01	22	6.82	13.6	400.1	419	270	75	9	0.14	0.03
D-41-UB	06/12/01	20	6.72	12.3	401.4	433	248	215	9	0.06	0.02
D-41-UB	08/21/01	19	6.80	13.7	400.0	884	364	29	52	3.14	0.24
D-41-UB	12/06/01	20	6.63	13.5	400.2	445	290	71	10	2.57	0.13
D-41-UB	02/19/02	19	6.57	12.4	401.3	460	276	61	10	0.58	0.11
D-41-UB	06/06/02	20	6.68	13.0	400.7	480	294	66	10	0.19	0.05
D-41-UB	07/25/02	19	6.60	13.5	400.2	467	290	66	10	0.07	0.14
D-41-UB	11/14/02	19	6.34	14.4	399.3	460	300	67	9	0.26	0.10
D-41-UB	01/15/03	18	6.40	12.9	400.8	471	304	71	9	1.28	0.06
D-41-UB	05/27/03	18	6.64	13.2	400.5	494	278	80	10	0.31	0.05
D-41-UB	09/08/03	21	6.34	13.5	400.2	482	280	70	8	0.15	0.14
D-41-UB	12/17/03	20	6.52	14.8	398.9	466	288	45	10	0.03	0.13
D-41-UB	01/09/04	18	6.60	15	398.7	486	322	65	9	0.14	0.09
D-41-UB	07/16/10	22.5	6.42	13.25		638	414	55	10	1.64	0.048
D-42-UB	06/27/86	21	6.55		402	241	216	23	11	5.76	0.11
D-42-UB	08/28/86	20	6.48		400	250	192	20	12	5.09	0.1
D-42-UB	11/17/86	19.5	6.72		400	270	248	24	20	6.4	0.12
D-42-UB	03/24/87	21	6.58		404	235	154	20	13	5.58	0.09
D-42-UB	09/19/87	22	6.50		400	242	200	19.6	8.5	4.9	0.09
D-42-UB	11/18/87	21	6.80		400	256	203	23.1	10	5.79	0.09
D-42-UB	02/15/88	21	6.56		401	258	202	19.7	9.7	4.85	0.09
D-42-UB	05/13/88	21	6.46		407	249	191	19	9	4.47	0.08
D-42-UB	08/13/88	22	6.47		400	250	199	30	9.7	4.75	0.07
D-42-UB	11/19/88	22	6.73		398	213	181	41.3	9.7	4.18	0.07
D-43-UB	09/19/87	21	6.41		383	315	243	23.6	20.6	5.07	0.27
D-43-UB	11/18/87	20.5	6.66		383	315	232	27.6	23.5	5.09	0.2
D-43-UB	02/15/88	21	6.59		384	320	237	32.6	23.6	5.68	0.16
D-43-UB	05/13/88	21	6.62		384	330	244	35	23	4.65	0.13
D-43-UB	08/13/88	21	7.01		383	332	244	35	22.6	4.44	0.12
D-43-UB	11/19/88	22	6.86		381	322	221	35	26.3	4.3	0.11
D-44-S	08/09/95	28	6.10	13.7	403.5	323	201	4	10	3.34	0.30
D-44-S	10/04/95	22	6.18	14.4	402.8	351	219	10	10	8.34	0.23
D-44-S	05/02/96	19	5.88	15.7	401.5	183	154	24	12	0.16	0.05
D-44-S	07/16/96	21	5.80	15.6	401.6	177	154	24	11	0.19	0.09
D-44-S	10/28/96	20	5.63	14.8	402.4	172	146	34	12	3.48	0.08
D-44-S	03/04/97	19	6.03	9.5	407.7	181.5	162	22	9	0.52	0.07
D-44-S	05/21/97	18	5.79	10.2	407.0	139	203	37	11	2.84	0.12
D-44-S	07/08/97	21	5.78	11.4	405.8	160.7	187	18	11	0.26	0.13

D-44-S	10/30/97	20	5.62	13.2	404.0	173	269	40	13	0.33	0.09
D-44-S	03/03/98	17	5.55	9.3	407.9	138	287	39	11	1.75	0.12
D-44-S	05/20/98	19	5.03	11.4	405.8	160	265	29	11	0.15	0.13
D-44-S	09/11/98	20	5.23	11.7	405.5	220	278	25	17	1.40	0.21
D-44-S	10/29/98	24	4.92	13.3	403.9	144	380	37	17	2.37	0.18
D-44-S	02/10/99	20	4.71	8.9	408.3	131	151	37	12	0.11	0.15
D-44-S	04/19/99	19	5.01	9.0	408.2	132	264	22	12	0.32	0.09
D-44-S	08/24/99	22	5.40	12.2	405.0	1420	552	313	39	16.70	1.31
D-44-S	11/12/99	23	4.71	19.0	398.2	175	296	70	23	0.67	0.22
D-44-S	01/07/00	20	4.59	14.7	402.5	156	185	59	18	0.06	0.17
D-44-S	06/07/00	22	5.30	11.2	406.0	139	84	75	14	0.19	0.15
D-44-S	07/17/00	22	5.00	12.4	404.8	176	117	36	19	0.49	0.14
D-44-S	11/29/00	22	5.05	14.1	403.1	160.2	82	20	17	2.48	0.39
D-44-S	02/07/01	19	5.00	9.3	407.9	117	164	42	12	0.40	0.11
D-44-S	08/21/01	25	5.00	11.7	405.5	213	138	125	15	0.80	0.21
D-44-S	12/06/01	20	4.95	12.3	404.9	151	82	66	13	1.43	0.17
D-44-S	02/19/02	18	5.06	10.1	407.1	127.5	77	37	13	0.01	0.11
D-44-S	06/06/02	21	5.17	11.8	405.4	581	160	160	14	1.37	0.28
D-44-S	07/19/02	22	4.83	12.6	404.6	238	150	120	13	0.71	0.14
D-44-S	11/14/02	20	3.90	14.4	402.8	589	388	285	24	0.85	0.22
D-44-S	01/15/03	19	4.75	11.4	405.8	135	106	17	15	0.19	0.08
D-44-S	05/27/03	19	4.87	12.2	405.0	169.7	106	20	17	0.90	0.12
D-44-S	09/08/03	21	4.42	13.4	403.8	1426	1078	1100	55	5.36	0.77
D-44-S	01/08/04	20	4.51	15.5	401.7	122.1	136	<1	22	0.10	0.09
D-44-S	04/30/04	20	6.96	25	392.2	360	72	24	17	0.65	0.11
D-44-S	07/29/04	22	4.53	12.9	404.3	131.4	138	30	17	0.43	0.11
D-44-S	11/05/04	18	5.19	14.1	403.1	49.2	86	9	10	1.03	0.02
D-44-S	03/03/05	18	4.01	8.6	408.6	226	154	29	16	3.10	0.06
D-44-S	04/07/05	17	5.06	9.2	408.0	130.3	108	23	17	0.16	0.10
D-44-S	08/31/05	21	5.91	14.4	402.8	245	156	34	23	2.11	0.16
D-44-S	10/17/05	21	5.19	11.1	406.1	140.3	104	24	25	0.77	0.07
D-44-S	02/22/06	19	5.18	16.1	401.1	121.2	118	23	24	0.10	0.04
D-44-S	05/31/06	20	4.80	15.5	401.7	118	140	18	25	0.08	0.03
D-44-S	05/30/07	20	4.10	13.1	404.1	123.6	90	8	15	1.41	0.05
D-44-S	08/22/07	22	4.41	13.4	403.8	136.8	86	7	7	3.00	0.07
D-44-S	10/09/07	23	4.37	15.2	402.0	114.2	110	5	18	0.96	0.05
D-44-S	02/20/08	20	4.38	16	401.2	124.1	92	9	16	0.04	0.05
D-44-S	05/06/08	18	4.29	12.3	404.9	157.8	124	30	15	1.03	0.12
D-44-S	07/08/08		4.46	14.7	402.5	158.2	142	14	16	1.98	0.28
D-44-S	12/05/08	21	4.73	16.3	400.9	134.1	102	5	20	0.08	0.04
D-44-S	06/09/09	20	4.49	13.8	403.4	136.9	114	9	17	0.15	0.10
D-44-S	08/10/09	22	4.58	15.6	401.6	127	110	6	8	0.15	0.08
D-44-S	12/08/09	21	4.76	13.4	403.8	135.4	104	51	20	0.53	0.16
D-44-S	03/23/10		4.38	9.6	407.6	141.4	112	25.4	20	0.73	0.063
D-44-S	04/26/10	19	4.38	11.32		135.5	152	29	20	0.427	0.104
D-44-S	10/13/10	23.5	4.31	16.2		126.2	112	14	22	0.465	0.085
D-44-S	05/15/12	21	4.68	14.8		138.5	104	21	21	0.052	0.172
D-45-S	12/26/95	17	5.70	16.80	335.1	1543	1218	741	68	14.50	2.85

D-45-S	01/05/96	16	4.71	13.2	338.7	683	514	298	27	12.80	0.96
D-45-S	05/01/96	17	4.71	9.9	342.1	1238	964	582	54	3.54	0.70
D-45-S	07/09/96	21	4.96	13.7	338.2	1812	1556	976	75	13.60	1.21
D-45-S	10/21/96	20	5.51	9.5	342.4	955	798	439	48	2.33	0.49
D-45-S	03/04/97	18	5.54	4.9	347.0	364	255	97	21	0.66	0.46
D-45-S	05/19/97	19	5.70	7.4	344.5	492	351	174	31	2.45	0.78
D-45-S	07/08/97	20	5.79	14.4	337.5	537	360	135	28	8.51	0.85
D-45-S	10/29/97	20	5.25	14.0	337.9	994	812	516	53	5.22	0.90
D-45-S	03/04/98	15	5.43	3.8	348.1	468	385	138	30	2.99	0.63
D-45-S	05/19/98	20	5.38	14.1	337.8	568	382	140	31	0.48	0.78
D-45-S	09/11/98	18	5.66	19.7	332.2	751	558	233	40	8.12	0.99
D-45-S	10/29/98	22	4.22	12.2	339.7	852	626	341	46	0.61	0.51
D-45-S	02/10/99	21	5.26	3.5	348.5	411	333	150	27	70.40	0.75
D-45-S	04/19/99	21	5.14	3.7	348.2	501	280	127	24	16.90	0.54
D-45-S	08/24/99	21	5.04	11.7	340.2	1620	1244	728	68	14.70	1.36
D-45-S	11/08/99	23	6.35	13.3	338.6	812	516	254	40	0.05	0.28
D-45-S	01/10/00	19	4.27	7.3	344.6	481	328	173	27	0.09	0.23
D-45-S	06/07/00	20	4.78	7.8	344.1	437	252	300	25	0.49	0.17
D-45-S	07/18/00	22	4.95	11.1	340.8	622	472	300	35	3.86	0.27
D-45-S	12/04/00	19	4.67	4.1	347.8	634	288	170	27	8.47	0.29
D-45-S	02/07/01	18	5.17	3.4	348.5	440	352	60	22	0.17	0.19
D-45-S	06/12/01	25	4.56	4.9	347.0	375	230	140	17	0.15	0.19
D-45-S	08/21/01	22	4.51	9.1	342.8	454	360	300	28	1.20	0.29
D-45-S	12/06/01	20	4.38	7.0	344.9	486	288	215	22	0.67	0.28
D-45-S	02/20/02	18	5.16	5.1	346.8	592	345	265	22	14.20	0.50
D-45-S	07/19/02	20.5	4.18	6.9	345.0	571	428	320	23	2.78	0.20
D-45-S	11/14/02	21	3.74	5.4	346.5	597	382	320	25	0.63	0.22
D-45-S	01/15/03	18	4.34	6.2	345.7	537	396	350	22	0.73	0.22
D-45-S	05/27/03	19	4.16	7.4	344.5	519	308	125	25	4.37	0.30
D-45-S	09/08/03	21	4.05	10.5	341.4	1375	1096	1050	51	3.79	0.70
D-45-S	12/12/03	20	3.99	7.6	344.3	564	344	285	25	1.70	0.15
D-45-S	01/09/04	18	5.05	5.6	346.3	511	348	100	28	0.16	0.17
D-45-S	07/19/10	27	4.69	9.4		577	468	215	19	2.46	0.202
D-4-UB	02/29/84	17	6.20		365	410	263	80	12	3	
D-4-UB	06/23/84	21	5.99		365	390	250	81	18	5.38	0.1
D-4-UB	09/29/84	19	6.05		365	405	242	68	14	6.46	0.08
D-4-UB	01/08/85	19	5.72		365	420	264	69	16	5.94	0.12
D-4-UB	04/22/85	19.5	6.03		366	400	346	67	19	7.46	0.09
D-4-UB	07/23/85	21	6.00		366	410	248	79	20	6.68	0.11
D-4-UB	10/17/85	19	6.45		366	400	268	68	17	4.91	0.1
D-4-UB	01/23/86	19	6.39		366	400	220	84	19	5.7	0.08
D-4-UB	06/28/86	21	6.50		366	349	300	81	14	5.36	0.09
D-4-UB	09/05/86	20	6.41		366	345	262	79	13	4.84	0.08
D-4-UB	11/18/86	19	6.41		366	365	260	76	17	5.42	0.07
D-4-UB	03/16/87	20	6.29		369	325	272	72	16	4.8	0.08
D-4-UB	09/21/87	21	6.73		366	362	285	77	12	3.76	0.08
D-4-UB	11/16/87	19	6.60		366	333	283	76.1	12	4.29	0.08
D-4-UB	02/18/88	19	6.05		366	325	285	99.8	16	4.13	0.09

D-4-UB	05/12/88	20	6.38		366	350	284	77	13	4.5	0.09
D-4-UB	08/13/88	21	6.48		366	362	290	80.4	13	4.73	0.12
D-4-UB	11/17/88	19	6.72		365	331	298	80	15	4.6	0.09
D-6-UB	02/22/93	21.1	5.30	43.0	342.8	149	115	21	10	3.70	0.11
D-6-UB	04/16/93	23.9	5.60	42.5	343.3	158	122	31	9	4.79	0.10
D-6-UB	07/14/93	24.3	6.10	42.6	343.2	155	43	20	9	1.64	0.10
D-6-UB	10/27/93	17.5	5.70	43.5	342.3	158	113	20	8	6.54	0.10
D-6-UB	01/04/94	13.3	6.00	43.7	342.1	155	138	21	9	3.53	0.09
D-6-UB	06/30/94	13.6	6.01	43.0	342.8	155	148	18	9	1.21	0.13
D-6-UB	09/07/94	17	6.04	43.9	341.9	172	151	18	10	1.18	0.13
D-6-UB	10/04/94	19.1	5.62	43.0	342.8	168	133	28	10	3.68	0.11
D-6-UB	02/17/95	17.2	5.81	43.3	342.5	138	137	26	9	2.00	0.09
D-6-UB	05/15/95	21	6.09	41.8	344.0	21	127	17	8	5.31	0.10
D-7-OB-T	03/22/84	21	3.80		423	82	71	17	4	1.1	
D-7-OB-T	06/21/84	21	3.41		418	60	30	10	12	1.14	0.03
D-7-OB-T	09/28/84	19	4.90		414	45	76	12	8	5.3	0.01
D-7-OB-T	01/04/85	20	3.86		423	105	68	25	10	5.69	0.06
D-7-OB-T	04/18/85	21	3.60		421	73	30	13	12	1.69	0.01
D-7-OB-T	07/22/85	22	3.00		417	63	36	8	10	1.09	0.02
D-7-OB-T	10/17/85	22	4.21		414	53	48	6	10	0.88	0.01
D-7-OB-T	01/23/86	20	4.26		421	70	28	14	11	1.8	0.03
D-7-UB	03/21/84	22	7.40		388	750	337	105	101	<0.01	
D-7-UB	06/21/84	21	7.31		387	780	520	116	100	0.28	0.08
D-7-UB	09/28/84	19	7.43		386	814	472	100	96	0.32	0.08
D-7-UB	01/05/85	20	7.14		387	850	476	101	96	0.14	0.08
D-7-UB	04/22/85	20	7.42		387	780	494	100	108	0.11	0.05
D-7-UB	07/22/85	21	7.20		387	870	490	115	104	0.14	0.05
D-7-UB	10/19/85	20	7.69		386	810	544	118	104	0.09	0.05
D-7-UB	01/23/86	20	8.07		387	810	374	113	104	0.21	0.05
D-8-OB	03/01/84	18.5	3.80		421	190	119	40	6	4	
D-8-OB	06/23/84	20	3.62		415	260	189	101	18	25	0.2
D-8-OB	09/28/84	17	3.26		411	320	260	99	8	8.1	0.13
D-8-OB	01/07/85	19	3.38		422	250	166	78	12	16.6	0.14
D-8-OB	04/22/85	19	3.30		419	250	250	79	15	28	0.11
D-8-OB	07/20/85	19	3.91		413	280	206	85	13	23	0.12
D-8-OB	10/17/85	19	3.35		411	400	264	99	19	12.5	0.15
D-8-OB	01/23/86	19	3.80		420	190	140	64	11	15.6	0.05
D-8-OB	06/25/86	19.5	3.64		421	158	146	54	7	8.94	0.05
D-8-OB	09/03/86	19	4.30		413	235	174	97	11	28	0.14
D-8-OB	11/18/86	19.5	3.75		413	250	168	64	17	17.5	0.1
D-8-OB	03/16/87	20	3.62		424	205	210	71	14	23	0.08
D-8-OB	09/20/87	20	3.65		412	253	235	96.5	9.3	23	0.13
D-8-OB	11/16/87	19.5	3.82		412	270	220	110	12.1	27	0.21
D-8-OB	05/11/88	19.5	4.71		419	235	237	97	11	39.1	0.19
D-8-OB	02/15/88	19.5	3.74		420	249	219	114	10	53.8	0.16
D-8-OB	08/12/88	21	4.26		413	250	214	102	12	34.1	0.19
D-8-OB	11/15/88	20	4.10		412	249	221	100	12.4	32.2	0.14
D-9-OBa	02/21/84	19	5.60		421	64	95	9	6	1.8	

D-9-OBa	06/22/84	19.5	4.93		415	68	57	10	12	0.31	0.04
D-9-OBa	09/27/84	19	4.70		412	70	50	8	12	5.78	0.19
D-9-OBa	01/06/85	19	4.86		423	60	40	5	10	2.66	0.1
D-9-OBa	04/24/85	18.5	5.30		418	57	33	7	10	2.72	0.05
D-9-OBa	07/21/85	20	5.41		414	62	32	10	9	2.71	0.05
D-9-OBa	10/18/85	20	5.57		412	55	34	9	12	0.29	0.03
D-9-OBa	01/23/86	19	5.78		421	61	16	7	10	0.4	0.05
D-9-OBa	06/27/86	21	5.84		418	51	106	9	7	2.64	0.05
D-9-OBa	09/04/86	20	5.52		413	45	46	8	9	2.48	0.03
D-9-OBa	11/18/86	19	5.80		412	80	50	8	10	3.16	0.05
D-9-OBa	03/22/87	19	5.72		423	45	70	6	10	2.94	0.03
D-9-OBa	09/21/87	21	5.95		414	50	102	6	6.9	3.04	0.05
D-9-OBa	11/16/87	20	5.92		412	62	94	5.2	6.7	2.1	0.05
D-9-OBa	02/19/88	19	5.20		416	50	95	9.1	8.64	2.82	0.06
D-9-OBb	02/21/84	18	4.20		425	71	21	4	6	<0.01	
D-9-OBb	06/22/84	19	3.27		419	72	56	6	14	0.03	0.02
D-9-OBb	01/06/85	19	3.17		427	85	60	4	11	1.13	0.02
D-9-OBb	04/24/85	18.5	4.00		421	67	42	5	12	0.22	0.01
D-9-OBb	07/21/85	20	3.64		418	76	70	5	10	0.24	0.01
D-9-OBb	10/18/85	23	3.92		416	72	54	5	8	0.56	<0.01
D-9-OBb	01/22/86	19	3.60		424	75	24	7	14	0.37	0.01
D-9-OBb	06/27/86	21	4.04		422	72	64	9	8	0.3	0.02
D-9-OBb	09/04/86	21.5	3.94		417	68	42	7	8	1.33	
D-9-OBb	11/18/86	19	4.12		416	100	72	8	11	0.49	<0.01
D-9-OBb	03/22/87	18	4.12		428	74	60	6	10	0.24	0.01
D-9-OBb	09/21/87	21	4.10		418	71	63	5.4	6.9	1.1	0.05
D-9-OBb	11/16/87	20.5	4.21		416	60	62	6	5.4	1.96	0.05
D-9-OBb	02/19/88	18	3.50		419	65	58	5.2	7.8	0.3	0.05
D-9-UB	02/22/84	18.5	6.80		403	450	243	50	8	1.4	
D-9-UB	06/22/84	21	6.40		401	440	300	64	16	2.04	0.11
D-9-UB	09/27/84	19	6.79		398	458	294	52	12	2.6	0.07
D-9-UB	01/06/85	20	6.21		403	470	296	56	13	2.08	0.14
D-9-UB	04/24/85	19	6.85		402	447	314	55	12	1.7	0.08
D-9-UB	07/21/85	21	6.85		400	465	330	62	11	1.89	0.09
D-9-UB	10/18/85	20	6.89		397	450	272	64	13	1.98	0.09
D-9-UB	01/23/86	19	6.92		402	450	236	71	16	2.61	0.07
D-9-UB	06/27/86	21	7.00		403	383	318	63	10	2.55	0.09
D-9-UB	09/04/86	20	6.95		401	370	260	57	11	2.2	0.08
D-9-UB	11/18/86	19	6.98		400	380	260	57	11	2.36	0.07
D-9-UB	03/22/87	17	6.95		406	310	208	30	10	1.81	0.05
D-9-UB	09/21/87	21	7.17		400	282	211	24.4	5.3	1	0.05
D-9-UB	11/16/87	20	6.81		399	283	200	23.8	6.1	1.39	0.07
D-9-UB	02/19/88	19	6.65		397	280	212	32.9	7.01	1.23	0.07
DII-14-R-08	02/28/08	20	4.59	35.6	330.4	174.5	140	62	7	1.16	0.34
DII-14-R-08	05/06/08	19	4.62	34	332.0	102.9	60	16	4	0.31	0.10
DII-14-R-08	07/09/08		4.17	33.2	332.8	176	120	60	2	7.03	0.27
DII-14-R-08	12/15/08	20	3.66	32.4	333.6	328	262	125	4	2.47	0.62
DII-14-R-08	02/09/09	19	3.89	32.2	333.8	458	280	190	2	3.89	0.66

DII-14-R-08	06/12/09	20	3.42	31.2	334.8	837	716	460	3	6.80	1.31
DII-14-R-08	08/19/09	22	3.47	31.5	334.5	881	864	305	4	6.59	1.00
DII-14-R-08	12/10/09	19	3.79	29.7	336.3	1100	992	456	5	15.90	1.85
DII-14-R-08	03/19/10		3.61	29.4	336.6	963	878	554	3	11.9	1.17
DII-14-R-08	04/21/10	21.5	3.39	29.23		948	1006	750	6	14.4	1.08
DII-14-R-08	07/13/10	21.5	3.43	29.77		976	946	620	6	25.9	1.24
DII-14-R-08	10/14/10	21	3.20	30.4		1022	1068	28	7	40	1.2
DII-14-R-08	03/01/11	21	3.61	31.3		965	964	600	8	46.85	0.836
DII-14-R-08	04/14/11	22	3.59	31.4		923	1084	620	8	56.16	0.749
DII-14-R-08	09/07/11	22.5	3.79	32.2		916	918	600	9	65.9	0.828
DII-14-R-08	11/03/11	21	3.83	32.7		869	890	580	9	61.48	0.818
DII-14-R-08	02/01/12	22	3.74	42.6		807	862	480	11	59.3	0.598
DII-14-R-08	05/16/12	22	3.72	31.7		824	694	480	10	49.54	0.609
DII-37-R-91	07/14/93	26	5.30	19.8	413.3	1242	976	611	10	28.30	5.75
DII-37-R-91	01/04/94	16.4	5.00	17.8	415.3	1344	1106	781	14	52.80	7.44
DII-37-R-91	06/24/94	12.8	4.20	13.5	419.6	2040	2089	1373	10	103.00	14.10
DII-37-R-91	09/13/94	13.5	3.95	14.0	419.1	2800	3158	1025	9	184.00	26.50
DII-37-R-91	10/04/94	28.2	3.71			2600	2750	1787	9	139.00	20.90
DII-37-R-91	02/17/95	16.9	3.50	9.6	423.5	3210	3556	2316	10	221.00	27.60
DII-37-R-91	05/30/95	18	3.65	7.7	425.4	3700	4508	3062	9	338.00	33.90
DII-37-R-91	08/10/95	24	3.54	9.0	424.1	3000	3842	2583	9	2.76	29.90
DII-37-R-91	10/04/95	21	3.85	9.6	423.5	3000	3062	1915	9	208.00	24.80
DII-37-R-91	01/04/96	21	3.55	10.4	422.7	2600	2670	1739	9	199.00	20.30
DII-37-R-91	04/30/96	20	3.75	9.4	423.7	2480	2516	1674	10	187.00	19.60
DII-37-R-91	03/05/97	19	3.85	3.7	429.4	2530	2604	1650	9	168.00	17.20
DII-37-R-91	05/22/97	18	3.91	5.3	427.8	1859	1918	1242	10	132.00	13.10
DII-37-R-91	10/30/97	23	3.81	7.5	425.6	1499	1662	1050	10	107.00	11.90
DII-37-R-91	03/05/98	18	3.38	3.6	429.5	1726	1524	1017	9	87.60	9.76
DII-37-R-91	05/20/98	18	3.76	6.3	426.8	1578	1360	885	9	84.50	8.71
DII-37-R-91	09/18/98	25	4.01	7.4	425.7	1518	1372	845	10	98.20	7.83
DII-37-R-91	10/30/98	23	3.21	6.4	426.7	1323	1112	706	10	51.60	7.50
DII-37-R-91	02/11/99	20	3.30	3.6	429.5	1292	1094	725	11	0.05	0.05
DII-37-R-91	04/23/99	20	3.32	4.0	429.1	1422	1072	700	10	56.60	6.68
DII-37-R-91	08/25/99	21	3.49	6.7	426.4	1325	1106	696	9	78.20	5.84
DII-37-R-91	11/12/99	22	3.85	7.5	425.6	1251	1102	683	10	83.70	5.27
DII-37-R-91	01/24/00	18	2.58	6.2	426.9	1257	964	613	10	46.00	5.42
DII-37-R-91	06/08/00	22	3.24	5.3	427.8	1269	827	550	10	12.67	4.59
DII-37-R-91	07/20/00	23	3.48	6.4	426.7	1121	762	550	11	47.20	3.34
DII-37-R-91	11/30/00	22	3.77	5.5	427.6	1123	900	650	9	65.50	5.71
DII-37-R-91	02/07/01	19	3.37	3.1	430.0	1149	822	475	10	6.92	4.42
DII-37-R-91	06/12/01	25	3.09	3.1	430.0	1280	838	1350	8	33.05	3.43
DII-37-R-91	08/24/01	19	4.41	6.3	426.8	1246	990	350	8	93.50	3.83
DII-37-R-91	12/10/01	20	3.15	4.8	428.3	1214	870	475	9	39.90	4.24
DII-37-R-91	02/20/02	17	3.07	3.7	429.4	1249	787	500	11	12.80	2.89
DII-37-R-91	06/10/02	21	5.41	4.9	428.2	1147	920	600	9	121.60	1.79
DII-37-R-91	07/24/02	22	4.37	5.3	427.8	1027	820	1250	10	54.60	2.29
DII-37-R-91	11/15/02	21	5.03	5.0	428.1	1032	816	800	10	90.13	2.09
DII-37-R-91	01/15/03	19	4.50	3.4	429.7	956	776	550	10	71.80	2.23

DII-37-R-91	05/29/03	19	5.23	6.0	427.1	1100	954	750	13	109.00	1.56
DII-37-R-91	09/09/03	22	4.95	6.3	426.8	1046	946	725	9	97.30	1.67
DII-37-R-91	12/11/03	18	5.34	6.5	426.6	970	746	550	10	86.40	1.66
DII-37-R-91	01/13/04	18	3.87	6.0	427.1	978	746	600	8	45.54	2.41
DII-37-R-91	05/04/04	19	4.03	2.9	430.2	956	814	525	10	64.10	1.68
DII-37-R-91	08/03/04	22	4.86	5.5	427.6	1113	1034	725	11	127.00	1.60
DII-37-R-91	11/05/04	23	4.30	6.4	426.7	1013	764	650	11	60.40	1.85
DII-37-R-91	03/08/05	15	5.15	2.4	430.7	1025	938	625	14	116.90	1.61
DII-37-R-91	04/08/05	17	4.96	3.9	429.2	1004	910	600	12	88.70	1.66
DII-37-R-91	09/02/05	22	5.34	5.7	427.4	901	826	600	10	62.00	1.40
DII-37-R-91	10/19/05	20	5.45	6.7	426.4	881	792	550	11	73.20	1.74
DII-37-R-91	02/23/06	15	5.59	5.5	427.6	806	840	525	11	63.10	1.81
DII-37-R-91	06/02/06	20	5.05	7	426.1	948	842	500	26	59.50	1.36
DII-37-R-91	09/08/06	23	4.50	7.7	425.4	871	80	32	14	51.30	1.84
DII-37-R-91	11/29/06	21	4.33	8.7	424.4	805	700	500	10	50.80	1.57
DII-37-R-91	02/07/07	18	4.96	3.9	429.2	808	764	400	9	14.50	1.76
DII-37-R-91	05/31/07	20	4.20	4.2	428.9	792	382	360	5	55.20	0.58
DII-37-R-91	08/24/07	23	4.46	5.3	427.8	761	772	400	7	42.30	1.72
DII-37-R-91	10/11/07	22	4.66	6.7	426.4	733	784	360	8	55.20	1.44
DII-37-R-91	02/29/08	16	5.59	4.5	428.6	936	740	540	8	87.10	9.77
DII-37-R-91	05/07/08	19	4.73	3.8	429.3	823	738	300	8	54.90	1.31
DII-37-R-91	07/10/08		4.75	6.6	426.5	801	656	400	5	46.40	1.51
DII-37-R-91	12/17/08	16	4.89	4.8	428.3	655	540	260	6	30.20	1.13
DII-37-R-91	02/06/09	18	3.75	4.6	428.5	760	614	340	5	27.20	1.56
DII-37-R-91	06/15/09	21	5.27	3.9	429.2	754	606	340	6	61.30	1.10
DII-37-R-91	08/18/09	24	5.08	5.1	428.0	821	610	330	6	55.20	1.08
DII-37-R-91	12/10/09	19	4.84	3	430.1	656	512	303	8	42.40	1.28
DII-37-R-91	03/19/10		5.44	2.5	430.6	729	560	301	8	17.8	1.01
DII-37-R-91	04/22/10	18.5	5.32	3.13		726	608	360	8	69.7	0.963
DII-37-R-91	07/15/10	24.5	5.03	4.02		770	602	200	9	55.9	0.938
DII-37-R-91	10/15/10	22.5	5.17	7		663	604	350	10	54.4	1.09
DII-37-R-91	03/01/11	18.5	4.97	3.9		621	546	320	8	35.76	1.148
DII-37-R-91	04/15/11	19	4.73	4.1		662	616	360	8	48.87	0.975
DII-37-R-91	09/08/11	24	5.92	7.3		740	640	360	13	77.08	1.11
DII-37-R-91	11/03/11	22	5.42	7.8		686	540	420	9	51.04	1.15
DII-37-R-91	02/02/12	20	4.01	3.5		680	500	320	9	13.49	1.13
DII-37-R-91	05/17/12	20	4.60	4.2		686	552	340	8	20.95	0.947
DII-4-OB	03/25/04	19	4.43	28.2	312.9	55.2	80	18	9	0.05	0.01
DII-4-OB	03/30/04	20	5.93	39.8	301.3	194	148	34	6	0.17	0.05
DII-4-OB	05/04/04	20	4.22	27.9	313.2	58.8	32	7	8	0.81	0.02
DII-4-OB	08/03/04	20	3.81	27.1	314.0	54.4	68	38	9	1.34	0.02
DII-4-OB	11/10/04	18	4.55	28.0	313.1	50.7	40	32	9	0.14	0.00
DII-4-OB	03/04/05	19	4.41	22.7	318.4	51.2	62	24	9	0.17	<0.003
DII-4-OB	04/19/05	20	4.80	26.2	314.9	67.3	94	8	11	0.02	0.05
DII-4-OB	09/02/05	20	5.46	27.2	313.9	56.2	114	19	10	0.26	0.01
DII-4-OB	10/18/05	20	4.98	18.1	323.0	51.3	36	14	10	0.08	0.01
DII-4-OB	02/22/06	18	5.24	33	308.1	51.7	78	10	10	0.28	0.01
DII-4-UB	05/04/04	20	5.83	39.4	301.2	182.5	82	16	6	2.38	0.07

DII-4-UB	08/03/04	20	5.53	40.0	300.6	173.1	108	30	6	0.96	0.06
DII-4-UB	11/10/04	18	5.76	47.0	293.6	168	124	38	6	2.14	0.02
DII-4-UB	03/04/05	17	5.69	39.6	301.0	153.6	126	30	7	1.66	<0.003
DII-4-UB	04/19/05	19	5.89	39.6	301.0	152.4	128	29	6	0.04	0.01
DII-4-UB	09/02/05	21	6.77	41.1	299.5	149.1	102	21	7	1.01	0.04
DII-4-UB	10/18/05	21	6.25	42	298.6	157.6	114	24	7	1.57	0.05
DII-4-UB	02/22/06	19	6.32	44.1	296.5	150.2	160	32	7	1.29	0.04
DII-5-OB	06/02/06	19	6.16	49.7	327.1	35.6	80	7	10	1.62	0.00
DII-5-OB	09/11/06	20	5.48	50.7	326.1	93.8	114	10	11	0.07	0.04
DII-5-OB	12/01/06	19	5.77	51.4	325.4	105.6	102	51	10	0.78	0.17
DII-5-OB	02/07/07	20	4.39	51.8	325.0	33.5	60	10	4	3.31	0.07
DII-5-OB	05/31/07	24	4.24	52.2	324.6	37.7	42	<1	4	0.83	0.01
DII-5-OB	08/23/07	24	4.63	51.6	325.2	38.9	32	4	5	1.07	0.03
DII-5-OB	10/10/07	22	4.50	50.9	325.9	33.1	38	<1	3	0.14	0.01
DII-5-OB	02/28/08	20	4.65	51	325.8	32.2	38	5	1	0.09	0.01
DII-5-OB	05/08/08	21	4.52	51.2	325.6	53.7	48	2	9	0.05	0.01
DII-5-OB	07/09/08		4.99	51	325.8	36.4	74	<1	3	0.37	0.01
DII-5-OB	12/16/08	20	4.70	51.1	325.7	42.8	46	<1	3	0.11	0.02
DII-5-OB	02/09/09	20	4.71	51.4	325.4	42.4	28	4	2	0.56	0.02
DII-5-OB	06/15/09	22	4.42	51.7	325.1	36.6	34	2	4	0.11	0.01
DII-5-OB	08/18/09	21	5.05	51.5	325.3	34.7	28	2	3	0.32	0.01
DII-5-OB	12/10/09	20	4.98	51.3	325.5	55.2	38	25	3	0.40	0.01
DII-5-OB	03/23/10		4.37	50.1	326.7	32.6	40	9.4	2	0.016	<0.005
DII-5-OB	04/30/10	22	4.17	49.63		31.9	88	11	3	0.036	0.009
DII-5-OB	07/13/10	22	4.04	49.03		32.3	46	6	3	0.114	< 0.01
DII-5-OB	10/15/10	21	4.36	49.6		32.8	34	8	4	0.051	< 0.01
DII-5-OB	03/02/11	21	5.43	50.7		282	32	4	4	0.134	< 0.01
DII-5-OB	04/14/11	21.5	5.03	51.1		32.8	40	11	3	0.049	< 0.01
DII-5-OB	09/08/11	21.5	5.66	52.3		32	18	4	3	0.061	< 0.01
DII-5-OB	11/03/11	21	5.42	52.7		32.4	22	3	4	0.112	< 0.01
DII-5-OB	02/01/12	21	5.97	54.9		90.5	24	8	5	0.319	0.042
DII-5-OB	05/16/12	22	4.96	53.6		30	36	3	3	0.489	0.014
DII-5-UB	06/02/06	19	6.19	62.8	313.6	101.3	58	9	8	0.22	0.08
DII-5-UB	09/11/06	20	5.45	53.6	322.8	90.1	132	7	1	0.04	0.03
DII-5-UB	12/01/06	21	5.78	53.7	322.7	105.9	64	22	5	<0.006	0.03
DII-5-UB	02/07/07	20	5.57	53.8	322.6	81.2	94	61	4	0.56	0.45
DII-5-UB	05/31/07	20	5.37	54	322.4	84.8	90	11	3	0.53	0.12
DII-5-UB	08/23/07	21	5.38	53.6	322.8	85.1	82	2	4	0.27	0.09
DII-5-UB	10/10/07	20	5.41	53.4	323.0	81.2	76	<1	3	0.90	0.10
DII-5-UB	02/28/08	20	5.68	53.2	323.2	86.1	102	5	6	0.37	0.09
DII-5-UB	05/08/08	20	5.41	53.2	323.2	89	90	<1	5	0.73	0.21
DII-5-UB	07/09/08		5.66	53.4	323.0	92.2	108	3	3	0.46	0.04
DII-5-UB	12/16/08	19	5.53	53.6	322.8	96.7	106	5	3	0.47	0.05
DII-5-UB	02/09/09	20	5.47	53.8	322.6	96.1	78	<1	2	0.71	0.07
DII-5-UB	06/15/09	22	5.40	54	322.4	92.8	96	5	4	0.29	0.04
DII-5-UB	08/18/09	21	5.80	54.4	322.0	95.6	100	4	4	2.02	0.05
DII-5-UB	12/10/09	19	5.79	53.2	323.2	91.6	82	9	3	0.24	0.03
DII-5-UB	03/23/10		5.58	52.5	323.9	93.2	88	6.2	4	2.35	0.062

DII-5-UB	05/03/10	21.5	5.32	52.48		98	84	4	4	2.43	0.232
DII-5-UB	07/14/10	22	5.25	52.35		91.3	78	5	7	0.642	0.22
DII-5-UB	10/15/10	21.5	5.26	53		87.9	78	5	5	1.09	0.058
DII-5-UB	03/02/11	20.5	6.11	53.4		110.1	84	10	5	0.282	0.041
DII-5-UB	04/14/11	21.5	5.99	53.7		113.2	92	11	4	0.52	0.044
DII-5-UB	09/08/11	21	6.41	54.8		79	90	11	5	0.253	0.049
DII-5-UB	11/03/11	20.5	6.18	55.1		92.9	86	10	4	0.982	0.04
DII-5-UB	02/01/12	21	5.33	53.2		365	34	3	4	0.072	< 0.01
DII-5-UB	05/16/12	22	6.02	55		90.3	70	6	7	0.609	0.062
DII-6(ALLUV)-04	03/10/05	18	5.60	5.2	310.8	377	244	29	23	17.23	0.50
DII-6(ALLUV)-04	04/19/05	20	5.46	5.4	310.6	389	310	150	22	22.40	0.33
DII-6(ALLUV)-04	09/01/05	25	6.70	6.5	309.5	405	270	100	25	18.40	0.42
DII-6(ALLUV)-04	10/18/05	22	6.59	6.7	309.3	471	276	125	23	11.40	0.49
DII-6(ALLUV)-04	02/22/06	17.5	6.11	6.2	309.8	163.7	180	48	8	3.33	0.16
DII-6(ALLUV)-04	06/01/06	20	6.05	8.1	307.9	516	416	185	32	22.60	0.44
DII-6(ALLUV)-04	09/07/06	20	5.33	9.3	306.7	437	344	145	28	8.63	0.56
DII-6(ALLUV)-04	11/30/06	18	6.20	7.8	308.2	322	218	27	20	4.29	0.28
DII-6(ALLUV)-04	02/07/07	19	5.99	6.3	309.7	302	218	52	16	0.86	0.35
DII-6(ALLUV)-04	05/31/07	19	5.89	6.4	309.6	368	258	27	18	7.36	0.33
DII-6(ALLUV)-04	08/23/07	21	5.49	6.6	309.4	354	250	50	20	4.25	0.33
DII-6(ALLUV)-04	10/10/07	20	5.93	6.9	309.1	316	304	<1	14	0.36	0.25
DII-6(ALLUV)-04	02/28/08	16	6.71	6	310.0	288	188	10	20	0.09	0.09
DII-6(ALLUV)-04	05/07/08	18	6.26	6	310.0	298	262	25	10	0.18	0.14
DII-6(ALLUV)-04	07/09/08		6.70	7.2	308.8	312	222	18	9	0.23	0.09
DII-6(ALLUV)-04	12/15/08	18	5.96	5.8	310.2	413	226	5	8	0.96	0.10
DII-6(ALLUV)-04	02/09/09	19	6.42	6	310.0	293	194	15	2	0.38	0.06
DII-6(ALLUV)-04	06/12/09	20	6.67	6.5	309.5	300	172	16	8	0.28	0.07
DII-6(ALLUV)-04	08/19/09	23	6.74	7.3	308.7	277	192	7	6	0.02	0.05
DII-6(ALLUV)-04	12/10/09	20	6.93	5.3	310.7	296	216	127	9	0.08	0.02
DII-6(ALLUV)-04	03/19/10		6.70	5.5	310.5	295	208	61.8	9	0.03	0.043

DII-6(ALLUV)-04	04/22/10	19.5	6.46	6.14		298	208	39	9	0.129	0.05
DII-6(ALLUV)-04	07/14/10	21.5	6.67	6.73		287	170	35	8	0.077	0.042
DII-6(ALLUV)-04	10/14/10	21.5	7.13	8		287	90	19	11	0.074	0.032
DII-6(ALLUV)-04	03/01/11	20	7.04	6.2		296	156	18	9	0.1	0.028
DII-6(ALLUV)-04	04/14/11	19.5	7.05	6.7		273	192	13	8	0.175	0.031
DII-6(ALLUV)-04	09/08/11	20.5	7.23	9.7		283	182	22	8	0.054	0.035
DII-6(ALLUV)-04	11/03/11	20	7.30	8.7		285	180	51	10	0.142	0.028
DII-6(ALLUV)-04	02/01/12	21	7.39	6.5		285	184	75	9	0.163	0.031
DII-6(ALLUV)-04	05/16/12	20	7.06	6.8		317	164	24	9	1.218	0.053
DIII-12-OB	03/26/04	19	3.01	58.5	308.2	62.5	82	9	4	0.07	0.01
DIII-12-OB	05/03/04	20	3.38	58.4	308.3	60.3	80	12	5	0.48	0.03
DIII-12-OB	08/04/04	21	2.29	57.4	309.3	58	40	6	5	0.17	0.02
DIII-12-OB	11/09/04	19	3.09	58.3	308.4	63.3	50	10	6	0.16	0.01
DIII-12-OB	03/08/05	18	3.15	57.4	309.3	56.5	78	13	7	0.91	<0.004
DIII-12-OB	04/19/05	19	3.44	56.9	309.8	55.6	68	9	5	0.10	0.01
DIII-12-OB	09/06/05	20	4.21	58	308.7	61.4	48	8	6	0.14	0.01
DIII-12-OB	10/20/05	19	4.13	58.2	308.5	71.4	72	9	7	0.16	0.01
DIII-12-OB	02/24/06	17	4.39	59.4	307.3	62.4	70	10	8	0.25	0.03
DIII-12-OB	06/02/06	20	3.80	59.8	306.9	63.8	78	7	11	0.06	0.02
DIII-12-OB	09/11/06	21	3.06	60.4	306.3	67.2	92	6	11	0.07	0.02
DIII-12-OB	12/04/06	19	3.36	61	305.7	58.6	52	8	5	<0.006	0.02
DIII-12-OB	02/08/07	18	3.45	61.1	305.6	50.1	68	8	4	0.17	0.02
DIII-12-OB	06/01/07	20	3.28	60.4	306.3	56.1	70	2	3	0.18	0.01
DIII-12-OB	08/24/07	22	3.42	59.3	307.4	51.8	94	3	2	0.16	0.01
DIII-12-OB	10/11/07	20	3.51	59.3	307.4	48.6	84	1	1	2.28	0.01
DIII-12-OB	02/29/08	19	4.00	60.3	306.4	57	58	10	4	0.17	0.02
DIII-12-OB	05/07/08	20	3.55	59.1	307.6	52.6	62	3	3	0.13	0.01
DIII-12-OB	07/10/08		3.72	59	307.7	59.4	38	6	3	0.10	0.02
DIII-12-OB	12/17/08	20	3.13	59.7	307.0	63.9	70	4	4	0.11	0.02
DIII-12-OB	02/05/09	20	3.21	60.4	306.3	60.2	80	10	5	0.11	0.03
DIII-12-OB	06/12/09	21	3.55	59.3	307.4	58.3	52	7	4	0.07	0.02
DIII-12-OB	08/19/09	21	3.71	59.6	307.1	68.1	68	2	5	0.09	0.02
DIII-12-OB	12/11/09	20	4.52	59.2	307.5	53.7	74	7	5	0.99	0.02
DIII-12-OB	03/23/10		4.66	58	308.7	47.8	64	11.5	4	2.97	<0.005
DIII-12-OB	04/27/10	22	4.12	57.81		46	88	12	4	3.59	0.017
DIII-12-OB	07/15/10	22	3.46	57.68		55.3	70	5	6	1.01	0.021
DIII-12-OB	10/15/10	22	3.52	58.4		72.2	58	5	6	0.255	0.014
DIII-12-OB	03/02/11	20.5	3.97	59.3		62.7	58	6	5	0.079	0.016
DIII-12-OB	04/15/11	20.5	3.53	59.5		79.4	62	7	9	0.158	0.016
DIII-12-OB	09/08/11	21.5	4.54	60.4		59	64	8	6	0.111	0.013

DIII-12-OB	11/03/11	20.5	4.66	60.7		60.2	42	7	6	0.324	0.015
DIII-12-OB	05/17/12	21	3.95	60.4		59.4	12	8	4	0.12	0.015
DIII-13-OB-98	02/15/99	20	5.64	13.9	376.6	121	979	74	10	1.41	0.05
DIII-13-OB-98	08/06/99		5.00	16.0	374.5	81	270	13	6		
DIII-13-OB-98	08/23/99	21	3.17	17.2	373.3	88	74	11	5	0.17	0.05
DIII-13-OB-98	11/17/99	15	5.75	19.9	370.6	77	373	62	9	0.90	0.05
DIII-13-OB-98	01/21/00	19	4.90	20.4	370.1	72	338	68	9	0.42	0.05
DIII-13-OB-98	06/09/00	22	6.13	16.1	374.4	137	210	33	8	1.37	0.11
DIII-13-OB-98	07/20/00	23	6.12	16.2	374.3	258	200	34	9	0.39	0.07
DIII-13-OB-98	11/30/00	20	6.20	16.9	373.6	283	280	80	6	0.56	0.74
DIII-13-OB-98	02/09/01	17	6.45	13.0	377.5	331	156	37	7	0.26	0.38
DIII-13-OB-98	06/13/01	25	6.24	10.0	380.5	272	148	11	5	3.91	0.39
DIII-13-OB-98	09/06/01	23	5.61	12.1	378.4	279	160	110	6	6.31	0.29
DIII-13-OB-98	12/11/01	20	6.10	12.3	378.2	211	114	20	6	0.04	0.20
DIII-13-OB-98	02/21/02	19	5.82	10.8	379.7	174.7	105	36	5	0.52	0.14
DIII-13-OB-98	06/10/02	21	6.33	12.0	378.5	181	170	13	12	1.44	0.10
DIII-13-OB-98	11/18/02	22	5.82	15.5	375.0	148.1	130	29	6	0.49	0.15
DIII-13-OB-98	01/16/03	20	5.56	10.1	380.4	112.6	70	25	11	1.76	0.20
DIII-13-OB-98	09/10/03	21	5.24	14.6	375.9	128.8	62	<1	10	0.43	0.11
DIII-13-OB-98	12/17/03	21	5.11	16.7	373.8	133.8	110	5	11	0.68	0.11
DIII-13-OB-98	01/14/04	20	5.39	16.5	374.0	169.6	96	10	10	0.28	0.08
DIII-13-OB-98	05/03/04	20	4.73	5.5	385.0	89.4	88	26	12	0.06	0.08
DIII-13-OB-98	08/04/04	21	4.39	12.0	378.5	111.9	72	26	18	0.21	0.07
DIII-13-OB-98	11/09/04	20	4.76	8.5	382.0	108.4	82	8	14	0.22	0.04
DIII-13-OB-98	03/04/05	18	4.60	7.2	383.3	71.3	58	7	9	<0.006	<0.003
DIII-13-OB-98	04/19/05	19	4.61	7.1	383.4	70.9	78	6	11	0.62	0.05
DIII-13-OB-98	09/02/05	24	5.72	16	374.5	84.1	80	35	13	0.19	0.04

DIII-13-OB-98	10/19/05	22	5.49	17.1	373.4	99.2	108	7	13	0.06	0.04
DIII-13-OB-98	02/24/06	15	6.67	18.7	371.8	229	83	10	12	1.62	0.07
DIII-13-OB-98	06/02/06	22	5.46	17.2	373.3	116.8	118	28	13	0.09	0.04
DIII-13-OB-98	09/08/06	20	4.98	19.7	370.8	108.5	78	18	20	0.19	0.04
DIII-13-OB-98	11/30/06	21	5.12	21	369.5	42.7	70	30	5	0.15	0.02
DIII-13-OB-98	02/08/07	15	5.29	11.9	378.6	104.7	82	15	8	0.40	0.04
DIII-13-OB-98	05/31/07	20	4.73	8.8	381.7	87.3	86	<1	10	0.04	0.02
DIII-13-OB-98	08/24/07	20	5.02	12.4	378.1	91.9	88	<1	10	0.38	0.03
DIII-13-OB-98	10/11/07	21	4.87	17	373.5	97.2	76	2	11	0.29	0.04
DIII-13-OB-98	02/29/08	19	5.44	18.5	372.0	98	64	1	10	0.08	0.02
DIII-13-OB-98	05/07/08	20	4.88	8.4	382.1	100.4	110	<1	12	0.26	0.02
DIII-13-OB-98	07/10/08		5.22	15.7	374.8	107.4	246	<1	10	0.12	0.03
DIII-13-OB-98	12/17/08	13	5.07	15	375.5	577	472	250	6	36.70	1.18
DIII-13-OB-98	02/05/09	18	5.06	17.6	372.9	132.9	114	1	8	0.06	0.03
DIII-13-OB-98	06/12/09	20	4.68	16.1	374.4	102.8	80	<1	10	0.03	0.01
DIII-13-OB-98	08/18/09	22	4.91	19.6	370.9	99.2	82	<1	9	0.07	0.01
DIII-13-OB-98	12/11/09	19	4.65	8.7	381.8	86.7	120	100	6	0.09	0.01
DIII-13-OB-98	03/18/10		4.58	7.4	383.1	82.1	116	32	6	<0.01	0.023
DIII-13-OB-98	04/27/10	20.5	4.53	9.4		81.4	80	15	9	0.389	0.015
DIII-13-OB-98	07/15/10	22.5	4.64	17.18		108.4	80	36	8	0.055	0.022
DIII-13-OB-98	10/15/10	21.5	4.89	21.7		451	316	185	19	60.6	0.432
DIII-13-OB-98	03/01/11	21	5.10	21.4		107.9	100	6	7	0.029	0.019
DIII-13-OB-98	04/15/11	21.5	4.99	22.4		91.9	76	22	8	0.101	0.018
DIII-13-OB-98	09/08/11	24.5	5.74	27.1		81.9	70	19	9	0.114	0.015
DIII-13-OB-98	02/02/12	21	5.42	26.8		407	304	160	16	51.43	0.403
DIII-13-OB-98	05/17/12	21	5.28	19.5		108.1	72	27	8	0.193	0.017

DIII-15(Alluv)-04	03/10/05	16	4.90	6.2	300.8	84.2	108	45	8	1.30	0.06
DIII-15(Alluv)-04	04/19/05	19	4.08	5.6	301.4	60.6	72	11	9	1.05	0.03
DIII-15(Alluv)-04	09/06/05	23.5	5.07	5.5	301.5	63.1	78	5	10	0.10	0.02
DIII-15(Alluv)-04	10/19/05	21.5	4.75	5.2	301.8	50.3	74	22	9	0.12	0.01
DIII-15(Alluv)-04	02/24/06	15.5	4.79	4.8	302.2	61.2	148	8	12	0.06	0.01
DIII-15(Alluv)-04	06/02/06	21	4.32	5.2	301.8	69.6	80	6	17	0.53	0.01
DIII-15(Alluv)-04	09/08/06	21	3.61	6.7	300.3	67.1	84	6	17	0.32	0.01
DIII-15(Alluv)-04	11/30/06	20	3.60	5.4	301.6	65.7	72	16	15	1.06	0.02
DIII-15(Alluv)-04	02/08/07	18	3.59	5.1	301.9	48.8	72	10	5	0.22	0.03
DIII-15(Alluv)-04	05/31/07	19	3.97	5	302.0	59.4	70	2	11	0.29	0.01
DIII-15(Alluv)-04	08/24/07	23	4.34	5.3	301.7	60.1	96	1	10	0.18	0.01
DIII-15(Alluv)-04	10/11/07	24	3.35	5.2	301.8	97.2	88	12	4	0.69	0.02
DIII-15(Alluv)-04	02/29/08	17	4.07	5	302.0	70	70	9	11	0.15	0.01
DIII-15(Alluv)-04	05/08/08	19	4.03	4.9	302.1	71.5	68	6	12	0.10	0.01
DIII-15(Alluv)-04	07/10/08		4.23	5.4	301.6	77.4	40	5	9	0.83	0.02
DIII-15(Alluv)-04	12/17/08	18	4.12	4.8	302.2	81.1	82	4	12	0.35	0.02
DIII-15(Alluv)-04	02/05/09	19	4.04	5	302.0	90.3	100	8	10	0.32	0.03
DIII-15(Alluv)-04	06/12/09	21	3.75	5	302.0	93.8	68	7	13	0.07	0.01
DIII-15(Alluv)-04	08/19/09	22	3.81	5.2	301.8	126.3	40	4	11	0.67	0.04
DIII-15(Alluv)-04	12/10/09	19	4.48	4.7	302.3	191.9	82	48	17	1.17	0.05
DIII-15(Alluv)-04	03/18/10		3.90	4.6	302.4	119.1	118	5.4	29	0.029	0.019
DIII-15(Alluv)-04	04/27/10	20.5	3.91	4.89		154.6	160	9	34	0.458	0.023
DIII-15(Alluv)-04	07/15/10	23.5	3.54	5.05		187.3	134	2	43	0.13	0.023
DIII-15(Alluv)-04	10/15/10	24	3.36	5.3		144.9	106	12	25	0.156	0.019
DIII-15(Alluv)-04	03/01/11	17.5	4.49	4.9		260	168	4	58	0.296	0.038
DIII-15(Alluv)-04	04/15/11	19.5	4.44	4.3		256	164	7	64	1.302	0.048

DIII-15(Alluv)-04	09/08/11	23.5	4.18	7		248	156	7	61	1.214	0.028
DIII-15(Alluv)-04	11/03/11	21.5	4.17	5.8		315	212	10	89	0.315	0.041
DIII-15(Alluv)-04	02/02/12	21	4.01	4.9		414	234	16	104	0.67	0.071
DIII-15(Alluv)-04	05/17/12	22	4.10	5.2		480	244	23	115	0.266	0.06
DIII-1-OB2	06/26/96		4.58	69.2	370.3	45.4	69	13	6		
DIII-1-OB2	07/12/96		4.67	59.1	380.4	49	58	11	6		
DIII-1-OB2	10/17/96		4.31	59.5	380.0	45.9	60	16	6		
DIII-1-OB2	03/06/97		4.55	58.0	381.5	52.2	65	7	6		
DIII-1-OB2	05/23/97		4.41	56.4	383.1	55.5	70	9	7		
DIII-1-OB2	07/09/97		4.90	56.7	382.8	42.5	55	9	6		
DIII-1-OB2	10/29/97		4.71	58.0	381.5	182	66	8	6		
DIII-1-OB2	03/06/98		3.70	55.7	383.8	50	44	7	6		
DIII-1-OB2	05/21/98	21	3.78	55.9	383.6	53	77	7	6		
DIII-1-OB2	09/11/98		3.36	65.6	373.9	170	114	30	20		
DIII-1-OB2	10/27/98		3.59	66.8	372.7	210	136	34	25		
DIII-1-OB2-R-99	11/16/99	20	4.92	67.1	372.4	280	152	78	14	23.90	0.66
DIII-1-OB2-R-99	01/19/00	19	4.63	66.7	372.8	260	184	76	14	20.00	0.64
DIII-1-OB2-R-99	06/09/00	22	3.85	65.5	374.0	248	170	50	19	6.88	0.36
DIII-1-OB2-R-99	07/20/00	21	3.45	65.1	374.4	281	92	35	17	3.93	0.28
DIII-1-OB2-R-99	12/04/00	20	4.69	64.0	375.5	530	120	200	18	20.10	0.25
DIII-1-OB2-R-99	02/20/01	22	4.68	63.6	375.9	146	112	135	16	19.00	0.21
DIII-1-OB2-R-99	06/13/01	21	3.48	61.1	378.4	189.7	76	51	12	9.23	0.17
DIII-1-OB2-R-99	09/06/01	22	4.13	59.7	379.8	173	6	135	12	15.86	0.16
DIII-1-OB2-R-99	12/11/01	20	3.45	59.0	380.5	183.5	58	56	10	6.02	0.14
DIII-1-OB2-R-99	02/21/02	20	4.00	58.6	380.9	157.8	98	120	9	15.35	0.16
DIII-1-OB2-R-99	06/10/02	21	4.34	57.2	382.3	173.6	106	47	10	18.72	0.18
DIII-1-OB2-R-99	07/25/02	21	4.30	57.1	382.4	169.4	102	90	9	15.95	0.15
DIII-1-OB2-R-99	11/18/02	21	4.27	54.6	384.9	218	168	55	12	22.68	0.24
DIII-1-OB2-R-99	01/16/03	20	4.55	57.3	382.2	242	140	125	7	28.23	0.25
DIII-1-OB2-R-99	05/27/03	21	4.23	56.3	383.2	214	160	60	14	0.05	0.04
DIII-1-OB2-R-99	09/10/03	22	4.31	56.4	383.1	239	138	56	12	28.68	0.26

DIII-1-OB2-R-99	12/17/03	21	4.41	57.2	382.3	314	224	120	15	36.73	0.34
DIII-1-OB2-R-99	01/14/04	20	4.21	57.0	382.5	328	184	115	15	42.35	0.36
DIII-1-OB2-R-99	05/03/04	21	4.28	56.6	382.9	425	296	160	14	60.20	0.59
DIII-1-OB2-R-99	08/04/04	21	3.63	56.1	383.4	460	338	160	19	64.50	0.51
DIII-1-OB2-R-99	11/09/04	19	4.55	56.6	382.9	485	320	220	18	60.30	0.44
DIII-1-OB2-R-99	03/10/05	19	4.01	55.6	383.9	482	168	9	20	65.40	0.54
DIII-1-OB2-R-99	04/20/05	20	4.71	55.2	384.3	496	376	230	25	2.82	0.93
DIII-1-OB2-R-99	09/06/05	20	5.05	55.9	383.6	398	296	125	20	47.50	0.41
DIII-1-OB2-R-99	10/20/05	20	5.04	56	383.5	405	318	115	20	51.80	0.41
DIII-1-OB2-R-99	02/24/06	20	5.00	57.1	382.4	487	344	235	26	54.20	0.49
DIII-1-OB2-R-99	06/05/06	22	4.61	57.5	382.0	561	428	225	27	58.20	0.52
DIII-1-OB2-R-99	09/11/06	21	4.47	58.3	381.2	632	576	295	27	76.80	0.78
DIII-1-OB2-R-99	12/01/06	20	4.98	59.1	380.4	682	558	340	20	111.00	0.78
DIII-1-OB2-R-99	02/08/07	20	4.53	60.4	379.1	655	612	360	20	117.00	0.97
DIII-1-OB2-R-99	06/01/07	21	4.26	58.4	381.1	502	476	210	20	76.40	0.60
DIII-1-OB2-R-99	08/24/07	20	4.59	58.1	381.4	443	448	175	20	69.50	0.53
DIII-1-OB2-R-99	10/11/07	22	4.43	58.2	381.3	451	476	140	18	67.50	0.49
DIII-1-OB2-R-99	02/29/08	21	4.80	58.9	380.6	611	426	265	20	81.20	0.06
DIII-1-OB2-R-99	05/08/08	20	4.45	58.2	381.3	452	374	150	22	61.70	0.50
DIII-1-OB2-R-99	07/10/08		4.60	58.2	381.3	505	390	210	18	68.30	0.56
DIII-1-OB2-R-99	12/17/08	20	4.71	58.7	380.8	506	404	155	20	65.00	0.52
DIII-1-OB2-R-99	02/05/09	20	4.31	59.2	380.3	518	392	190	22	55.00	0.49
DIII-1-OB2-R-99	06/15/09	20	4.50	58.5	381.0	472	362	200	21	52.00	0.46
DIII-1-OB2-R-99	08/19/09	22	4.41	58.7	380.8	475	394	132	17	56.30	0.45
DIII-1-OB2-R-99	12/11/09	20	4.38	58.8	380.7	446	328	129	18	51.10	0.48
DIII-1-OB2-R-99	03/22/10		5.72	57.9	381.6	259	180	127	10	11.5	0.226

DIII-1-OB2-R-99	04/26/10	21.5	4.49	57.45		477	404	170	16	60	0.495
DIII-1-OB2-R-99	07/15/10	21.5	4.64	57.61		408	356	145	20	42.8	0.406
DIII-1-OB2-R-99	10/15/10	21	4.50	58.1		453	396	185	19	61.2	0.451
DIII-1-OB2-R-99	03/02/11	22	4.94	58.9		427	314	195	17	64.47	0.473
DIII-1-OB2-R-99	04/15/11	21.5	4.61	58.9		450	448	210	18	53.88	0.469
DIII-1-OB2-R-99	09/08/11	21.5	5.00	59.9		492	344	260	19	62.48	0.539
DIII-1-OB2-R-99	11/03/11	21.5	5.07	60.3		530	378	260	20	72.98	0.551
DIII-1-OB2-R-99	02/02/12	20	4.95	60.7		579	448	240	19	81.68	0.581
DIII-1-OB2-R-99	05/17/12	21	4.90	60.1		485	380	210	18	37.37	0.496
DIII-1-UB	06/26/96		6.24	67.8	372.7	160.3	131	26	5		
DIII-1-UB	07/12/96		6.38	68.0	372.5	166.4	133	20	4		
DIII-1-UB	10/17/96		6.24	68.2	372.3	179.7	156	53	5		
DIII-1-UB	03/06/97		6.20	66.3	374.2	161.8	147	20	4		
DIII-1-UB	05/23/97		6.20	65.4	375.1	149.8	133	29	4		
DIII-1-UB	07/09/97		6.15	65.7	374.8	155.4	149	23	4		
DIII-1-UB	10/29/97		6.23	66.6	373.9	158	152	21	4		
DIII-1-UB	03/06/98		6.02	85.0	355.5	160	134	23	4		
DIII-1-UB	05/21/98	21	6.01	65.1	375.4	159	138	18	4		
DIII-1-UB	09/11/98		5.60	70.2	370.3	159	137	20	4		
DIII-1-UB	10/28/98		6.39	69.4	371.1	171	149	18	4		
DIII-1-UB-R-99	11/16/99	20	6.03	68.1	371.4	383	413	94	12	2.62	1.78
DIII-1-UB-R-99	01/19/00	19	6.32	67.6	371.9	282	183	42	8	1.05	1.12
DIII-1-UB-R-99	06/09/00	20	6.28	66.2	373.3	211	182	29	7	0.72	0.80
DIII-1-UB-R-99	07/20/00	21	5.80	69.5	370.0	180	101	27	7	0.07	0.41
DIII-1-UB-R-99	12/04/00	20	5.53	65.6	373.9	241	182	61	8	7.18	0.42
DIII-1-UB-R-99	02/20/01	24	5.52	64.2	375.3	239	122	46	8	6.92	0.35
DIII-1-UB-R-99	06/13/01	22	5.66	61.6	377.9	175.3	98	28	11	1.13	0.30
DIII-1-UB-R-99	09/06/01	21	5.66	60.3	379.2	205	86	18	8	3.94	0.47
DIII-1-UB-R-99	12/11/01	20	5.82	59.7	379.8	169	114	64	6	4.21	0.21
DIII-1-UB-R-99	02/21/02	20	5.60	59.2	380.3	193	151	48	8	1.65	0.19
DIII-1-UB-R-99	06/10/02	21	5.53	57.6	381.9	188.1	116	25	8	3.31	0.25

DIII-1-UB-R-99	07/25/02	21	5.48	57.8	381.7	205	136	75	7	4.68	0.21
DIII-1-UB-R-99	11/18/02	22	5.52	58.3	381.2	184.6	150	38	5	2.57	0.21
DIII-1-UB-R-99	01/16/03	20	5.51	57.9	381.6	184.6	144	23	8	2.16	0.20
DIII-1-UB-R-99	05/30/03	21	5.40	59.0	380.5	180.6	122	32	10	0.30	0.18
DIII-1-UB-R-99	09/10/03	21	5.13	57.0	382.5	231	124	15	10	7.84	0.24
DIII-1-UB-R-99	12/17/03	21	5.30	57.7	381.8	196.7	154	31	8	2.09	0.20
DIII-1-UB-R-99	05/03/04	21	5.42	57.1	382.4	215	158	29	10	6.49	0.24
DIII-1-UB-R-99	08/04/04	21	4.90	56.8	382.7	220	124	43	11	6.51	0.19
DIII-1-UB-R-99	11/09/04	18	5.52	57.3	382.2	186	142	32	11	1.63	0.14
DIII-1-UB-R-99	04/20/05	19	5.66	55.7	383.8	181.9	160	32	10	3.11	0.25
DIII-1-UB-R-99	09/06/05	21	6.10	56.5	383.0	198	158	29	13	6.53	0.16
DIII-1-UB-R-99	10/20/05	21	5.87	55.7	383.8	198	174	23	11	6.45	0.17
DIII-1-UB-R-99	02/24/06	20.5	5.87	57.8	381.7	173.5	130	32	10	2.08	0.16
DIII-1-UB-R-99	06/05/06	22	5.68	58.2	381.3	255	164	37	15	8.35	0.16
DIII-1-UB-R-99	09/11/06	20	5.38	58.9	380.6	209	172	32	15	10.70	0.17
DIII-1-UB-R-99	12/01/06	18	6.05	59.5	380.0	190.3	126	31	10	11.50	0.14
DIII-1-UB-R-99	02/08/07	20	5.49	59.5	380.0	222	198	16	10	12.20	0.24
DIII-1-UB-R-99	06/01/07	20	5.33	58.9	380.6	210	172	23	9	12.10	0.18
DIII-1-UB-R-99	08/24/07	21	5.52	58.6	380.9	187.2	172	10	10	1.42	0.14
DIII-1-UB-R-99	10/11/07	22	5.47	58.6	380.9	210	186	21	6	9.47	0.19
DIII-1-UB-R-99	02/29/08	22	5.64	59.3	380.2	211	154	32	10	3.01	9.50
DIII-1-UB-R-99	05/08/08	20	5.43	58.5	381.0	182.6	124	21	10	1.34	0.17
DIII-1-UB-R-99	07/10/08		5.62	58.7	380.8	200	134	25	6	3.58	0.18
DIII-1-UB-R-99	12/17/08	19	5.45	59.4	380.1	263	190	35	11	15.00	0.21
DIII-1-UB-R-99	02/05/09	20	5.34	59.6	379.9	250	190	30	10	7.87	0.20
DIII-1-UB-R-99	06/15/09	22	5.44	59	380.5	246	162	33	6	9.48	0.20

DIII-1-UB-R-99	08/19/09	22	5.33	59.2	380.3	248	134	3	9	11.10	0.18
DIII-1-UB-R-99	12/11/09	20	5.25	58.9	380.6	239	178	39	10	8.29	0.20
DIII-1-UB-R-99	03/22/10		4.82	58.2	381.3	451	332	220	17	13.2	0.491
DIII-1-UB-R-99	04/27/10	22	5.41		57.92	256	204	41	9	14	0.219
DIII-1-UB-R-99	07/16/10	22.5	5.22		58.11	261	150	33	12	12.6	0.208
DIII-1-UB-R-99	10/15/10	21	5.64		58.6	263	182	39	11	15.8	0.218
DIII-1-UB-R-99	03/02/11	21	5.70		106.5	271	184	47	10	21.97	0.244
DIII-1-UB-R-99	04/15/11	21.5	5.15		59.4	277	180	39	14	9.168	0.24
DIII-1-UB-R-99	09/08/11	22	5.92		60.5	201	154	31	10	0.347	0.177
DIII-1-UB-R-99	11/03/11	21	6.06		60.6	231	140	36	9	8.198	0.214
DIII-1-UB-R-99	02/02/12	19	5.86	61.2		252	168	36	11	9.08	0.21
DIII-1-UB-R-99	05/17/12	21	5.74	60.5		244	170	41	9	9.548	0.21
DIII-3-OB	06/26/96		4.81	27.6	385.0	32.5	55	11	3		
DIII-3-OB	07/12/96		4.70	27.8	384.8	58.8	53	17	3		
DIII-3-OB	10/21/96		4.79	28.2	384.4	44	68	22	3		
DIII-3-OB	03/06/97		4.95	16.8	395.8	27.8	50	8	3		
DIII-3-OB	05/23/97		4.90	20.6	392.0	26.1	59	25	4		
DIII-3-OB	07/10/97		4.69	23.7	388.9	27.9	91	5	6		
DIII-3-OB	10/29/97		5.25	26.2	386.4	124	78	13	3		
DIII-3-OB	03/06/98		4.76	16.9	395.7	28.7	25	6	4		
DIII-3-OB	05/21/98	20	5.33	23.0	389.6	43	58	2	3		
DIII-3-OB	09/11/98		4.18	26.3	386.3	34	41	7	4		
DIII-3-OB	10/28/98		6.16	26.6	386.0	290	213	43	5		
DIII-3-OB	02/03/99		4.27	15.0	397.7	33.6	61	17	4		
DIII-3-OB	04/21/99		4.01	16.3	396.3	30	52	5	3		
DIII-3-OB	08/23/99	19	4.12	24.4	388.2	38	54	12	4	0.05	0.05
DIII-3-OB	11/16/99	20	6.35	26.1	386.5	37	27	10	9	0.11	0.05
DIII-3-UB	06/26/96		6.66	64.9	347.7	337	265	45	6		
DIII-3-UB	07/12/96		6.68	65.2	347.4	363	362	60	7		
DIII-3-UB	10/21/96		6.68	65.3	347.3	303	330	88	10		
DIII-3-UB	03/06/97		6.47	62.5	350.1	287	227	42	5		
DIII-3-UB	05/23/97		6.55	61.4	351.2	294	229	50	6		
DIII-3-UB	07/10/97		6.76	62.5	350.1	291	251	58	6		
DIII-3-UB	10/29/97		6.71	64.3	348.3	247	246	47	6		
DIII-3-UB	03/06/98		6.26	63.9	348.7	348	231	52	6		
DIII-3-UB	05/21/98	20	6.05	62.6	350.0	318	236	43	5		
DIII-3-UB	09/11/98		6.16	64.9	347.7	303	234	47	5		
DIII-3-UB	10/28/98		4.42	64.7	347.9	27	61	2	3		

DIII-3-UB	02/03/99		6.25	62.6	350.0	418	215	79	7		
DIII-3-UB	04/21/99		6.24	62.0	350.6	306	193	50	6		
DIII-3-UB	08/23/99	21	6.15	63.8	348.8	295	190	42	5	0.05	0.05
DIII-3-UB	11/16/99	19	6.05	66.1	346.5	304	182	46	5	0.05	0.05
DIII-5-OB2	06/26/96		3.78	68.0	360.6	90.4	60	15	5		
DIII-5-OB2	07/12/96		4.05	68.0	360.6	99.7	65	14	5		
DIII-5-OB2	10/17/96		3.88	68.6	360.0	97.8	70	16	5		
DIII-5-OB2	03/06/97		3.58	69.9	358.7	98.5	68	14	5		
DIII-5-OB2	05/23/97		4.02	68.5	360.1	99.5	66	15	5		
DIII-5-OB2	07/10/97		3.89	68.1	360.5	94.5	61	14	5		
DIII-5-OB2	03/06/98		3.40	68.3	360.3	74.3	56	11	5		
DIII-5-OB2	05/21/98	21	3.70	67.6	361.0	79	65	14	5		
DIII-5-OB2	09/11/98		3.09	68.0	360.6	97	67	14	5		
DIII-5-OB2	10/28/98		3.16	68.4	360.2	96	80	12	5		
DIII-5-OB2	02/03/99		3.27	67.7	360.9	97	87	13	5		
DIII-5-OB2	04/21/99		3.24	67.0	361.6	103	75	11	5		
DIII-5-OB2	08/23/99	21	3.34	75.4	353.2	94	64	10	5	0.05	0.05
DIII-5-OB2	11/15/99	22	5.76	76.5	352.1	109	98	13	5	0.05	0.05
DIII-5-OB2	01/19/00	20	3.12	78.5	350.1	91	70	11	4	0.12	0.05
DIII-5-OB2	06/08/00	21	4.09	83.8	344.8	81	59	15	5	0.24	0.03
DIII-5-OB2	07/20/00	21	3.37	85.0	343.6	95.2	17	12	6	0.08	0.01
DIII-5-OB2	11/30/00	20	4.09	88.6	340.0	102.2	52	20	5	0.52	0.08
DIII-5-OB2	02/09/01	18	4.26	89.4	339.2	66.6	100	35	7	3.81	0.04
DIII-5-OB2	06/04/01	22	3.76	91.0	337.6	92.9	206	5	26	0.04	0.02
DIII-5-OB2-R-03	09/10/03	22	2.84	75.7	355.8	1180	1018	1050	4	47.72	0.50
DIII-5-OB2-R-03	12/01/03	21	2.75	75.3	356.2	935	690	550	5	6.83	0.29
DIII-5-OB2-R-03	01/14/04	20	2.84	75.0	356.5	692	380	150	6	4.41	0.21
DIII-5-OB2-R-03	08/04/04	22	1.71	74.2	357.3	1022	642	625	6	7.53	0.24
DIII-5-OB2-R-03	11/09/04	19	2.61	73.7	357.8	888	446	425	9	3.88	0.14
DIII-5-OB2-R-03	03/08/05	19	2.47	72.9	358.6	1033	558	425	7	7.58	0.21
DIII-5-OB2-R-03	04/19/05	18	2.88	72.5	359.0	257	116	51	4	1.29	0.04
DIII-5-OB2-R-03	09/02/05	21	3.95	71.9	359.6	294	164	100	6	1.61	0.08
DIII-5-OB2-R-03	10/19/05	22	3.69	71.8	359.7	198	132	10	7	0.29	0.04
DIII-5-OB2-R-03	02/24/06	17.5	3.88	72.1	359.4	175.6	216	47	10	0.35	0.03
DIII-5-OB2-R-03	06/02/06	21	3.38	72.2	359.3	186.3	136	43	8	0.06	0.04
DIII-5-OB2-R-03	09/11/06	21	6.55	72.4	359.1	1142	904	475	26	0.05	0.32
DIII-5-OB2-R-03	11/30/06	18	3.78	72.6	358.9	115.6	100	71	5	5.64	0.08

DIII-5-OB2-R-03	02/08/07	19	3.15	72.8	358.7	142.1	80	7	5	0.68	1.76
DIII-5-OB2-R-03	06/01/07	21	3.14	72.3	359.2	154.7	110	37	4	1.79	0.05
DIII-5-OB2-R-03	08/24/07	22	5.13	71.4	360.1	95.4	100	<1	10	0.63	0.03
DIII-5-OB2-R-03	10/11/07	20	3.81	71.3	360.2	62.2	90	1	11	0.45	0.01
DIII-5-OB2-R-03	02/29/08	20	3.14	70.7	360.8	349	180	120	5	1.57	4.79
DIII-5-OB2-R-03	05/08/08	20	3.12	71.1	360.4	440	300	170	6	1.01	0.22
DIII-5-OB2-R-03	07/10/08		3.00	71.2	360.3	522	386	195	4	0.64	0.30
DIII-5-OB2-R-03	12/17/08	20	3.34	71.8	359.7	152.8	62	22	3	0.60	0.03
DIII-5-OB2-R-03	02/05/09	20	3.06	72.3	359.2	102.6	96	13	6	0.28	0.02
DIII-5-OB2-R-03	06/12/09	22	2.83	72.5	359.0	812	702	470	3	0.66	0.44
DIII-5-OB2-R-03	08/19/09	21	2.80	72.7	358.8	1130	1112	485	4	0.95	0.50
DIII-5-OB2-R-03	12/11/09	20	2.87	72.8	358.7	1163	1058	618	4	1.00	0.80
DIII-5-OB2-R-03	03/22/10		2.93	72.2	359.3	866	616	296	4	0.691	0.496
DIII-5-OB2-R-03	04/27/10	15	2.85	72.08		853	652	460	5	1.03	0.387
DIII-5-OB2-R-03	07/15/10	23	2.69	71.75		845	628	280	6	0.762	0.312
DIII-5-OB2-R-03	10/15/10	22.5	2.55	71.9		1255	1034	700	5	1.52	0.767
DIII-5-OB2-R-03	03/02/11	22	3.09	72.4		1316	908	640	3	1.8	0.609
DIII-5-OB2-R-03	04/15/11	21.5	2.59	72.4		1334	1424	780	7	1.555	0.612
DIII-5-OB2-R-03	09/08/11	22	3.18	73.1		1135	726	560	8	1.25	0.435
DIII-5-OB2-R-03	11/03/11	21.5	3.20	73.3		1426	1024	820	14	2.065	0.533
DIII-5-OB2-R-03	02/02/12	21	2.89	73.5		1844	1868	1100	11	5.135	0.794
DIII-5-OB2-R-03	05/17/12	22	2.94	78.3		2060	1710	1000	6	8.977	0.728
DIII-6-OB	01/20/00	20	5.23	55.7	375.0	253	178	71	7	14.80	0.18
DIII-6-OB	06/09/00	21	6.28	53.3	377.4	340	224	50	8	0.22	0.32
DIII-6-OB	07/20/00	21	5.90	53.9	376.8	312	188	115	5	19.10	0.19
DIII-6-OB	11/30/00	20	6.04	55.5	375.2	293	184	135	6	21.25	0.23
DIII-6-OB	02/09/01	20	5.87	51.4	379.3	304	224	85	7	30.55	0.19
DIII-6-OB	06/13/01	22	5.77	50.5	380.2	317	154	100	4	20.42	0.18
DIII-6-OB	09/06/01	22	5.56	52.3	378.4	333	172	150	7	19.40	0.18
DIII-6-OB	12/11/01	20	5.98	52.8	377.9	351	192	105	6	13.48	0.20

DIII-6-OB	02/21/02	19	5.84	51.0	379.7	358	181	125	6	22.87	0.18
DIII-6-OB	06/10/02	21	5.68	51.6	379.1	339	182	95	7	28.17	0.22
DIII-6-OB	07/25/02	21	5.54	53.0	377.7	332	188	90	5	20.23	0.17
DIII-6-OB	11/18/02	22	5.70	55.3	375.4	327	216	135	5	20.88	0.19
DIII-6-OB	01/16/03	20	5.64	53.1	377.6	320	162	64	6	21.91	0.20
DIII-6-OB	05/30/03	21	5.39	52.2	378.5	330	176	105	8	19.50	0.18
DIII-6-OB	09/10/03	21	5.50	57.0	373.7	319	164	48	5	19.39	0.19
DIII-6-OB	12/17/03	21	5.66	55.4	375.3	314	172	85	7	15.77	0.18
DIII-6-OB	01/14/04	22	5.31	55.6	375.1	300	128	80	9	16.16	0.19
DIII-6-OB	05/03/04	21	5.59	52.1	378.6	325	168	95	6	23.03	0.22
DIII-6-OB	08/04/04	21	5.08	53.1	377.6	311	226	90	9	18.62	0.17
DIII-6-OB	11/10/04	19	5.58	54.2	376.5	328	176	105	7	20.47	0.14
DIII-6-OB	03/10/05	20	5.68	50.1	380.6	307	186	29	7	19.11	0.10
DIII-6-OB	04/20/05	20	5.82	50.1	380.6	296	244	120	8	20.80	0.26
DIII-6-OB	09/06/05	21	6.14	54	376.7	313	212	75	7	18.70	0.17
DIII-6-OB	10/20/05	21	6.08	54.7	376.0	280	166	95	7	14.60	0.15
DIII-6-OB	02/24/06	18	6.38	55.7	375.0	265	208	105	7	18.10	0.17
DIII-6-OB	06/05/06	21	5.82	56.2	374.5	310	210	85	11	15.80	0.15
DIII-6-OB	09/11/06	20	5.46	63.3	367.4	327	210	75	12	13.10	0.23
DIII-6-UB	01/20/00	18	7.21	77.7	351.8	1279	928	540	22	0.05	0.22
DIII-6-UB	06/09/00	21	7.18	77.9	351.6	1319	942	500	22	20.18	0.19
DIII-6-UB	07/20/00	21	7.07	77.9	351.6	1289	895	550	22	0.23	0.34
DIII-6-UB	11/30/00	21	7.05	78.1	351.4	1139	232	80	15	1.23	0.41
DIII-6-UB	02/09/01	17	6.86	77.8	351.7	1140	918	750	22	2.60	0.36
DIII-6-UB	06/13/01	24	6.73	76.4	353.1	1229	1152	75	18	1.24	0.34
DIII-6-UB	09/06/01	21	6.71	76.9	352.6	1269	888	625	23	3.34	0.33
DIII-6-UB	12/11/01	19	6.88	76.0	353.5	1139	842	500	19	2.66	0.35
DIII-6-UB	02/21/02	20	6.71	76.0	353.5	1189	904	475	20	3.79	0.35
DIII-6-UB	06/10/02	21.5	6.83	75.5	354.0	1232	854	650	20	3.87	0.39
DIII-6-UB	07/25/02	21.5	6.62	75.3	354.2	1225	870	1000	20	3.43	0.32
DIII-6-UB	11/18/02	20	6.78	76.5	353.0	1182	814	800	18	2.68	0.34
DIII-6-UB	01/16/03	20	7.00	76.5	353.0	1175	856	550	20	3.72	0.34
DIII-6-UB	05/30/03	22	6.70	75.7	353.8	1191	860	800	22	3.29	0.33
DIII-6-UB	09/10/03	21	6.62	76.2	353.3	1193	824	725	19	2.48	0.35
DIII-6-UB	12/17/03	21	6.82	76.9	352.6	1185	860	575	20	4.35	0.35
DIII-6-UB	01/14/04	21	6.65	77.1	352.4	1221	880	425	20	3.11	0.34
DIII-6-UB	05/03/04	20	6.80	76.8	352.7	1243	898	550	7	5.17	0.42
DIII-6-UB	08/04/04	20	6.55	76.8	352.7	1234	862	650	21	3.18	0.30
DIII-6-UB	11/10/04	20	6.92	78.1	351.4	1256	884	725	23	4.30	0.27
DIII-6-UB	04/20/05	21	6.98	77.4	352.1	1140	900	575	21	5.04	0.47
DIII-6-UB	09/06/05	21	7.10	79.4	350.1	1109	846	500	23	3.11	0.29
DIII-6-UB	10/20/05	21	6.99	79.5	350.0	1104	854	525	20	3.10	0.29
DIII-6-UB	02/24/06	20	7.04	51.4	378.1	986	850	675	21	4.75	0.29
DIII-6-UB	06/05/06	21	7.00	82.8	346.7	1168	900	525	24	3.13	0.26
DIII-6-UB	09/11/06	21	6.57	87.3	342.2	1151	884	450	27	2.56	0.33
DIII-7-UB	03/26/04	20	5.25	17.5	353.9	125.3	172	21	7	0.15	0.15
DIII-7-UB	05/04/04	21	5.25	17.2	354.2	133.8	138	27	6	0.30	0.17
DIII-7-UB	08/04/04	21	4.48	18.2	353.2	132.2	100	39	8	0.34	0.14

DIII-7-UB	11/10/04	19	5.75	18	353.4	143.8	124	28	8	4.68	0.59
DIII-7-UB	03/04/05	16	5.13	16.9	354.5	113.5	118	32	8	<0.006	<0.003
DIII-7-UB	04/20/05	19	5.77	16.8	354.6	128	154	30	9	0.13	0.03
DIII-7-UB	09/06/05	20	5.92	19.3	352.1	119.5	146	37	9	0.46	0.52
DIII-7-UB	10/20/05	21	4.06	19	352.4	66.3	98	9	7	1.38	0.04
DIII-7-UB	02/24/06	21	7.00	18	353.4	984	878	625	20	3.93	0.29
DIII-7-UB	06/05/06	25	5.78	17.1	354.3	117	144	52	11	0.39	0.12
DIII-7-UB	09/11/06	23	5.24	18.1	353.3	244	214	41	17	13.50	0.22
DIII-7-UB	12/01/06	17	3.93	17.4	354.0	50.4	34	14	5	0.16	0.03
DIII-7-UB	02/08/07	20	5.21	16.1	355.3	110.8	130	16	7	0.60	0.09
DIII-7-UB	06/01/07	21	5.18	16.5	354.9	134.8	120	17	4	0.13	0.05
DIII-7-UB	08/24/07	20	5.18	16.4	355.0	126.4	154	20	5	1.14	0.49
DIII-7-UB	10/11/07	21	4.77	18.5	352.9	98.3	118	20	5	0.44	0.18
R-16(S)	02/10/99	20	4.23	14.6	411.2	721	562	364	7	4.94	2.44
R-16(S)	11/12/99	16.1	4.13	16.1	409.6	1099	836	527	9	48.00	4.02
R-16(S)	01/12/00	21	3.89	16.9	408.8	1140	1068	655	7	68.20	5.69
R-16(S)	06/07/00	22	5.52	16.9	408.8	141	100	100	15	1.98	0.12
R-16(S)	07/17/00	21	3.63	16.6	409.1	1651	1503	1050	11	56.10	0.72
R-16(S)	11/29/00	21	3.39	17.4	408.3	1298	1346	1000	9	54.25	8.34
R-16(S)	02/07/01	20	3.52	11.8	413.9	1092	884	500	6	18.90	6.16
R-16(S)	08/21/01	23	3.11	10.9	414.8	1246	1138	350	6	55.70	6.36
R-16(S)	12/06/01	20	3.68	12.9	412.8	2340	2876	2200	6	239.50	14.96
R-16(S)	02/19/02	19	2.81	12.2	413.5	1810	1772	750	6	79.78	12.73
R-16(S)	06/06/02	20	2.71	11.5	414.2	1915	94	1600	6	70.40	9.93
R-16(S)	11/14/02	21	4.46	14.0	411.7	159	122	13	19	0.69	0.10
R-16(S)	01/15/03	18	3.04	13.3	412.4	1758	1606	1600	8	96.50	12.00
R-16(S)	05/27/03	19	2.96	11.6	414.1	1910	1800	1150	10	159.20	9.20
R-16(S)	09/08/03	22	3.19	12.8	412.9	1655	1470	1400	9	148.50	8.42
R-16(S)	12/12/03	20	2.94	14.5	411.2	1485	1284	975	10	99.40	7.21
R-16(S)	01/09/04	18	3.27	15.1	410.6	1428	1240	1000	11	113.10	8.47
R-16(S)	04/30/04	19	2.27	13.6	412.1	1460	1012	800	10	33.41	8.18
R-16(S)	07/29/04	21	2.93	13.6	412.1	1234	1294	725	11	118.00	7.32
R-16(S)	11/05/04	19	4.13	15.3	410.4	338	276	165	22	12.06	0.92
R-16(S)	03/03/05	19	2.89	24.3	401.4	1504	1342	1050	10	84.40	7.91
R-16(S)	04/07/05	18.3	3.16	10.9	414.8	1562	1434	1100	13	96.20	7.24
R-16(S)	08/31/05	20	4.15	13.6	412.1	1182	998	875	15	101.00	6.02
R-16(S)	10/18/05	20	4.21	14.4	411.3	1216	1194	700	12	100.00	5.71
R-16(S)	02/22/06	16	5.80	16.4	409.3	80.7	42	9	15	0.09	0.01
R-16(S)	05/31/06	20	3.34	17.4	408.3	551	344	190	14	9.55	1.30
R-16(S)	09/08/06	25	4.07	17.9	407.8	67.9	80	32	17	1.03	0.04
R-16(S)	01/30/07	19	3.85	18.9	406.8	465	340	190	6	35.60	1.44
R-16(S)	05/30/07	19	2.87	17.8	407.9	571	350	170	6	10.90	1.79
R-16(S)	08/22/07	20	3.15	17.1	408.6	561	400	185	7	17.60	2.05
R-16(S)	10/09/07	23	3.22	17.2	408.5	533	464	200	7	16.70	2.09
R-16(S)	02/20/08	20	3.57	18.6	407.1	605	474	330	9	34.90	2.25
R-16(S)	05/05/08	18	3.36	17.7	408.0	746	510	220	7	22.00	2.62
R-16(S)	07/08/08		3.35	17.3	408.4	729	584	340	5	23.00	2.70
R-16(S)	12/05/08	20	3.77	18.6	407.1	735	594	310	10	42.20	2.70

R-16(S)	02/02/09	20	3.62	18.9	406.8	750	652	240	9	38.80	2.96
R-16(S)	06/09/09	20	3.57	18.4	407.3	872	722	480	6	41.00	3.29
R-16(S)	08/10/09	21	3.44	18.4	407.3	890	708	400	21	31.90	2.74
R-16(S)	12/08/09	20	3.82	16.7	409.0	870	726	382	11	39.20	3.94
R-16(S)	03/24/10	18.5	3.66	14	411.7	861	640	410	11	27	3.31
R-16(S)	04/27/10	20.5	3.21	13.49		872	692	480	9	36.8	3.34
R-16(S)	07/16/10	24	2.89	14.61		939	760	360	10	22.5	3.6
R-16(S)	10/13/10	21.5	3.18	15.6		942	770	420	12	31.8	5
R-16(S)	02/28/11	20.5	3.51	17.5		676	594	400	9	28.01	4.35
R-16(S)	04/06/11	20.5	3.50	17.9		715	576	390	9	25.72	2.82
R-16(S)	08/31/11	22	4.04	18.7		860	820	540	9	60.47	3.95
R-16(S)	11/01/11	22.5	4.07	19.2		855	876	660	9	71.58	4.74
R-16(S)	05/16/12	21	4.68	12.1		2180	2426	1600	8	1.165	4.95
R-18(S)-98	02/15/99	20	5.50	49.7	357.2	795	488	171	10	27.00	2.94
R-18(S)-98	08/24/99	25	4.23	48.7	358.2	132	128	43	4	0.80	0.28
R-18(S)-98	11/09/99	20	6.46	48.4	358.5	472	143	54	10	0.44	0.08
R-18(S)-98	01/12/00	22	6.68	48.1	358.8	442	294	55	11	0.25	0.08
R-18(S)-98	06/09/00	23	4.98	47.3	359.6	420	292	150	11	30.00	0.93
R-18(S)-98	07/18/00	23	4.81	47.1	359.8	391	62	275	10	33.50	0.87
R-18(S)-98	11/29/00	20	4.65	46.5	360.4	1264	1208	925	5	41.75	5.55
R-18(S)-98	06/13/01	25	4.56	42.2	364.7	1057	960	375	7	125.50	2.44
R-18(S)-98	08/24/01	20	4.13	40.6	366.3	2080	2140	1050	6	349.50	6.12
R-18(S)-98	12/11/01	20	4.50	39.6	367.3	1055	998	20	8	167.60	2.28
R-18(S)-98	06/07/02	21	3.06	35.9	371.0	1974	1866	1850	8	349.50	3.76
R-18(S)-98	07/19/02	21	3.15	35.3	371.6	701	546	375	7	94.10	1.11
R-18(S)-98	11/15/02	19	4.20	34.4	372.5	319	244	160	9	25.19	0.62
R-18(S)-98	01/14/03	20	3.07	32.9	374.0	3070	3584	2600	9	669.00	9.18
R-18(S)-98	05/27/03	21	3.66	31.5	375.4	876	694	525	16	97.20	2.37
R-18(S)-98	09/08/03	20	3.88	30.5	376.4	416	274	225	10	25.49	0.97
R-18(S)-98	12/11/03	18	4.28	30.4	376.5	267	56	105	11	14.84	0.58
R-18(S)-98	01/13/04	20	3.64	30.4	376.5	245	132	70	10	7.97	0.47
R-18(S)-98	04/30/04	21	3.58	29.0	377.9	1329	1164	525	10	153.10	5.15
R-18(S)-98	08/02/04	21	3.63	28.3	378.6	447	352	185	8	43.08	1.33
R-18(S)-98	03/03/05	17	3.43	24.5	382.4	1604	1624	950	8	303.10	4.19
R-18(S)-98	04/07/05	19.2	4.04	24.0	382.9	1288	1256	680	11	183.00	3.11
R-18(S)-98	09/01/05	21.5	6.25	23.6	383.3	55	172	5	10	0.69	0.01
R-18(S)-98	10/19/05	20.5	4.18	23.6	383.3	443	318	185	33	31.10	0.83
R-18(S)-98	02/22/06	16	4.07	23.9	383.0	567	508	325	13	41.90	1.20
R-18(S)-98	06/01/06	19	4.39	24.4	382.5	949	912	450	16	93.20	1.74
R-18(S)-98	09/07/06	20	4.90	24.7	382.2	53.3	120	9	9	0.17	0.05
R-18(S)-98	11/30/06	19	3.75	24.9	382.0	1230	1332	900	10	193.00	3.21
R-18(S)-98	02/07/07	19	2.79	24.4	382.5	1359	1068	500	11	14.80	3.14
R-18(S)-98	05/31/07	20	2.75	23.6	383.3	1884	2022	1060	10	267.00	4.24
R-18(S)-98	08/23/07	21	3.83	21.7	385.2	1921	2486	1280	6	298.00	5.08
R-18(S)-98	10/10/07	20	3.83	21.6	385.3	1548	1856	800	8	256.00	4.98
R-18(S)-98	02/28/08	17	4.09	22.1	384.8	1109	1088	780	10	160.00	2.49
R-18(S)-98	05/06/08	19	2.33	20.3	386.6	1739	858	650	11	62.20	2.53
R-18(S)-98	12/16/08	17	4.07	21.1	385.8	1172	1248	640	15	143.00	2.55

R-18(S)-98	02/09/09	20	3.78	20.5	386.4	1180	1058	640	5	117.00	1.92
R-18(S)-98	06/12/09	20	4.31	18.4	388.5	1058	1018	620	6	103.00	2.09
R-18(S)-98	08/18/09	21	4.11	18.6	388.3	910	848	470	6	92.70	1.74
R-18(S)-98	12/09/09	19	3.82	17.7	389.2	944	902	498	8	114.00	2.00
R-18(S)-98	03/19/10		4.03	15.4	391.5	985	856	523	6	20.2	1.93
R-18(S)-98	04/21/10	20	4.16	15.12		908	768	540	8	93	1.63
R-18(S)-98	07/12/10	21	3.98	15.58		708	730	420	7	79	1.54
R-18(S)-98	10/14/10	20.5	3.50	16.7		882	800	490	9	150	1.92
R-18(S)-98	03/01/11	20.5	4.43	17.9		927	828	520	5	98.5	2.2
R-18(S)-98	04/14/11	20.5	4.67	17.8		890	832	560	19	97.96	1.93
R-18(S)-98	09/07/11	22	4.92	19.2		921	868	550	6	116.2	2.17
R-18(S)-98	11/02/11	22	4.95	19.6		957	918	640	9	115.9	2.06
R-18(S)-98	02/01/12	21	4.77	19.3		996	940	580	8	116.8	2.06
R-18(S)-98	05/16/12	21	4.78	17.7		955	876	580	7	94.8	1.82
R-2(S)	02/19/93	21.2	6.00	10.8	427.0	779	507	244	8	39.00	0.84
R-2(S)	04/19/93	22.3	6.00	9.0	428.8	836	546	321	7	33.80	1.12
R-2(S)	07/22/93	23.3	5.70	88.0	349.8	901	668	328	9	63.80	1.29
R-2(S)	11/02/93	17.3	5.20	12.2	425.6	874	586	353	8	54.60	1.17
R-2(S)	01/06/94	17.3	5.40	13.0	424.8	880	630	362	7	74.30	1.54
R-2(S)	06/23/94	12.4	5.50	10.2	427.6	666	458	234	8	48.30	1.02
R-2(S)	09/09/94	17.1	5.43	12.0	425.8	695	523	262	7	41.50	1.07
R-2(S)	10/03/94	23.5	5.69	12.7	425.1	847	580	331	8	56.80	1.51
R-2(S)	02/14/95	14	5.61	9.4	428.4	676	472	266	7	55.60	1.34
R-2(S)	05/11/95	21	5.65	7.6	430.2	673	472	241	7	48.20	1.31
R-2(S)	08/09/95	22	5.71	10.4	427.4	673	452	226	7	41.00	1.20
R-2(S)	03/04/97	20	5.80	8.2	429.6	895	732	394	9	78.60	1.80
R-2(S)	05/19/97	22	5.48	75.5	362.3	991	868	546	7	104.00	2.15
R-2(S)	07/07/97	20	5.90	9.4	428.4	800	598	335	7	63.40	1.59
R-2(S)	10/30/97	20	5.99	12.0	425.8	947	721	378	9	57.20	1.40
R-2(S)	03/03/98	19	5.29	8.1	429.7	841	684	426	7	78.00	1.79
R-2(S)	05/19/98	23	5.17	6.0	431.8	1168	906	552	7	98.00	2.23
R-2(S)	09/18/98	22	5.07	12.6	425.2	951	746	436	7	85.40	1.90
R-2(S)	10/28/98	20	5.45	12.9	424.9	776	576	305	7	70.20	1.69
R-2(S)	02/03/99	20	5.22	7.7	430.1	911	678	465	8	79.40	1.85
R-2(S)	04/19/99	20	5.03	7.9	429.9	795	488	313	7	62.40	1.68
R-2(S)	08/24/99	21	5.33	10.8	427.0	828	554	324	6	67.00	1.66
R-2(S)	11/08/99	20	5.61	75.4	362.4	822	592	367	8	72.00	1.86
R-2(S)	01/10/00	19	5.29	13.4	424.4	866	662	382	7	71.20	1.83
R-2(S)	06/07/00	20	5.66	13.6	424.2	898	704	500	8	75.83	1.75
R-2(S)	07/18/00	22	5.59	13.7	424.1	832	560	350	11	73.85	1.74
R-2(S)	11/29/00	20	5.31	15.1	422.7	845	504	475	8	82.00	2.18
R-2(S)	02/06/01	18	5.28	10.6	427.2	1105	988	750	7	119.50	0.11
R-2(S)	06/11/01	20	5.10	8.6	429.2	1071	928	550	6	102.10	2.41
R-2(S)	08/21/01	20	5.23	9.8	428.0	893	704	200	7	77.80	2.07
R-2(S)	12/06/01	20	5.14	11.7	426.1	1141	896	475	9	88.50	2.70
R-2(S)	02/19/02	20	4.81	10.9	426.9	1035	895	650	6	104.50	2.66
R-2(S)	06/06/02	20	5.05	9.8	428.0	1098	878	775	17	103.40	2.52
R-2(S)	07/19/02	21	5.11	10.8	427.0	1082	894	800	7	133.80	2.55

R-2(S)	11/14/02	20	5.04	12.9	424.9	1117	906	900	7	115.50	2.90
R-2(S)	01/09/03	20	5.05	12.2	425.6	1061	890	750	7	110.50	3.09
R-2(S)	05/23/03	21	5.12	10.5	427.3	1031	772	750	7	95.90	2.52
R-2(S)	09/03/03	21	4.96	11.6	426.2	1170	966	800	8	117.70	3.35
R-2(S)	12/12/03	21	5.12	13.3	424.5	1023	822	625	7	104.30	2.97
R-2(S)	01/09/04	20	5.12	13.7	424.1	1000	816	500	5	101.50	3.74
R-5(S)	02/19/93	21	3.20	13.0	405.0	1947	1742	1094	22	195.00	6.24
R-5(S)	04/16/93	21.8	3.30	9.5	408.5	2100	2130	1368	22	231.00	9.13
R-5(S)	07/14/93	26.1	3.50	9.5	408.5	1808	1798	1136	19	198.00	7.64
R-5(S)	11/01/93	18.6	3.80	11.8	406.2	1399	1367	857	18	40.90	6.05
R-5(S)	01/05/94	16.2	3.10	12.2	405.8	1471	1348	836	18	138.00	5.29
R-5(S)	06/24/94	13.7	3.30	9.0	409.0	1340	1292	781	17	143.00	5.38
R-5(S)	09/09/94	17.6	3.30	46.3	371.7	1219	1094	670	18	126.00	4.17
R-5(S)	10/03/94	23.2	3.38	9.4	408.6	1193	1008	638	21	89.50	3.96
R-5(S)	02/14/95	14.9	3.81	6.4	411.6	969	866	494	18	105.00	4.17
R-5(S)	05/11/95	19	3.97	4.0	414.0	852	742	403	16	92.30	3.14
R-5(S)	08/10/95	20	3.75	8.0	410.0	740	634	381	17	68.60	2.77
R-5(S)	10/04/95	19	3.77	8.8	409.2	723	604	335	19	53.20	2.52
R-5(S)	01/05/96	19	3.38	10.5	407.5	1029	540	288	20	50.70	2.04
R-5(S)	04/30/96	20	3.81	11.9	406.1	578	436	238	17	45.20	1.95
R-5(S)	03/03/97	18	4.14	3.0	415.0	506	430	218	20	41.60	1.76
R-5(S)	05/19/97	20	4.36	7.4	410.6	445	381	192	18	50.20	1.20
R-5(S)	07/08/97	19	4.05	6.8	411.2	447	375	181	18	37.60	1.41
R-5(S)	10/29/97	18	4.65	37.3	380.7	386	297	129	16	28.20	1.09
R-5(S)	03/03/98	17	4.29	3.7	414.3	352	293	140	17	27.40	1.08
R-5(S)	05/19/98	20	4.77	6.8	411.2	373	269	119	13	22.20	1.21
R-5(S)	09/18/98	21	4.42	8.8	409.2	318	262	97	15	20.40	0.76
R-5(S)	10/28/98	21	4.64	7.9	410.1	311	242	92	14	10.50	1.24
R-5(S)	02/10/99	19	4.25	2.8	415.2	306	272	118	13	23.50	0.98
R-5(S)	04/19/99	20	4.05	3.6	414.4	381	282	128	13	17.50	1.03
R-5(S)	08/24/99	19	4.63	7.7	410.3	350	265	119	14	15.10	0.94
R-5(S)	11/08/99	20	4.64	12.6	405.4	370	268	134	14	16.40	0.86
R-5(S)	01/10/00	19	3.84	9.8	408.2	411	324	157	12	8.50	1.11
R-5(S)	06/07/00	18	4.46	10.6	407.4	730	528	350	14	36.09	1.32
R-5(S)	07/18/00	20	4.11	10.5	407.5	707	509	250	14	33.80	1.32
R-5(S)	11/29/00	19	4.43	11.0	407.0	678	536	325	13	35.75	1.81
R-5(S)	02/06/01	20	4.66	3.7	414.3	704	568	600	13	45.30	0.09
R-5(S)	08/21/01	20	4.15	6.6	411.4	1267	748	400	14	8.32	1.16
R-5(S)	12/06/01	20	4.18	7.5	410.5	1159	1012	625	11	60.70	2.71
R-5(S)	02/19/02	18	4.40	5.4	412.6	1123	943	700	13	54.60	2.62
R-5(S)	06/06/02	20	4.66	6.6	411.4	1122	920	850	15	53.20	2.55
R-5(S)	07/19/02	20	4.01	7.4	410.6	1211	1012	800	15	63.00	2.47
R-5(S)	11/14/02	19	4.56	8.9	409.1	1103	876	850	13	46.70	2.83
R-5(S)	01/09/03	18	4.14	8.5	409.5	1306	1136	1200	12	84.00	3.18
R-5(S)	05/23/03	18	4.43	7.1	410.9	1307	1036	950	14	64.80	2.64
R-5(S)	09/03/03	20	4.45	8.1	409.9	1248	1018	1100	12	56.80	2.96
R-5(S)	12/12/03	19	4.83	9.7	408.3	1264	1096	850	13	59.70	3.45
R-5(S)	01/09/04	19	4.57	10.1	407.9	1307	1220	850	13	49.72	4.43

R-5(S)	08/05/04	20	4.40	8.6	409.4	1604	1364	850	14	80.90	2.84
R-5(S)	06/05/06	19	4.59	12.1	405.9	1970	2204	1900	17	108.00	4.51
R-5(S)	09/22/06	20	4.59	12.4	405.6	2130	2080	1300	21	0.21	4.34
R-5(S)	12/01/06	18	4.97	13.4	404.6	1907	2164	1400	10	119.00	3.17
R-5(S)	01/31/07	18	4.22	13.1	404.9	1662	1658	1000	12	54.10	3.62
R-5(S)	10/10/07	21	3.28	11.9	406.1	1368	1554	880	10	22.50	4.05
R-5(S)	02/28/08	18	3.68	13.1	404.9	1633	1860	1500	14	93.90	5.03
R-5(S)	05/06/08	17	3.35	11.1	406.9	1695	1570	900	9	60.70	3.82
R-5(S)	12/15/08	20	3.07	13	405.0	1455	1460	880	7	81.10	2.60
R-5(S)	02/06/09	19	2.76	13.3	404.7	1620	1448	480	11	48.80	2.50
R-5(S)	08/18/09	21	4.14	13.2	404.8	1925	2060	1360	10	43.10	2.12
R-5(S)	12/09/09	20	3.47	10.3	407.7	1296	1234	661	10	29.50	3.53
R-5(S)	03/18/10		4.43	7.7	410.3	1766	1834	957	9	15.7	4.36
R-5(S)	03/01/11	20	3.48	17.1		1660	1802	1140	11	55.92	5.3
R-5(S)	09/07/11	21.5	5.17	13.2		2150	2502	1750	12	127	5.66
R-5(S)	02/01/12	21	4.42	12.1		1810	1852	1180	11	79.68	6.09
R-6(S)	06/27/94	16.8	4.00	25.0	374.7	1273	1084	681	13	107.00	1.44
R-6(S)	09/13/94	14	4.43	25.0	374.7	1232	1140	659	17	100.00	1.66
R-6(S)	10/04/94	18.3	4.01	23.8	375.9	1259	1036	647	14	92.00	1.26
R-6(S)	02/15/95	18.9	4.16	25.2	374.5	1724	1649	1130	13	182.00	2.48
R-6(S)	05/30/95	19	4.25	24.4	375.3	1310	1214	778	14	139.00	1.59
R-6(S)	08/14/95	20	4.14	24.8	374.9	1116	970	621	15	50.10	1.29
R-6(S)	10/04/95	19	4.05	24.8	374.9	1057	914	553	26	95.50	1.16
R-6(S)	01/05/96	19	4.12	25.1	374.6	1029	854	551	14	88.50	1.13
R-6(S)	05/02/96	20	4.28	25.4	374.4	966	732	496	20	76.60	0.95
R-6(S)	03/04/97	19	4.21	22.6	377.1	1372	1220	771	18	102.00	1.81
R-6(S)	06/04/97	20	4.31	24.0	375.7	1045	1034	616	16	112.00	1.18
R-6(S)	07/11/97	20	4.14	24.1	375.6	1000	916	570	19	96.60	1.18
R-6(S)	10/31/97	19	4.23	24.3	375.4	856	726	484	17	83.00	1.08
R-6(S)	03/05/98	20	3.67	23.5	376.2	1101	926	604	15	100.00	4.77
R-6(S)	05/20/98	22	4.08	24.3	375.4	940	728	421	15	73.00	0.97
R-6(S)	09/21/98	20	4.34	23.0	376.7	847	628	413	16	75.80	0.88
R-6(S)	10/29/98	20	4.90	25.6	374.1	831	718	413	15	70.60	1.17
R-6(S)	02/11/99	20	4.63	24.7	375.0	885	662	422	15	79.20	1.00
R-6(S)	04/23/99	19	4.54	2.6	397.1	869	642	444	15	45.40	0.88
R-6(S)	08/25/99	21	4.59	25.7	374.0	874	630	402	15	69.40	0.86
R-6(S)	11/12/99	22	4.35	25.9	373.8	856	696	434	18	75.80	0.83
R-6(S)	01/07/00	18	4.36	26.2	373.5	793	562	368	15	64.60	0.84
R-6(S)	06/05/00	21	4.37	26.2	373.5	800	544	700	70	58.15	0.72
R-6(S)	07/17/00	21	4.78	26.2	373.5	738	576	700	50	98.50	8.20
R-6(S)	11/28/00	21	4.72	25.8	373.9	674	102	310	15	53.30	0.79
R-6(S)	02/05/01	20	4.65	25.8	373.9	734	650	450	14	80.28	0.04
R-6(S)	08/15/01	20	3.76	25.3	374.4	852	684	225	14	66.70	0.83
R-6(S)	12/04/01	19	4.35	25.3	374.4	823	660	350	15	71.00	0.90
R-6(S)	02/18/02	19	4.45	25.2	374.5	841	654	375	14	58.13	0.97
R-6(S)	06/05/02	20	4.14	25.5	374.2	874	630	650	13	70.10	0.95
R-6(S)	07/18/02	21	4.01	25.6	374.1	865	698	525	7	88.40	0.98
R-6(S)	11/13/02	20	4.05	25.0	374.7	850	688	800	14	74.20	1.07

R-6(S)	01/14/03	17	4.01	25.4	374.3	848	666	500	14	82.60	1.20
R-6(S)	05/22/03	20	3.97	25.8	373.9	861	588	525	17	73.50	1.02
R-6(S)	07/17/03	20	3.87	25.7	374.0	854	770	575	15	78.30	1.22
R-6(S)	12/02/03	18	3.95	26.0	373.7	832	656	400	16	78.00	1.19
R-6(S)	01/08/04	20	3.99	26.2	373.5	834	676	450	16	72.00	1.61
R-6(S)	04/27/04	20	3.90	25.6	374.1	863	656	350	7	70.60	1.19
R-6(S)	07/28/04	21	3.72	25.7	374.0	881	688	275	14	91.00	1.47
R-6(S)	11/05/04	18	4.02	25.7	374.0	926	690	450	15	75.70	1.30
R-6(S)	03/03/05	17	4.01	11.2	388.5	825	734	600	13	77.30	1.23
R-6(S)	04/08/05	20.1	4.34	24.8	374.9	863	718	600	13	78.50	1.28
R-6(S)	08/31/05	20	4.70	25.8	373.9	906	652	500	20	76.30	1.45
R-6(S)	10/17/05	19	4.45	25.6	374.1	888	716	525	15	72.10	1.38
R-6(S)	02/21/06	16	4.24	26.3	373.4	837	694	500	16	60.60	1.20
R-6(S)	05/31/06	20	4.36	26.6	373.1	850	694	500	19	55.40	1.17
R-6(S)	09/06/06	21	3.60	26.4	373.3	820	678	90	19	59.60	1.30
R-6(S)	11/29/06	21	4.05	26.4	373.3	772	676	540	5	76.20	1.40
R-6(S)	01/30/07	19	4.15	25.9	373.8	758	650	480	12	71.60	1.27
R-6(S)	05/30/07	20	4.02	25.9	373.8	758	804	340	14	74.30	1.33
R-6(S)	08/22/07	20	4.54	23.7	376.0	804	726	450	14	65.30	1.62
R-6(S)	10/09/07	20	4.69	25.8	373.9	830	792	27	13	80.40	1.66
R-6(S)	02/20/08	20	4.54	26	373.7	890	746	560	10	84.90	1.51
R-6(S)	05/05/08	19	4.49	25.6	374.1	951	890	420	14	85.10	1.66
R-6(S)	07/08/08		4.50	25.9	373.8	963	930	530	10	88.40	1.73
R-6(S)	12/05/08	19	5.01	15.8	383.9	902	820	43	15	93.80	1.59
R-6(S)	02/02/09	19	4.63	25.7	374.0	886	880	470	13	71.20	1.61
R-6(S)	06/09/09	20	5.29	25.5	374.2	1059	1002	600	10	88.10	1.75
R-6(S)	08/10/09	21	4.91	24.8	374.9	985	902	500	10	88.50	1.79
R-6(S)	12/08/09	19	5.18	24.1	375.6	913	904	273	11	101.00	2.00
R-6(S)	03/15/10		4.06	23.8	375.9	1084	1000	257	12	18.7	4.36
R-6(S)	04/23/10	20	3.67	24.55		1078	980	700	10	86.1	1.96
R-6(S)	10/13/10	21	4.01	25.8		1083	1136	560	26	101	1.85
R-6(S)	02/28/11	21	4.17	26		986	856	620	12	118.2	2.84
R-6(S)	04/06/11	21	4.45	25.6		913	956	640	10	81.9	2.01
R-6(S)	08/31/11	22.5	4.77	26.5		921	1032	620	12	106.4	2.27
R-6(S)	11/01/11	22	4.45	26.4		948	926	680	13	101	2.2
R-6(S)	01/31/12	20	4.57	26		1005	826	600	11	113.6	2.45
R-6(S)	05/15/12	21	4.46	25.8		986	976	560	13	96.94	2.17
TP-C5	03/23/84	18	5.60		367	173	69	26	8	13	
TP-C5	06/24/84	19	5.29		365	171	110	33	10	29.9	0.29
TP-C5	09/27/84	19	5.61		364	174	116	<5	8	27.9	0.25
TP-C5	01/07/85	19	5.36		366	179	92	17	8	22.5	0.17
TP-C5	04/25/85	20	5.02		366	143	46	28	10	0.17	0.04
TP-C5	07/20/85	20	5.85		365	155	78	20	10	31	0.19
TP-C5	10/13/85	20	5.88		364	155	88	17	12	22	0.18
TP-C5	01/25/86	19	5.63		366	165	94	27	7	21	0.21
TP-C5	06/29/86	21	5.88		365	150	126	26	8	33	0.18
TP-C5	09/05/86	19	6.03		364	148	80	20	9	26	0.15
TP-C5	11/19/86	19	5.89		364	169	68	18	10	29	0.14

TP-C5	03/24/87	19	5.87		367	135	70	26	10	33	0.18
TP-C5	09/20/87	20	6.04		364	120	100	15.5	6.7	22	0.13
TP-C5	11/15/87	20	5.99		364	125	108	15.5	7.1	20.1	0.13
TP-C5	02/17/88	19	5.91		366	135	52	18.5	7.4	62.2	0.19
TP-C5	05/11/88	19	5.95		366	137	72	17	8	28	0.19
TP-C5	08/12/88	21	5.98		364	115	92	10.9	7.3	23	0.14
TP-C5	11/15/88	21	6.01		363	102	78	14.5	6.2	20	0.05
TP-DG	03/21/84	18	5.20		364	110	69	17	10	0.02	
TP-DG	06/24/84	19	4.13		363	85	50	12	14	0.14	0.07
TP-DG	09/27/84	19	3.68		361	77	54	15	10	0.15	0.04
TP-DG	01/07/85	19	4.45		363	92	74	14	9	0.22	0.08
TP-DG	04/24/85	18	4.18		364	85	64	15	14	0.24	0.21
TP-DG	07/20/85	20	4.20		362	82	54	14	12	0.27	0.03
TP-DG	10/13/85	21	4.37		361	80	66	7	14	0.14	0.04
TP-DG	01/24/86		5.17		363	80	54	14	9	0.2	0.03
TP-DG	07/08/86	21	4.21		362	75	42	14	10	0.17	0.03
TP-DG	09/05/86	21	3.85		361	80	80	14	15	0.19	0.03
TP-DG	11/19/86	21	4.60		362	77	46	13	11	0.15	0.03
TP-DG	03/24/87	19	4.78		364	65	68	13	12	0.5	0.02
TP-DG	09/20/87	22	4.25		361	78	79	12.8	9.1	0.05	0.05
TP-DG	11/15/87	20.5	4.35		362	90	67	12.7	10	0.05	0.05
TP-DG	02/17/88	18	4.66		363	69	78	11.8	9.8	0.08	0.05
TP-DG	05/11/88	18	4.08		363	81	75	13	10	0.37	0.05
TP-DG	08/12/88	21	3.90		361	90	72	12.8	9.3	0.05	0.05
TP-DG	11/15/88	21	3.86		361	91	73	12.5	11	0.05	0.05
TP-UG	03/22/84	19.5	5.20		369	75	93	21	8	1.5	
TP-UG	06/24/84	19	3.86		368	85	54	23	12	3.65	0.03
TP-UG	09/27/84	18.5	3.90		366	86	76	25	8	4.1	0.04
TP-UG	01/07/85	18	3.92		368	92	58	19	11	2.71	0.06
TP-UG	04/24/85	18	3.51		369	85	26	15	13	1.85	0.02
TP-UG	07/20/85	20	4.10		368	840	54	19	8	1.58	0.03
TP-UG	10/13/85	18.5	4.27		367	950	68	19	12	1.96	0.04
TP-UG	01/25/86	18	4.17		369	85	40	20	6	2.14	0.04
TP-UG	06/29/86	19.5	4.15		368	82	86	21	8	2.15	0.03
TP-UG	09/05/86	18	4.14		367	82	90	20	10	1.7	0.05
TP-UG	11/19/86	18	4.18		368	103	88	21	10	1.92	0.03
TP-UG	03/24/87	19	4.10		372	80	66	20	12	1.97	0.04
TP-UG	09/20/87	19	4.10		369	87	74	20.8	6.8	1	0.05
TP-UG	11/15/87	19.5	4.15		368	100	70	22.4	7.1	1.16	0.06
TP-UG	02/17/88	18	4.16		368	88	78	21.9	7.1	1.2	0.05
TP-UG	05/11/88	19	3.96		371	90	83	22	7	1.46	0.05
TP-UG	08/12/88	19	3.80		369	90	79	21	7.1	1.01	0.08
TP-UG	11/15/88	19	4.06		368	92	81	25.3	7	1.15	0.05

Well Name	Date	Tot. Fe	Tot. Mn	Ca	Mg	Na	K	HCO_3	F	SiO_2	Al	B	Zn	Lab pH	Lab EC	Lab CBE%
89-1-OB	none															
89-2-OB	none															
89-2-OB-R-03	1/13/04										0.2	0.46	0.02			
89-2-OB-R-03	3/3/05										0.18	<0.01	0.63			
89-2-OB-R-03	2/23/06										5.65	<0.006	0.63			
89-2-OB-R-03	1/30/07										3.27	<0.006	0.49			
89-2-OB-R-03	2/20/08										3.65	0.16	0.43			
89-2-OB-R-03	2/2/09										4.94	<0.006	0.74			
89-3-OB-R-99	2/19/02										2.74	0.17	0.35			
89-3-OB-R-99	1/9/03										7.79	<0.001	1.35			
89-3-OB-R-99	1/9/04										1.44	0.11	0.32			
89-3-OB-R-99	3/3/05										3.44	<0.01	0.69			
89-3-OB-R-99	2/22/06										0.77	<0.006	0.16			
89-3-OB-R-99	2/28/08										0.23	<0.006	0.18			
89-3-OB-R-99	2/9/09										0.56	<0.006	0.29			
89-3-UB	none															

89-3-UB-R-99	2/7/01										0.08	0.08	0.03			
89-3-UB-R-99	2/19/02										0.08	0.11	0.02			
89-3-UB-R-99	1/9/03										0.15	<0.01	0.07			
89-3-UB-R-99	1/9/04										0.27	0.18	0.11			
89-3-UB-R-99	3/3/05										0.1	<0.01	0.05			
89-3-UB-R-99	2/22/06										0.36	<0.006	0.03			
89-3-UB-R-99	2/28/08										0.23	<0.006	0.06			
89-3-UB-R-99	2/9/09										0.09	<0.006	0.08			
89-4-OB	none															
89-4-OB-R-99	2/20/02										13.5	0.88	4.07			
89-4-OB-R-99	1/16/03										19.9	<0.001	4.61			
89-4-OB-R-99	1/13/04										19.7	0.94	0.13			
89-4-OB-R-99	3/8/05										0.03	<0.01	<0.005			
89-4-OB-R-99	2/23/06										12.2	<0.006	2.16			
89-4-OB-R-99	2/7/07										8.46	0.54	2.36			
89-4-OB-R-99	2/28/08										<0.006	<0.006	0.04			
89-4-OB-R-99	2/9/09										7.17	<0.006	1.64			

89-4-UB	none															
89-4-UB-R-99	2/20/02										0.02	0.11	0.02			
89-4-UB-R-99	1/15/03										0.18	<0.001	0.1			
89-4-UB-R-99	1/13/04										0.2	0.13	0.01			
89-4-UB-R-99	3/8/05										12.5	<0.01	3.63			
89-4-UB-R-99	2/23/06										0.46	<0.006	0.05			
89-4-UB-R-99	2/7/07										0.04	<0.001	0.04			
89-4-UB-R-99	2/28/08										6.62	0.72	2.25			
89-4-UB-R-99	2/9/09										0.09	<0.006	0.09			
D-1-(Alluv)	2/24/84	1.90		3.91	1.34	6.0	1.70	15.00						5.9	60	2.0
D-1-(Alluv)	6/23/84	98.8	0.69	4.68	0.99	6.8	1.07	9.00						5.8	60	-7.7
D-1-(Alluv)	9/30/84	34.1	0.36	2.81	1.06	4.5	1.34	9.00						5.5	55	-9.1
D-1-(Alluv)	1/7/85	37.0	0.35	4.77	1.32	4.6	0.78	10.00						5.5	62	0.0
D-1-(Alluv)	4/20/85	30.0	0.27	3.84	1.34	4.0	0.85	15.00	0.01		<0.1		0.08	5.7	60	-16.7
D-1-(Alluv)	7/22/85	71.0	0.38	2.98	1.41	4.0	1.19	11.00	0.08	8.4	0.1		0.05	5.4	70	-9.1
D-1-(Alluv)	10/18/85	57.0	0.60	2.47	0.54	4.0	1.22	<5	0.06	21	0.3		0.05	5.4	48	-11.1
D-1-(Alluv)	1/23/86	119	0.55	4.17	1.04	1.0	3.84	7.00	0.11	15.2	0.3		0.02	5.4	42	-9.1
D-1-(Alluv)	6/28/86	99.0	0.48			3.0								4.7	60	

D-1-(Alluv)	9/5/86	67.0	0.40			4.0								5.5	57	
D-1-(Alluv)	11/18/86	20.0	0.14			3.7								4.7	50	
D-1-(Alluv)	3/16/87	29.0	0.15			3.0								5.6	78	
D-1-(Alluv)	9/21/87					3.0										
D-1-(Alluv)	11/16/87					3.5										
D-1-(Alluv)	2/18/88					1.0										
D-1-(Alluv)	5/13/88					3.0										
D-1-(Alluv)	8/13/88					2.8										
D-1-(Alluv)	11/15/88					4.7										
D-1-(Alluv)	2/20/93	59.9	0.31	4.5	1.4	2.9	0.4							6.1	61	
D-1-(Alluv)	4/15/93	66.0	0.44	5.2	1.6	2.8	0.6							6.7	67	
D-1-(Alluv)	7/13/93	38.2	0.34	3.5	1.0	2.6	0.6							6.5	49	
D-1-(Alluv)	10/26/93	51.0	0.29	3.7	1.2	2.7	1.4							6.9	54	
D-1-(Alluv)	1/4/94	45.4	0.26	6.6	3.5	2.4	2.2							5.9	51	
D-1-(Alluv)	6/27/94	50.8	0.28	6.5	3.3	2.7	2.5								54	
D-1-(Alluv)	9/12/94	45.6	0.24	6.5	3.7	3.1	3.1								53	
D-1-(Alluv)	10/4/94	28.3	0.13	4.6	2.5	2.7	1.6									

D-1-(Alluv)	2/15/95	37.8	0.25	5.8	3.0	3.0	2.5									
D-1-(Alluv)	5/15/95	10.2	0.07	3.5	1.4	1.9	1.0									
D-1-(Alluv)	8/14/95	32.6	0.19	4.5	2.6	2.1	1.9								41	
D-1-(Alluv)	10/4/95	21.8	0.11	3.7	1.9	2.2	1.4								42	
D-14-OBa	6/20/84	7.7	0.2	8.3	3.74	10	3.01	<1						3.9	160	-3.2
D-14-OBa	9/28/84	14	0.1	6.4	4.35	18	3.36	<1						3.9	202	3.2
D-14-OBa	1/5/85	7.3	0.2	12.9	4.27	4.4	2.99	<5						3.7	199	-6.7
D-14-OBa	4/23/85	4.4	0.1	3.57	4.05	4.9	3.13	<1	0.1		3.1		0.18	3.5	231	-4.8
D-14-OBa	7/24/85	8	0.1	2.82	3.36	3.9	2.48	<5	0.1	58	2.8		0.13	3.4	200	0.0
D-14-OBa	10/14/85	6.2	0.1	3.62	3.73	5.9	2.91	<5	0.2	69	2.9		0.16	3.5	222	-10
D-14-OBa	1/23/86	9.9	0.1	7.12	4.15	4.7	2.97	<5	0.2	55	4		0.3	3.5	180	-11
D-14-OBa	6/24/86	7.6	0.1			4.3								3.6	189	
D-14-OBa	9/3/86	4.6	0.2			4.2								3.8	200	
D-14-OBa	11/18/86	7.2	0.1			3.7								3.3	183	
D-14-OBa	3/22/87	6.1	0.1			3.3								3.9	178	
D-14-OBa	9/20/87					3.8										
D-14-OBa	11/17/87					3.9										
D-14-OBa	2/16/88					3.5										
D-14-OBa	5/11/88					4										
D-14-OBa	8/12/88					5.5										
D-14-OBa	11/18/88					7.5										
D-14-OBb	6/20/84	32	0.3	7.5	6.98	25	4.16	<1						3.7	308	-2.0
D-14-OBb	9/28/84	124	0.2	9.98	11	17	5.2	<1						3.5	368	-2.0

D-14-OBb	1/5/85	13	0.3	26	8.8	5.7	4.6	<5						3.3	360	-8.8
D-14-OBb	4/23/85	340	0.4	9.91	5.98	6.2	3.82	<1	0.1		3.4		0.21	3.1	442	-5.6
D-14-OBb	7/24/85	24	0.2	9.97	9.96	6.4	5.7	<5	0.1	89	2.8		0.13	3.1	378	-5.0
D-14-OBb	10/14/85	41	0.3	10.2	11	7.3	5.52	<5	0.3	100	8		0.15	3.2	425	-4.9
D-14-OBb	1/23/86	24	0.2	9.24	7.44	5.2	5.1	<5	0.3	81	3.1		0.21	3.3	321	-4.2
D-14-OBb	6/24/86	28	0.2			5								3.4	350	
D-14-OBb	9/3/86	20	0.3			5.4								3.4	415	
D-14-OBb	11/18/86	24	0.3			4.9								3	390	
D-14-OBb	3/22/87	27	0.2			4.5								3.6	331	
D-14-OBb	9/20/87					5.1										
D-14-OBb	11/17/87					4.7										
D-14-OBb	2/16/88					5.1										
D-14-OBb	5/12/88					5										
D-14-OBb	8/12/88					4.5										
D-14-OBb	11/18/88					8.6										
D-14-OBc	6/20/84	27.3	0.73	2.64	2.09	3.21	1.66	21.00						5.8	89	-5.9
D-14-OBc	9/28/84	35.2	0.41	3.34	2.13	5.84	1.51	11.00						5.8	82	0.0
D-14-OBc	1/5/85	27.4	0.44	11.00	1.29	3.47	1.39	16.00						5.4	70	0.0
D-14-OBc	4/23/85	26.0	0.30	1.30	1.26	2.61	1.48	12.00	0.1		<0.1		0.06	3.9	86	0.0
D-14-OBc	7/24/85	249	0.65	1.12	1.22	2.07	1.16	7.00		40	0.30		0.02	3.9	70	0.0
D-14-OBc	10/16/85	279	0.82	1.19	1.26	3.71	1.38	15.00	0.1	51	0.20		0.04	3.9	90	-7.7
D-14-OBc	1/23/86	50.0	0.27	1.71	1.20	2.07	1.50	5.00	0.2	39	0.10		0.10	3.6	110	-11
D-14-OBc	6/23/86	187	0.31			2.37								4.3	60	
D-14-OBc	9/3/86	397	0.90			2.38								5	65	

D-14-OBc	11/18/86	483	0.82			2.17								3.8	70	
D-14-OBc	3/22/87	187	0.28			1.84								4.3	65	
D-14-OBc	9/20/87					1.40										
D-14-OBc	11/17/87					1.40										
D-14-OBc	2/16/88					1.19										
D-14-OBc	5/12/88					2.26										
D-14-OBc	8/12/88					4.25										
D-14-OBc	11/18/88					3.60										
D-14-OB-R-95	12/26/95	38.5	2.10	8.30	6.60	5.70	2.80									
D-14-OB-R-95	1/8/96	19.9	1.72	7.10	5.50	6.10	3.10				8.00		0.27			
D-14-OB-R-95	5/2/96	13.9	1.19	5.10	4.40	5.30	2.80									
D-14-OB-R-95	7/10/96	13.2	0.84	4.60	4.00	5.40	2.30									
D-14-OB-R-95	10/29/96	13.7	1.15	5.20	4.90	6.30	3.20									
D-14-OB-R-95	2/20/01										1.91	0.27	0.66			
D-14-OB-R-95	2/20/02										12	1.03	2.68			
D-14-OB-R-95	1/15/03										2.63	<0.001	1.17			
D-14-OB-R-95	1/13/04										1.04	0.21	0.27			
D-14-UB	6/21/84	295	6.6	25	10.3	66	5.42	173						6.8	580	-1.8
D-14-UB	9/28/84	161	2.5	15.9	5.8	81	4.7	157						6.7	450	2.2

D-14-UB	1/6/85	33	0.6	21.7	5.9	46	3.31	112						6.4	349	2.9
D-14-UB	4/23/85	26	0.4	15.5	5.26	55	3.63	121	0.3		<0.1		0.05	6.5	352	4.2
D-14-UB	7/25/85	101	1.1	20	7.58	55	3.73	152	0.1	13.1	0.2		0.12	6.5	380	-2.4
D-14-UB	10/16/85	15	0.3	18.6	7.8	46	4.02	130	0.2	24	0.3		0.04	6.5	350	4.2
D-14-UB	1/25/86	18	0.3	28	9.65	51	4.5	161	0.3	18.4	<0.1		0.02	6.6	385	1.1
D-14-UB	6/24/86	208	1.7			44								6.5	430	
D-14-UB	9/4/86	151	1.6			42								6.8	420	
D-14-UB	11/19/86	6.5	0.2			37								6.1	368	
D-14-UB	3/23/87	53	0.5			36								7.1	380	
D-14-UB	9/21/87					33										
D-14-UB	11/17/87					34										
D-14-UB	2/17/88					33										
D-14-UB	5/12/88					34										
D-14-UB	8/12/88					40										
D-14-UB	11/15/88					50										
D-14-UB-R-95	12/26/95	39.9	0.51	28.60	17.50	24.8	5.40									

D-14-UB-R-95	1/8/96	15.1	0.27	30.50	14.90	28.4	5.10									
D-14-UB-R-95	5/2/96	4.47	0.10	30.20	14.50	28.9	4.20									
D-14-UB-R-95	7/10/96	43.9	0.35	37.10	20.30	29.7	5.80									
D-14-UB-R-95	10/29/96	10.0	0.09	31.50	14.40	28.9	3.80									
D-14-UB-R-95	2/20/01										0	0.25	0.01			
D-14-UB-R-95	2/20/02										0.96	0.35	0.02			
D-14-UB-R-95	1/15/03										0.09	<0.001	<0.003			
D-14-UB-R-95	1/13/04										0.21	0.17	0.01			
D-16-OBal	2/17/84	0.41		2.72	1.21	4.33	0.698	2.00						5.2	60	0.3
D-16-OBal	6/22/84	5.26	0.04	1.58	1.01	6.33	0.54	1.00						4.6	63	-11.1
D-16-OBal	9/28/84	35.1	0.01	1.92	0.79	5.41	1.05	<1						4.1	80	0.0
D-16-OBal	1/6/85	10.0	0.05	7.01	1.14	4.40	0.49	<5						5	50	20.0
D-16-OBal	4/23/85	7.24	0.01	1.22	1.00	3.73	0.52	<1	0.1		0.40		0.08	4.2	62	-25.0
D-16-OBal	7/24/85	13.8	0.02	1.64	1.09	3.70	0.53	<5		24	0.30		0.08	4	50	-11.1
D-16-OBal	10/16/85	8.04	0.04	1.21	0.92	4.90	0.45	<5	0.1	33	0.50		0.04	4.1	90	0.0
D-16-OBal	1/23/86	5.00	0.02	3.54	1.05	3.92	0.64	5.00	0.1	25	0.30		0.19	4.2	55	-9.1
D-16-OBal	6/23/86	10.5	0.04			3.42								4.3	61	
D-16-OBal	9/3/86	8.68	0.09			3.40								4.2	75	
D-16-OBal	11/18/86	14.6	0.03			2.99								3.7	70	

D-16-OBal	3/22/87	13.4	0.02			3.00								4.3	72	
D-16-OBal	9/20/87					2.90										
D-16-OBal	11/17/87					3.40										
D-16-OBal	2/16/88					3.70										
D-16-OBal	5/12/88					3.68										
D-16-OBal	8/12/88					3.00										
D-16-OBal	11/19/88					3.80										
D-16-OBal	4/15/93	792	0.53	6.7	3.3	12.5	0.6							6.2	211	
D-16-OBal	6/28/94	310	0.37	28.7	14.6	19.1	8.2								298	
D-16-OBal	9/13/94	34.6	0.09	16.0	8.4	18.9	1.4								296	
D-16-OBal	10/5/94	31.5	0.09	16.8	8.5	18.2	2.0									
D-16-OBal	2/17/95	16.5	0.19	12.3	6.3	15.7	1.6									
D-16-OBal	10/4/95			2.1	1.1	5.4	0.4									
D-16-OBal	1/8/96			2.7	1.5	4.7	0.3									
D-16-OBal	5/6/96			3.3	1.9	3.8	1.4									
D-16-OBal	7/16/96			3.5	1.7	3.2	0.8									
D-16-OBal	10/29/96			3.0	1.6	3.5	1.3									
D-16-UB	2/17/84	10.0		4.98	2.58	25.9	2.70	54.00						6.1	162	2.9
D-16-UB	6/22/84	37.7	0.35	9.91	3.79	21.0	2.02	66.00						6.5	198	5.9
D-16-UB	9/28/84	35.9	0.34	9.47	3.62	24.0	2.17	61.00						6.3	180	5.9
D-16-UB	1/6/85	16.9	0.17	9.80	3.26	16.8	1.89	59.00						6.2	160	0.0
D-16-UB	4/24/85	4.17	0.06	10.10	3.55	17.6	1.92	65.00	0.3		<0.1		0.10	6.2	160	0.0
D-16-UB	7/24/85	28.0	0.16	14.30	2.90	16.4	1.56	59.00	0.1	31	0.10		0.01	6.1	142	-5.6
D-16-UB	10/16/85	25.0	0.20	9.53	3.21	18.6	1.74	59.00	0.3	41	0.30		0.03	6.1	150	0.0

D-16-UB	1/26/86	5.96	0.07	9.98	3.20	17.8	2.36	62.00	0.3	32	0.20		0.02	6.1	139	3.2
D-16-UB	6/24/86	9.08	0.09			14.3								5.8	155	
D-16-UB	9/4/86	5.21	0.13			14.5								6.3	158	
D-16-UB	11/19/86	2.64	0.05			14.6								5.7	140	
D-16-UB	3/23/87	3.60	0.05			15.0								6.7	150	
D-16-UB	9/21/87					14.1										
D-16-UB	11/17/87					14.8										
D-16-UB	2/17/88					14.5										
D-16-UB	5/13/88					15.5										
D-16-UB	8/13/88					16.4										
D-16-UB	11/19/88					23.0										
D-16-UB	2/20/93	23.1	0.12	10.1	3.9	15.2	1.7							6.8	171	
D-16-UB	4/15/93	73.7	0.31	8.2	3.4	14.6	1.3									
D-16-UB	7/14/93	4.84	0.05	9.3	3.4	15.2	1.5							7.6	163	
D-16-UB	1/4/94	102	0.35	17.5	0	14.6	4.5							6.7	154	
D-16-UB	6/28/94	42.2	0.17	12.6	8.3	13.8	3.5								150	
D-16-UB	9/13/94	40.5	0.17	13.2	8.8	15.6	3.6								155	
D-16-UB	10/5/94	47.7	0.22	13.9	10.6	15.0	3.8									
D-16-UB	2/17/95	5.47	0.08	10.8	4.4	14.3	1.9									
D-16-UB	5/15/95	19.8	0.09	10.7	4.6	15.2	2.4									
D-16-UB	8/14/95	43.6	0.15	15.0	6.9	15.1	3.2								173	
D-17-OB	2/20/84	0.4		0.74	0.42	10.8	1.41	4						4.3	100	4.8
D-17-OB	6/21/84	4.8	0	1.28	0.56	15.6	1.34	1						4.4	108	-5.9
D-17-OB	9/29/84	4.3	0	2.25	0.65	18.4	1.25	2						4.5	110	5.9

D-17-OB	1/4/85	8	0	6.8	0.6	12.9	1.09	<5						4.2	105	5.3
D-17-OB	4/23/85	8.2	0	1.58	0.71	13.7	1.29	2	0.02		0.2		0.09	3.5	190	-5.9
D-17-OB	7/23/85	15	0	2.72	0.89	13.6	1.11	5	0.01	17.8	0.3		0.04	3.8	120	-5.3
D-17-OB	10/21/85	6.2	0	1.56	0.71	13.3	0.74	<5	0.06	31	0.5		0.04	4	110	-5.9
D-17-OB	1/23/86	7.9	0	1.5	0.57	14.1	1.76	<5	0.06	22	0.3		0.07	3.6	140	-5.9
D-17-OB	7/9/86	3.2	0			11								4.3	110	
D-17-OB	9/3/86	3.2	0.1			10.4								4.4	108	
D-17-OB	11/19/86	1.9	0			10.6								4.1	105	
D-17-OB	3/16/87	3	0			10.2								4.5	115	
D-17-OB	9/17/87					12										
D-17-OB	11/16/87					11.2										
D-17-OB	2/17/88					11										
D-17-OB	5/12/88					11										
D-17-UB	3/2/84	42		14.5	7	42	4.38	57						6.7	250	31.4
D-17-UB	6/21/84	8.3	0.2	21	10.3	33	4.28	189						7.2	340	-1.4
D-17-UB	9/29/84	11	0.2	22	9.6	23	4.32	141						6.7	237	1.8
D-17-UB	1/4/85	5.1	0.1	21	6.9	33	4.4	166						6.8	308	-1.5
D-17-UB	4/23/85	3.2	0.1	22	9.65	28	4.18	185	0.2		<0.1		0.04	6.8	310	-5.7
D-17-UB	7/23/85	30	0.3	26	9.38	28	3.39	180	0.1	22	0.4		0.01	6.8	290	-2.9
D-17-UB	10/21/85	31	0.3	24	9.74	29	5.5	171	0.19	37	0.2		0.02	6.8	290	-1.4
D-17-UB	1/23/86	93	0.9	29	9.95	29	4.82	173	0.21	26	0.2		0.01	6.9	282	1.4
D-17-UB	7/9/86	17	0.4			27								7	340	
D-17-UB	9/3/86	14	0.2			25								6.6	335	
D-17-UB	11/19/86	7.4	0.1			26								6.6	310	

D-17-UB	3/16/87	7.4	0.1			26								7.2	325	
D-17-UB	9/17/87					28.3								7.02		
D-17-UB	11/16/87					25.2								7.03		
D-17-UB	2/17/88					26.2								6.94		
D-17-UB	5/12/88					24.5								7.04		
D-19-OB	none															
D-19-UB	none															
D-2-(Alluv)	2/18/84	0.18		27.10	9.50	50.0	4.32	178.00						8.1	360	4.0
D-2-(Alluv)	6/23/84	20.4	0.42	30.00	8.20	47.0	3.65	174.00						7.6	410	-1.1
D-2-(Alluv)	9/30/84	19.4	0.37	33.00	7.50	49.0	3.82	166.00						7.7	340	2.4
D-2-(Alluv)	1/8/85	41.0	0.73	38.00	6.90	35.0	3.36	166.00						7.5	390	0.0
D-2-(Alluv)	4/20/85	58.0	1.12	31.00	8.18	40.0	3.83	180.00	0.01		<0.1		0.05	7	382	-3.6
D-2-(Alluv)	7/23/85	77.0	0.93	29.00	7.78	35.0	2.91	170.00	<0.01		0.1		0.03	7.4	345	-5.1
D-2-(Alluv)	10/14/85	85.0	1.24	32.00	7.82	39.0	3.32	168.00	0.1		0.2		0.02	7.4	390	-1.2
D-2-(Alluv)	1/23/86	4.81	0.55	38.00	8.55	38.0	4.54	176.00	0.2		0.1		0.03	7.4	340	3.5
D-2-(Alluv)	6/28/86	7.04	0.19			33.0								7.3	410	
D-2-(Alluv)	9/5/86	15.5	0.30			32.0								7.6	398	
D-2-(Alluv)	11/19/86	3.16	0.12			36.0								6.9	335	
D-2-(Alluv)	3/16/87	34.0	0.39			37.0								7.8	395	

D-2-(Alluv)	9/20/87					35.7										
D-2-(Alluv)	11/16/87					37.2										
D-2-(Alluv)	2/15/88					36.8										
D-2-(Alluv)	5/11/88					38.1										
D-2-(Alluv)	8/13/88					36.5										
D-2-(Alluv)	11/15/88					50.0										
D-2-(Alluv)	2/20/93	7.27	0.26	33.40	8.70	38.4	2.60									
D-2-(Alluv)	10/26/93	164	2.07	31.90	7.80	35.8	3.50									
D-2-(Alluv)	1/4/94	50.3	0.55	40.60	15.70	35.9	6.30									
D-2-(Alluv)	6/27/94	24.1	0.32	35.60	11.20	33.5	4.50									
D-2-(Alluv)	9/13/94	31.5	0.32	37.40	13.30	36.4	4.80									
D-2-(Alluv)	10/4/94	130	1.44	58.70	32.40	36.9	8.30									
D-2-(Alluv)	2/17/95	21.5	0.39	36.20	12.10	35.1	4.20									
D-2-(Alluv)	5/16/95	3.24	0.16	30.60	8.10	33.7	3.30									
D-2-(Alluv)	8/14/95	11.1	0.20	32.80	9.90	35.9	3.40									
D-2-(Alluv)	10/4/95	17.5	0.23	33.70	10.30	33.9	4.10									
D-2-(Alluv)	1/8/96	28.0	0.32	34.20	10.70	34.9	3.70									
D-21-OB	2/20/84	2.70		0.88	0.81	6.86	0.361	7.0						5.4	30	0.2

D-21-OB	6/27/84	52.0	0.11	0.55	0.62	8.28	0.4	4.0						5.5	28	0.0
D-21-OB	9/29/84	30.5	0.10	0.82	0.86	3.2	0.47	2.0						5	30	0.0
D-21-OB	1/7/85	45.1	0.24	0.80	1.23	3.6	0.4	5.0						5.5	38	-14
D-21-OB	4/22/85	55.0	0.12	0.79	1.00	2.75	0.0	6.0			<0.1		0.05	4.7	31	-14
D-21-OB	7/23/85	97.0	0.12	0.55	0.81	2.92	0.24	7.0		7.3	0.10		0.02	4.9	30	-14
D-21-OB	10/13/85	144	0.11	0.53	0.58	4.32	0.38	<5	0	20	0.30		0.02	4.8	30	0.0
D-21-OB	1/24/86	120	0.05	1.24	1.04	2.61	0.35	7.0		15.4	0.40		0.03	4.8	32	-14
D-21-OB	6/29/86	175	0.07			2.56								4.4	30	
D-21-OB	9/4/86	180	0.12			2.2								4.9	30	
D-21-OB	11/19/86	18.0	0.01			1.9								4.6	28	
D-21-OB	3/24/87	29.0	0.01			2.26								5.1	39	
D-21-OB	9/21/87					2.2										
D-21-OB	11/16/87					2.2										
D-21-OB	5/12/88					2.6										
D-21-OB	8/13/88					1.9										
D-21-OB	11/17/88					3.6										
D-21-OB	4/15/93	91.0	0.11	1.2	1.1	3.9	0.6							5.8		
D-21-OB	7/13/93	95.0	0.08	1.0	1.0	4.5	0.2							5.6	38	
D-21-OB	10/26/93	126	0.08	1.4	1.0	2.8	0.1							5.8	42	
D-21-OB	1/4/94	91.7	0.10	4.9	5.5	2.9	4.5							5.5	38	
D-21-OB	6/27/94	135	0.10	4.7	5.2	3.2	3.4								39	
D-21-OB	9/12/94	113	0.07	4.2	5.7	2.8	4.1								36	
D-21-OB	10/4/94	44.5	0.05	2.0	2.5	2.8	1.5									
D-21-OB	2/15/95	114	0.08	5.6	5.1	3.2	2.7									

D-21-OB	5/15/95	53.9	0.05	1.7	2.1	3.0	1.0									
D-21-OB	8/14/95	64.6	0.06	2.8	4.1	2.7	1.9								39	
D-22-OB	4/14/84	5.1		2.24	1.01	5.8	1.02	12						5.9	60	20.8
D-22-OB	6/22/84	5	0.1	1.88	1.17	10.7	1.12	18						5.8	68	-6.7
D-22-OB	9/29/84	2.6	0.1	2.71	1.25	6.23	1.26	13						5.5	65	-9.1
D-22-OB	1/6/85	5.7	0.1	4.36	1.28	4.9	0.95	11						5.5	50	0.0
D-22-OB	4/22/85	3.4	0	6.03	1.19	4.79	1.74	13	0.07		<0.1		0.31	5.3	50	0.0
D-22-OB	7/25/85	4.2	0.1	1.74	1.05	4.29	0.82	11	0.04	17.3	<0.1		0.02	5.2	55	-9.1
D-22-OB	10/19/85	2.9	0	4.46	1.14	4.66	1	15	0.1	26	0.4		0.02	5.5	68	-7.7
D-22-OB	1/23/86	4.3	0	2.86	1.44	4.95	1.01	14	0.2	20	0.1		0.03	5.2	43	-7.7
D-22-OB	6/26/86	3.6	0			4.36								5.4	60	
D-22-OB	9/4/86	2.8	0.1			4.67								5.5	58	
D-22-OB	11/18/86	5.7	0			4.35								5.1	53	
D-22-OB	3/23/87	2	0			4.2								5.8	59	
D-22-OB	9/20/87					4										
D-22-OB	11/16/87					4.3										
D-22-OB	2/16/88					4										
D-23-OBa	2/22/84	16		27.2	15.7	40	6.33	127						6.9	320	11.4
D-23-OBa	6/22/84	8.4	0.2	24	13	30	5.36	129						6.5	375	-1.3
D-23-OBa	9/29/84	17	0.3	82	37	101	6.52	81						7.3	1340	4.5
D-23-OBa	1/8/85	38	0.7	27	11.2	21	4.4	68						4.7	280	3.1
D-23-OBa	4/24/85	13	0.2	25	12.6	24	4.82	123	0.3		0.1		0.02	6.4	335	4.1
D-23-OBa	7/21/85	67	1.1	23	12.6	23	4.06	115	0.3	26	0.1		0.07	6.2	335	-2.8
D-23-OBa	10/20/85	51	0.9	29	12.8	23	5.2	112	0.3	36	0.3		0.04	6.3	322	0.0

D-23-OBa	1/23/86	33	0.5	28	12.5	24	4.82	112	0.4	28	0.2		0.03	6.4	310	-1.3
D-23-OBb	3/2/84	6.2		0.84	0.53	5.8	0.814	1						4.8	38	10.2
D-23-OBb	6/22/84	21	0	0.6	0.05	6	0.46	2						4.8	39	0.0
D-23-OBb	1/8/85	19	0.1	10.6	2.88	13	2.36	51						6.3	320	-9.7
D-23-OBb	4/24/85	0.7	0	1.37	0.95	3.9	0.47	6	0.2		0.2		0.12	5.1	39	-14
D-23-OBb	7/21/85	50	0.1	0.25	0.82	2.9	0.4	5	0.1	17.1	1.4		0.01	4.5	38	0.0
D-23-OBb	10/20/85	18	0	0.58	0.75	3.4	0.54	5	0.1	30	0.2		0.01	4.3	40	-14
D-23-OBb	1/23/86	34	0	0.89	1.16	3.9	0.4	5	0.1	20	0.3		0.03	4.4	40	-11
D-23-UB	2/22/84	2.1		75.8	42	146	9.1	173						8.1	1150	0.1
D-23-UB	6/22/84	2.4	0.1	78	38.6	119	8.4	170						7.5	1020	-3.9
D-23-UB	9/29/84	9.6	0.1	81	34	98	5.84	55						7.1	1210	5.2
D-23-UB	1/8/85	7	0.1	97	35	95	7.6	162						7.3	1110	-1.2
D-23-UB	4/24/85	1.1	0.1	94	38	106	8.1	177	0.3		0.2		0.06	6.6	1290	1.6
D-23-UB	7/21/85	0.8	0.1	103	39	105	7.52	167	0.3	5.8	0.1		0.01	7	1250	-0.8
D-23-UB	10/20/85	3.4	0.1	100	40	108	9.3	160	0.3	16.3	0.1		<0.01	7.4	1220	-0.4
D-23-UB	1/23/86	3.2	0.1	104	39	107	8.55	167	0.3	14.1	0.1		0.02	7	1250	0
D-24-OB	2/18/84	0.6		0.82	0.53	7.3	0.824	10						5.7	30	0.6
D-24-OB	6/22/84	18	0.2	0.52	0.35	9.62	0.84	5						5.4	50	0.0
D-24-OB	9/29/84	30	0.1	1.16	0.69	4.29	1.02	2						4.9	39	0.0
D-24-OB	1/6/85	25	0.2	5.95	0.59	3.43	0.85	5						5	34	11.1
D-24-OB	4/22/85	12	0.1	0.58	0.88	2.3	0.66	5	0.02		<0.1		0.06	4.8	32	-14.3
D-24-OB	7/25/85	9.5	0	0.89	1.04	2	0.63	<5	<0.01	3.4	0.2		0.13	5	35	-20.0
D-24-OB	10/19/85	15	0	1.34	0.81	1.98	0.6	<5	0.04	13.7	0.1		0.03	4.5	31	0.0

D-24-OB	1/23/86	23	0.1	2.85	1.17	1.94	1	7	0.1	7.3	0.2		0.03	5	32	-11
D-24-OB	6/27/86	33	0.1			1.7								4.6	30	
D-24-OB	9/4/86	26	0.1			2.68								5	30	
D-24-OB	11/19/86	7.2	0			1.7								4.8	32	
D-24-OB	3/23/87	7.6	0			1.4								5.6	26	
D-24-OB	9/17/87					1.4										
D-24-OB	11/16/87					1.3										
D-24-OB	2/15/88					1.2										
D-24-OB	5/12/88					1.7										
D-24-OB	8/13/88					6.06										
D-24-OB	11/17/88					3.3										
D-25-OB-T	3/13/84	0.1		0.52	0.51	7.2	0.616	<1						4	80	0.6
D-25-OB-T	6/21/84	0.4	0	0.69	0.78	8.61	0.48	<1						4.2	70	0.0
D-25-OB-T	9/29/84	0.4	0	1.95	1.07	6.75	0.84	<1						4.1	72	-9.1
D-25-OB-T	1/4/85	0.3	0	7.05	0.65	3.66	0.45	<5						4.1	60	11.1
D-25-OB-T	4/18/85	0.1	<0.01	0.96	0.77	3.5	0.46	<1	<0.01		0.3		0.15	4	58	-25.0
D-25-OB-T	7/23/85	0.8	0	0.54	0.83	3.93	0.49	<5	<0.01	27	0.6		0.06	3.8	62	-14.3
D-25-OB-T	10/20/85	0.3	0	0.98	0.89	4.54	0.53	<5	0	34	0.7		0.06	3.8	90	-20.0
D-25-OB-T	1/23/86	0.4	<0.01	0.92	0.78	3.86	0.49	<5	0.1	27	0.5		0.05	3.9	63	-11.1
D-25-OB-T	6/30/86	0.3	0			3.26								3.7	70	
D-25-OB-T	8/27/86	0.3	0.1			3.22								3.2	75	
D-25-OB-T	11/18/86	0.9	0			4								3.5	90	
D-25-OB-T	3/15/87	0.8	0			2.96								4.4	57	

D-25-OB-T	9/17/87					3										
D-25-OB-T	11/17/87					3.9										
D-25-OB-T	2/17/88					3										
D-25-OB-T	5/12/88					3.2										
D-25-OB-T	8/13/88					2.8										
D-25-OB-T	11/17/88					5.5										
D-26-OB	7/8/86	0.38	0.03			4.82								5.6	50	
D-26-OB	8/28/86	0.16	0.08			3.88								4.8	48	
D-26-OB	11/17/86	0.26	0.03			4.50								5.3	49	
D-26-OB	3/15/87	0.40	0.02			4.59										
D-26-OB	9/18/87					4.40										
D-26-OB	11/19/87					15.7										
D-26-OB	2/18/88					1.50										
D-26-OB	5/14/88					4.73										
D-26-OB	8/15/88					2.80										
D-26-OB	11/20/88					9.60										
D-26-UB	7/8/86	0.50	0.16			44.0								7.2	430	
D-26-UB	8/28/86	0.45	0.20			42.0								6.6	440	
D-26-UB	11/17/86	3.79	0.19			44.0								6.8	400	
D-26-UB	3/15/87	1.10	0.11			43.0								7.8	420	
D-26-UB	9/18/87					43.7										
D-26-UB	11/19/87					43.5										
D-26-UB	2/18/88					48.0										
D-26-UB	5/14/88					44.6										

D-26-UB	8/15/88					43.0										
D-26-UB	11/20/88					60.0										
D-26-UB	3/5/93	0.18	0.11	25.3	10.0	44.8	3.5									
D-26-UB	4/20/93	0.38	0.11	25.1	10.2	45.3	3.3									
D-26-UB	7/23/93	0.25	0.10	23.9	9.8	43.9	3.2							8.1	427	
D-26-UB	11/2/93	0.19	0.10	25.1	9.9	42.6	3.7							8.1	424	
D-26-UB	1/6/94	0.16	0.09	24.3	9.6	43.6	4.4								428	
D-26-UB	6/23/94	2.30	0.11	24.1	9.8	44.5	3.6								429	
D-26-UB	9/9/94	3.17	0.14	24.2	10.4	44.1	3.3								422	
D-26-UB	10/4/94	0.75	0.10	24.9	10.2	46.0	2.7									
D-26-UB	2/14/95	9.17	0.22	25.6	12.1	45.3	5.9									
D-26-UB	5/11/95	3.04	0.12	24.2	10.1	42.9	3.0									
D-26-UB	8/9/95	8.62	0.18	24.7	11.4	45.2	4.3								426	
D-26-UB	10/3/95	49.9	0.85	33.9	21.0	45.1	7.1								435	
D-26-UB	1/8/96	5.98	0.18	24.4	10.4	43.6	3.4								433	
D-26-UB	4/30/96	11.6	0.21	26.4	12.2	47.2	4.4							8	434	
D-27-D	6/30/86	0.7	0.1			45								6.6	360	
D-27-D	8/28/86	0.4	0.1			43								6.8	375	
D-27-D	11/17/86	0.5	0.1			45								6.7	348	
D-27-D	3/16/87	1.2	0.5			46								7.2	370	
D-27-D	9/18/87					46										
D-27-D	11/19/87					45										
D-27-D	2/19/88					49										
D-27-D	5/14/88					43										

D-27-D	8/15/88					39										
D-27-D	11/20/88					60										
D-27-S	6/30/86	4.5	0.1			5.8								3.9	110	
D-27-S	8/28/86	3.5	0.1			5.4								3.9	120	
D-27-S	11/27/86	4.7	0.1			6.2								4.1	120	
D-27-S	3/16/87	3.9	0			5.4								4.2	128	
D-27-S	9/18/87					5.1										
D-27-S	11/19/87					5.2										
D-27-S	2/19/88					2.2										
D-27-S	5/14/88					5.5										
D-27-S	8/15/88					4.2										
D-27-S	11/20/88					11										
D-28-D	7/8/86	0.3	0			42								7.2	430	
D-28-D	8/28/86	0.7	0.1			42								7.5	440	
D-28-D	11/17/86	0.4	0			44								7.6	408	
D-28-D	3/24/87	0.6	0			45								8	420	
D-28-D	9/18/87					44										
D-28-D	11/18/87					44										
D-28-D	2/17/88					46										
D-28-D	5/14/88					44										
D-28-D	8/15/88					33										
D-28-D	11/20/88					57										
D-28-S	7/8/86	10	0.1			4.2								5.4	70	
D-28-S	8/28/86	6.2	0.1			3.6								5.1	65	

D-28-S	11/17/86	8.9	0.1			4.3								5.4	73	
D-28-S	3/24/87	6.5	0.1			4.3								4.5	77	
D-28-S	9/18/87					3										
D-28-S	11/18/87					3										
D-28-S	2/17/88					3.2										
D-28-S	5/14/88					2.7										
D-28-S	8/15/88					5										
D-28-S	11/20/88					4.9										
D-29-D	6/26/86	1.8	0.1			37								6.6	485	
D-29-D	8/27/86	6.7	0.2			37								7.1	495	
D-29-D	11/17/86	3.2	0.2			37								7	460	
D-29-D	3/15/87	1.7	0.1			39								7.7	475	
D-29-D	9/19/87					39										
D-29-D	11/18/87					40.8										
D-29-D	2/19/88					41										
D-29-D	5/14/88					41										
D-29-D	8/14/88					43										
D-29-D	11/20/88					55										
D-29-S	6/26/86	13	0.3			6.03								5.8	120	
D-29-S	8/27/86	11	0.3			5.05								6.3	105	
D-29-S	1/17/87	8.5	0.3			4.66								6.3	82	
D-29-S	3/15/87	17	0.3			4.87								6.4	97	
D-29-S	9/19/87					5.4										
D-29-S	11/18/87					4.6										

D-29-S	2/19/88					2.1										
D-29-S	5/14/88					5.82										
D-29-S	8/14/88					4.8										
D-30-D	6/26/86	###	0.26			23.0										
D-30-D	8/27/86	###	0.26			20.0										
D-30-D	11/17/86	###	0.38			21.0										
D-30-D	3/15/87	###	0.95			22.0										
D-30-D	9/18/87					19.9										
D-30-D	11/18/87					22.1										
D-30-D	2/19/88					19.2										
D-30-D	5/14/88					21.9										
D-30-D	8/15/88					20.0										
D-30-D	11/17/88					30.0										
D-30-D	2/18/93	0.24	0.05	21.6	10.8	22.3	1.9							7.7	292	
D-30-D	4/20/93	2.38	0.07	21.1	10.5	22.5	1.9									
D-30-D	7/15/93	1.40	0.07	20.6	10.4	21.7	2.3									
D-30-D	11/3/93	2.84	0.07	18.8	9.7	19.9	2.2							7.5	286	
D-30-D	1/5/94	2.25	0.07	20.1	9.3	20.4	1.8							7	299	
D-30-D	6/24/94	17.4	0.18	22.1	13.6	22.3	3.9								288	
D-30-D	9/13/94	5.83	0.09	21.2	11.2	22.0	2.4								278	
D-30-D	10/5/94	4.47	0.08	21.0	10.7	21.6	2.0									
D-30-D	2/16/95	17.0	0.27	26.7	16.5	21.5	3.1									
D-30-D	5/30/95	13.7	0.21	21.2	12.4	20.8	3.3									
D-30-D	8/10/95	15.5	0.24	21.8	13.6	21.3	3.7								266	

D-30-D	10/4/95	17.0	0.22	22.5	12.7	20.9	3.0								275	
D-30-D	1/4/96	12.2	0.17	19.6	10.9	20.6	2.6								271	
D-30-D	5/1/96	22.0	0.29	23.0	15.3	22.6	4.1							7.3	280	
D-30-S	6/26/86	9.76	0.27			14.4										
D-30-S	8/27/86	8.16	0.28			14.7										
D-30-S	11/17/86	7.24	0.25			15.9										
D-30-S	3/15/87	9.40	0.25			17.5										
D-30-S	9/18/87					16.1										
D-30-S	11/18/87					15.9										
D-30-S	2/19/88					14.2										
D-30-S	5/14/88					17.6										
D-30-S	8/15/88					14.0										
D-30-S	11/17/88					25.8										
D-30-S	2/17/93	12.5	0.55	6.7	8.4	26.7	2.0							7.1	242	
D-30-S	4/20/93	12.0	0.47	5.9	7.4	24.9	1.6									
D-30-S	7/15/93	8.69	0.29	3.9	4.6	18.4	1.7									
D-30-S	11/3/93	7.68	0.27	3.6	4.3	17.0	1.7							7	154	
D-30-S	1/6/94	8.82	0.34	4.1	4.8	18.8	2.4								185	
D-30-S	6/24/94	7.92	0.22	3.9	4.1	16.9	1.3								161	
D-30-S	9/13/94	9.64	0.27	4.0	4.6	17.9	1.1								162	
D-30-S	10/4/94	9.18	0.33	4.5	5.4	18.5	1.2									
D-30-S	2/15/95	17.2	0.60	6.6	8.3	25.7	2.3									
D-30-S	5/30/95	12.0	0.38	5.0	5.9	22.0	1.5									
D-30-S	8/10/95	7.74	0.29	3.9	4.3	17.7	1.3								175	

D-30-S	10/3/95	10.7	0.29	4.0	4.5	16.6	1.7								145	
D-30-S	1/4/96	12.7	0.46	5.0	6.2	21.1	2.1								209	
D-30-S	5/1/96	15.2	0.65	7.4	9.6	30.2	2.2							6.5	287	
D-31-OB	6/30/86	4	0.1			2.7								5.2	50	
D-31-OB	9/27/86	1	0.1			2.1								5.2	35	
D-31-OB	11/17/86	1.1	0			2								5.8	35	
D-31-OB	3/15/87	0.8	0			1.7								5.4	27	
D-31-OB	9/18/87					2.2										
D-31-OB	11/17/87					1.5										
D-31-OB	2/17/88					1.7										
D-31-OB	5/13/88					2.1										
D-31-OB	8/15/88					1.3										
D-31-OB	11/17/88					3.1										
D-31-UB	6/30/86	8	0.2			12.5								6	145	
D-31-UB	8/27/86	6.7	0.2			12								6.1	140	
D-31-UB	11/17/86	17	0.3			13.2								6.1	128	
D-31-UB	3/15/87	13	0.2			11								6.7	122	
D-31-UB	9/18/87					12.2										
D-31-UB	11/17/87					11										
D-31-UB	2/17/88					10.9										
D-31-UB	5/13/88					12										
D-31-UB	8/15/88					13.7										
D-31-UB	11/17/88					15.5										
D-32-D	7/9/86	2.2	0.2			55								6.8	700	

D-32-D	8/28/86	2.2	0.2			47								6.7	610	
D-32-S	7/9/86	6.8	0.2			47								6.9	620	
D-32-S	8/28/86	27	0.4			51								6.6	600	
D-35-OB	9/19/87					5.20										
D-35-OB	11/19/87					8.50										
D-35-OB	2/18/88					4.80										
D-35-OB	5/13/88					9.50										
D-35-OB	8/14/88					7.80										
D-35-OB	11/19/88					9.60										
D-35-OB	2/22/93	41.6	2.04	12.8	20.7	14.1	1.7									
D-35-OB	4/17/93	138	2.07	12.1	16.7	12.2	1.5							3.4	565	
D-35-OB	7/20/93	167	0.89	8.2	10.7	8.4	3.6								400	
D-35-OB	11/1/93	6.72	0.44	3.9	6.6	5.9	2.0							4.2	175	
D-35-OB	1/5/94	36.5	0.17	2.4	2.7	5.8	1.8							4.8	91	
D-35-OB	6/27/94	34.9	0.21	2.7	3.5	6.2	2.2								99	
D-35-OB	9/7/94	16.0	0.12	1.6	2.2	6.2	1.2								79	
D-35-OB	10/3/94	2.97	0.09	1.4	1.9	5.9	1.0									
D-35-OB	2/16/95	6.68	0.77	15.4	12.3	10.0	0.9									
D-35-OB	5/11/95	7.78	0.47	7.1	6.9	7.9	0.9									
D-35-OB	8/9/95	1.33	0.05	30.6	12.8	32.6	3.6								412	
D-35-OB	10/3/95	62.8	0.2	2.40	3.80	6.8	2.20									
D-35-OB	1/5/96	18.5	0.3	4.00	4.70	6.3	2.40									
D-35-OB	5/2/96	21.2	0.1	3.00	2.00	4.7	1.90									
D-36-OB	9/19/87					13										

D-36-OB	11/16/87					12										
D-36-OB	2/19/88					1.5										
D-36-OB	5/11/88					12										
D-36-OB	8/14/88					11										
D-36-OB	11/17/88					13										
D-37-OB	9/19/87					5.40										
D-37-OB	11/18/87					5.20										
D-37-OB	2/15/88					5.30										
D-37-OB	5/13/88					5.15										
D-37-OB	8/13/88					4.80										
D-37-OB	11/19/88					9.80										
D-38-UB	7/8/86	1.2	0.1			47								7.1	510	
D-38-UB	8/27/86	0.9	0.1			44								7	520	
D-38-UB	11/18/86	1.9	0.1			48								7.2	550	
D-38-UB	3/23/87	0.7	0			50								7.9	520	
D-39-UB	7/8/86	0.8	0			90								8.1	495	
D-39-UB	8/29/86	1	0.1			89								8	510	
D-39-UB	11/18/86	4.7	0.1			91								8	465	
D-39-UB	3/24/87	11	0.2			91								8.4	480	
D-39-UB	9/19/87					93.8										
D-3-OB	3/2/84	2.9		3.18	1.33	9.3	4	1						4.1	143	2.0
D-3-OB	6/23/84	2.6	0.1	4.05	1.3	16	2.25	<1						4	135	-4.3
D-3-OB	9/29/84	5.3	0.1	2.67	2.03	17	2.99	2						4.6	125	4.8
D-3-OB	1/8/85	6.7	0.1	4.47	1.41	8.4	2.02	<5						3.9	130	-5.9

D-3-OB	4/22/85	1.7	0.1	1.8	1.1	8.4	2.06	<1	0.1		1.4		0.25	3.7	142	-6.7
D-3-OB	7/23/85	2.9	0.1	1.56	1.89	7.8	2.27	<5	0.2	75	1.3		0.24	3.7	120	-13
D-3-OB	10/17/85	7.4	0.2	1.31	1.82	7.9	2.54	<5	0.2	79	0.5		0.25	3.7	158	-5.3
D-3-OB	1/23/86	11	0.1	1.74	1.3	7.1	1.91	<5	0.2	75	1.1		0.27	3.6	140	-5.9
D-3-OB	6/28/86	15	0.1			7.3								3.4	160	
D-3-OB	9/5/86	7	0.1			6.7								3.7	150	
D-3-OB	11/18/86	3.1	0.1			5.6								3.2	130	
D-3-OB	9/21/87					7.2										
D-3-OB	11/16/87					6.5										
D-3-OB	5/12/88					7.1										
D-3-OB	8/13/88					7.5										
D-3-OB	11/5/88					11										
D-41-UB	9/19/87					58.9										
D-41-UB	11/19/87					37.8										
D-41-UB	2/18/88					49.1										
D-41-UB	5/13/88					41.3										
D-41-UB	8/14/88					47.0										
D-41-UB	11/19/88					54.0										
D-41-UB	2/22/93	31.5	0.45	34.6	13.7	39.9	4.2									
D-41-UB	4/17/93	1.70	0.07	35.4	14.3	35.3	3.8							8	435	
D-41-UB	7/20/93	5.04	0.09	33.8	13.1	33.2	3.7								434	
D-41-UB	11/1/93	0.35	0.05	32.6	13.9	33.3	4.4							7.8	436	
D-41-UB	1/5/94	51.4	0.39	41.0	17.4	34.6	5.0							7.6	451	
D-41-UB	6/27/94	0.88	0.06	34.6	13.2	32.2	3.5								435	

D-41-UB	9/7/94	0.75	0.07	31.9	13.3	33.1	3.1								435	
D-41-UB	10/3/94	0.53	0.05	33.9	14.1	33.9	3.6									
D-41-UB	2/14/95	1.13	0.07	34.8	14.4	34.8	4.0									
D-41-UB	5/11/95	0.83	0.05	31.1	12.7	31.8	2.9									
D-41-UB	8/9/95	1.76	0.05	31.6	13.2	32.3	3.8								417	
D-41-UB	10/3/95	0.70	0.1	34.20	12.90	33	3.90									
D-41-UB	1/4/96	0.64	0.1	30.40	12.10	32	2.80									
D-41-UB	4/30/96	0.77	0.1	36.30	14.90	37	0.10									
D-42-UB	6/27/86	6	0.1			19								6.2	260	
D-42-UB	8/28/86	5.7	0.2			18								6.3	275	
D-42-UB	11/17/86	3.7	0.1			19								6.6	260	
D-42-UB	3/24/87	6.2	0.1			20								6.9	269	
D-42-UB	9/19/87					18										
D-42-UB	11/18/87					20										
D-42-UB	2/15/88					19										
D-42-UB	5/13/88					19										
D-42-UB	8/13/88					21										
D-42-UB	11/19/88					56										
D-43-UB	9/19/87					21.7										
D-43-UB	11/18/87					21.7										
D-43-UB	2/15/88					21.9										
D-43-UB	5/13/88					22.3										
D-43-UB	8/13/88					24.3										
D-43-UB	11/19/88					58.5										

D-44-S	8/9/95	64.2	0.43	43.1	12.3	14.4	3.1								312	
D-44-S	10/4/95	35.1	0.28													
D-44-S	5/2/96	16.0	0.12													
D-44-S	7/16/96	13.7	0.12													
D-44-S	10/28/96	12.1	0.09													
D-44-S	3/4/97										10.7	0.1	0.07			
D-45-S	12/26/95	363	7.51	120.00	189.00	96.3	20.90									
D-45-S	1/5/96	33.7	1.44	28.40	26.00	28.3	4.30									
D-45-S	5/1/96	306	84	64.60	3.09	88.6	2.10									
D-45-S	7/9/96	199	2.69	106.00	175.00	124	14.40									
D-45-S	10/21/96	9.47	0.50	52.20	65.50	64.7	5.30									
D-4-UB	2/29/84	37		19.2	10.1	50	5.66	109						6.4	357	4.0
D-4-UB	6/23/84	13	0.2	19.3	9	47	4.18	121						6.5	390	-2.4
D-4-UB	9/29/84	56	0.6	20	9.8	39	4.56	106						6.3	340	2.8
D-4-UB	1/8/85	33	0.4	20	7.6	35	4.04	107						6.4	370	-5.9
D-4-UB	4/22/85	13	0.1	21	9.7	40	4.66	115	0.2		<0.1		0.05	6.7	352	2.6
D-4-UB	7/23/85	20	0.2	23	9.06	40	3.72	111	0.3	50	0.2		0.04	6.3	300	0.0
D-4-UB	10/17/85	12	0.1	22	8.9	41	4.16	109	0.2	61	0.2		0.04	6.4	370	2.6
D-4-UB	1/23/86	23	0.2	27	9	38	4.94	109	0.3	46	0.2		0.02	6.3	330	0.0
D-4-UB	6/28/86	21	0.2			36								6	380	
D-4-UB	9/5/86	9.6	0.2			35								6.4	395	
D-4-UB	11/18/86	6.5	0.1			37								5.8	340	
D-4-UB	3/16/87	12	0.1			37								6.5	395	
D-4-UB	9/21/87					38										

D-4-UB	11/16/87					39										
D-4-UB	2/18/88					39										
D-4-UB	5/12/88					38										
D-4-UB	8/13/88					41										
D-4-UB	11/17/88					61										
D-6-UB	2/22/93	30.5	0.23	4.8	5.1	14.8	1.7									
D-6-UB	4/16/93	72.5	0.31	4.9	5.0	14.0	1.1							6.6	157	
D-6-UB	7/14/93	43.9	0.28	5.0	5.2	15.4	1.5							6.8	151	
D-6-UB	10/27/93	8.21	0.11	4.4	0	14.2	1.2							6.8	155	
D-6-UB	1/4/94	51.9	0.35	9.1	13.8	14.7	4.1							6.5	152	
D-6-UB	6/30/94	26.3	0.22	7.2	8.6	14.5	2.6								157	
D-6-UB	9/7/94	28.6	0.25	8.4	10.0	15.6	3.0								167	
D-6-UB	10/4/94	45.0	0.29	7.9	13.1	15.3	3.4									
D-6-UB	2/17/95	25.8	0.19	6.5	9.0	13.1	2.4									
D-6-UB	5/15/95	10.4	0.12	4.6	5.3	12.3	1.1									
D-7-OB-T	3/22/84	1.2		0.98	0.23	7.8	2.35	<1						3.8	90	
D-7-OB-T	6/21/84	4.58	0.04	0.81	0.59	8.8	0.96	1						4.6	60	0.0
D-7-OB-T	9/28/84	9.2	0.01	1.88	0.7	8.9	1.3	2						5.4	80	0.0
D-7-OB-T	1/4/85	3.76	0.08	11.2	1.38	6.6	2.32	5						5.2	98	5.3
D-7-OB-T	4/18/85	1.69	0.02	0.94	0.8	4.3	1.35	<1	<0.01		0.2		0.12	4	75	-20.0
D-7-OB-T	7/22/85	1.4	0.02	0.99	0.89	3.9	0.95	<5	<0.01	18	0.3		0.11	4	61	-11
D-7-OB-T	10/17/85	1.19	0.01	0.49	0.54	4.6	0.77	<5	0.1	29	0.1		0.08	4.1	60	-14
D-7-OB-T	1/23/86	1.9	0.03	1.82	0.83	4.6	1.39	<5	0.1	25	0.2		0.07	3.9	70	-9.1
D-7-UB	3/21/84	3.6		34.5	17.4	91	6.65	156						7.6	770	

D-7-UB	6/21/84	1.7	0.1	41	17.8	90	5.8	162						7.6	830	-1.3
D-7-UB	9/28/84	6.1	0.1	50	19.2	89	6.62	202						7.2	890	0.6
D-7-UB	1/5/85	1.2	0.1	37	13.8	89	5.7	157						7.1	800	-2.1
D-7-UB	4/22/85	3.6	0.1	45	18.2	92	6	158	0.1		<0.1		0.04	7.2	820	1.3
D-7-UB	7/22/85	4.3	0.1	47	16.4	86	3.76	156	0.2	7.1	<0.1		0.01	7.1	700	-2.6
D-7-UB	10/19/85	3	0.1	52	17.3	91	5.95	150	0.3	18.4	0.2		<0.01	7.3	800	1.2
D-7-UB	1/23/86	4.9	0.1	58	17.1	89	5.94	151	0.3	15.8	0.1		0.01	7	750	3.1
D-8-OB	3/1/84	45		2.12	0.43	13.4	3.14	<1						3.6	204	1.0
D-8-OB	6/23/84	54	0.3	4.24	2.43	26	3.34	<1						4.2	270	-2.0
D-8-OB	9/28/84	30	0.2	7.07	2.5	27	3.73	<1						3.5	319	-2.3
D-8-OB	1/7/85	26	0.7	8.6	2.08	9.47	2.54	<5						3.8	220	-5.6
D-8-OB	4/22/85	32	0.1	3.88	2.19	9.84	3	<1	0.21		1.9		0.18	2.9	500	-5.0
D-8-OB	7/20/85	30	0.1	4.71	2.63	11	3.36	<5	0.32	69	2.5		0.17	2.9	520	-5.0
D-8-OB	10/17/85	17	0.2	3.82	2.32	12	3.3	<5	0.24	91	5.5		0.24	3.1	392	-13.0
D-8-OB	1/23/86	20	0.1	1.77	0.92	6.7	1.96	<5	0.21	65	2.6		0.13	3.2	270	-6.7
D-8-OB	6/25/86	18	0.1			6.2								3.6	190	
D-8-OB	9/3/86	71	0.2			8.23								4	270	
D-8-OB	11/18/86	18	0.1			7								2.8	295	
D-8-OB	3/16/87	32	0.1			7.75								3.8	265	
D-8-OB	9/20/87					9.4										
D-8-OB	11/16/87					8.6										
D-8-OB	5/11/88					9.3										
D-8-OB	2/15/88					8.5										
D-8-OB	8/12/88					9.8										

D-8-OB	11/15/88					13.9										
D-9-OBa	2/21/84	2.5		1.43	0.61	8.22	1.76	17						6.1	60	1.0
D-9-OBa	6/22/84	15	0.3	0.82	0.4	13.2	1.2	15						6.2	81	-6.7
D-9-OBa	9/27/84	52	0.4	0.97	0.48	11.6	1.91	13						5.7	87	6.7
D-9-OBa	1/6/85	8.3	0.2	4.91	0.79	6.32	0.89	10						5.7	57	9.1
D-9-OBa	4/24/85	9.5	0.1	1.18	0.74	5.39	1.15	10	0.23		<0.1		0.07	5.2	45	-9.1
D-9-OBa	7/21/85	9.8	0.1	1.29	0.82	5.22	1.37	10	0.1	49	<0.1		0.02	5.2	40	-9.1
D-9-OBa	10/18/85	48	0.5	1.15	0.56	4.96	1.14	<5	0.1	59	0.1		0.06	5.3	50	-11
D-9-OBa	1/23/86	22	0.2	1.97	0.92	5.42	1.18	10	0.2	48	0.2		0.01	4.4	45	-9.1
D-9-OBa	6/27/86	23	0.2			4.6								5.1	55	
D-9-OBa	9/4/86	12	0.2			4.96								5.7	53	
D-9-OBa	11/18/86	4.4	0.1			4.44								5	55	
D-9-OBa	3/22/87	3	0			4.34								5.9	58	
D-9-OBa	9/21/87					5										
D-9-OBa	11/16/87					4.2										
D-9-OBa	2/19/88					1.3										
D-9-OBb	2/21/84	0		0.68	0.79	5.6	0.792	2						4.2	70	5.6
D-9-OBb	6/22/84	13	0.02	0.78	0.95	6.6	0.65	<1						4.1	72	-11
D-9-OBb	1/6/85	15	0	5.6	1.09	4.7	0.6	<5						4.2	68	11.1
D-9-OBb	4/24/85	1.3	0	1.1	1.11	4.3	0.6	<1	0.1		0.4		0.09	4	75	0.0
D-9-OBb	7/21/85	7	0	0.49	0.78	3.5	0.5	<5	0.1	22	0.3		0.02	3.9	73	-14
D-9-OBb	10/18/85	6	0	1.96	0.61	4.1	0.72	<5	0	36	0.2		0.07	3.9	68	14.3
D-9-OBb	1/22/86	3.2	0	0.98	0.88	4	0.58	<5	0.2	23	0.5		0.06	3.9	70	-11
D-9-OBb	6/27/86	62	0			3.7								3.6	70	

D-9-OBb	9/4/86	16				4.1								3.9	75	
D-9-OBb	11/18/86	9.6	0			3.6								3.3	75	
D-9-OBb	3/22/87	6	0			4.1								4.2	75	
D-9-OBb	9/21/87					3.9										
D-9-OBb	11/16/87					3.3										
D-9-OBb	2/19/88					1										
D-9-UB	2/22/84	2.7		27.8	12.5	55.8	5.74	190						7.1	390	6.5
D-9-UB	6/22/84	4.2	0.1	23	12.8	50	4.62	183						7.1	447	-2.2
D-9-UB	9/27/84	3.5	0.1	30	9.4	50	5.28	183						6.7	400	2.2
D-9-UB	1/6/85	3.1	0.1	30	10.3	44	4.8	176						6.8	350	0.0
D-9-UB	4/24/85	4.9	0.1	26	11.5	46	4.46	178	0.21		<0.1		0.04	6.9	420	0.0
D-9-UB	7/21/85	5.9	0.1	27	12.2	47	5.24	187	0.23	24	0.1		0.01	6.6	370	-1.1
D-9-UB	10/18/85	4.7	0.1	31	12	46	5.25	176	0.2	33	0.5		0.01	6.7	390	1.1
D-9-UB	1/23/86	3.1	0.1	34	12	46	5	181	0.26	25	0.2		0.02	6.8	390	0.0
D-9-UB	6/27/86	3.8	0.1			40								6.5	430	
D-9-UB	9/4/86	3.3	0.2			39								6.9	430	
D-9-UB	11/18/86	2.9	0.1			41								6.3	375	
D-9-UB	3/22/87	3	0.1			37								7.2	342	
D-9-UB	9/21/87					33										
D-9-UB	11/16/87					33										
D-9-UB	2/19/88					38.4										
DII-14-R-08	none															
DII-37-R-91	7/14/93	49.1	5.72	115.0	56.7	38.8	11.7							5.6	1134	

DII-37-R-91	1/4/94	59.0	7.39	118.0	66.2	36.7	11.5				2.55	0	2.19	5.5	1242	
DII-37-R-91	6/24/94	96.0	15.7	212.0	139.0	47.2	9.5								2060	
DII-37-R-91	9/13/94	202	26.4	275.0	205.0	47.6	14.1								2830	
DII-37-R-91	10/4/94	140	20.7	228.0	170.0	43.0	13.4									
DII-37-R-91	2/17/95	224	27.4	285.0	223.0	89.8	14.4				31		3.82			
DII-37-R-91	5/30/95	339	33.3	337.0	266.0	74.2	12.9									
DII-37-R-91	8/10/95	265	29.0	299.0	227.0	64.8	10.5								3000	
DII-37-R-91	10/4/95	210	25.2	257.0	180.0	53.8	13.2								2730	
DII-37-R-91	1/4/96	186	19.3	215.0	158.0	53.7	11.0				12		2.66		2540	
DII-37-R-91	4/30/96	181	18.8	222.0	154.0	46.8	10.5							3.8	2470	
DII-37-R-91	2/7/01										1.62	0.9	0.56			
DII-37-R-91	2/20/02										0.71	0.96	0.32			
DII-37-R-91	1/15/03										0.57	<0.001	0.26			
DII-37-R-91	1/13/04										1.05	0.86	0.17			
DII-37-R-91	3/8/05										0.13	<0.01	0.08			
DII-37-R-91	2/23/06										0.51	<0.006	0.16			
DII-37-R-91	2/7/07										0.29	0.41	0.16			

DII-37-R-91	2/29/08										0.03	0.42	0.14			
DII-37-R-91	2/6/09										0.19	<0.006	0.17			
DII-4-OB	none															
DII-4-UB	none															
DII-5-OB	none															
DII-5-UB	none															
DII-6(ALL UV)-04	none															
DIII-12-OB	none															
DIII-13-OB-98	none															
DIII-15(All uv)-04	none															
DIII-1-OB2	none															
DIII-1-OB2-R-99	2/20/01										0.12	0.11	0.1			
DIII-1-OB2-R-99	2/21/02										0.11	0.11	0.09			
DIII-1-OB2-R-99	1/16/03										0.16	<0.001	0.09			
DIII-1-OB2-R-99	1/14/04										0.46	0.14	0.12			
DIII-1-OB2-R-99	3/10/05										0.31	<0.01	0.26			
DIII-1-OB2-R-99	2/24/06										0.69	<0.006	0.24			
DIII-1-OB2-R-99	2/8/07										0.87	0.22	0.4			

DIII-1-OB2-R-99	2/29/08										0.41	0.23	0.28			
DIII-1-OB2-R-99	2/5/09										0.46	<0.006	0.22			
DIII-1-UB	none															
DIII-1-UB-R-99	2/20/01										0.02	0.12	0.01			
DIII-1-UB-R-99	2/21/02										0.07	0.1	0.04			
DIII-1-UB-R-99	1/16/03										0.16	<0.001	0.08			
DIII-1-UB-R-99	2/24/06										0.31	<0.006	<0.003			
DIII-1-UB-R-99	2/8/07										0.04	<0.001	0.06			
DIII-1-UB-R-99	2/29/08										<0.006	<0.006	0.08			
DIII-1-UB-R-99	2/5/09										0.01	<0.006	0.13			
DIII-3-OB	none															
DIII-3-UB	none															
DIII-5-OB2	none															
DIII-5-OB2-R-03	1/14/04										43.8	0.35	0.23			
DIII-5-OB2-R-03	3/8/05										49.7	<0.01	0.46			
DIII-5-OB2-R-03	2/24/06										3.41	<0.006	0.01			
DIII-5-OB2-R-03	2/8/07										2.2	<0.001	0.16			
DIII-5-OB2-R-03	2/29/08										8.88	<0.006	0.11			

DIII-5-OB2-R-03	2/5/09										1.03	<0.006	0.06			
DIII-6-OB	none															
DIII-6-UB	none															
DIII-7-UB	none															
R-16(S)	2/7/01										23.6	0.61	1.77			
R-16(S)	2/19/02										49.5	1.27	3.61			
R-16(S)	1/15/03										37.9	<0.001	3.35			
R-16(S)	3/3/05										31.3	<0.01	3.9			
R-16(S)	2/22/06										0.17	<0.006	0.03			
R-16(S)	1/30/07										1.23	<0.006	0.3			
R-16(S)	2/20/08										3.41	0.11	0.41			
R-16(S)	2/2/09										6.05	<0.006	0.53			
R-18(S)-98	1/14/03										28.4	<0.001	3.68			
R-18(S)-98	1/13/04										0.41	0.1	0.1			
R-18(S)-98	3/3/05										4.35	0.26	2.17			
R-18(S)-98	2/22/06										1.37	<0.006	0.03			
R-18(S)-98	2/7/07										2.3	0.3	1			
R-18(S)-98	2/28/08										1.22	<0.006	0.83			
R-18(S)-98	2/9/09										1.09	<0.006	0.65			
R-2(S)	2/19/93	43.0	0.82	72.3	38.7	25.8	5.9				0.05		0.34	6.8	732	
R-2(S)	4/19/93	58.9	1.11	74.4	40.6	25.1	7.1									

R-2(S)	7/22/93	61.4	1.20	65.6	36.5	24.8	6.9							6.5	832	
R-2(S)	11/2/93	52.1	1.10	62.6	35.8	24.2	6.6							6.6	796	
R-2(S)	1/6/94	76.7	1.52	60.4	35.0	22.7	5.7								825	
R-2(S)	6/23/94	65.8	1.26	54.9	31.6	22.2	5.5								616	
R-2(S)	9/9/94	94.5	1.26	48.3	33.0	21.1	7.5								659	
R-2(S)	10/3/94	80.1	1.55	57.0	37.4	25.7	7.1									
R-2(S)	2/14/95	69.8	1.35	44.6	27.7	21.7	5.5				7.5		0.27			
R-2(S)	5/11/95	87.4	1.39	45.2	29.6	19.7	6.2									
R-2(S)	8/9/95	73.4	1.27	44.7	28.4	20.2	6.4								604	
R-2(S)	2/6/01										2.87	0.74	1.32			
R-2(S)	2/19/02										3.04	0.76	1.14			
R-2(S)	1/9/03										1.8	<0.001	1.05			
R-2(S)	1/9/04										1.33	0.87	0.92			
R-5(S)	2/19/93	202	6.67	56.6	54.7	23.5	4.2				73.4		3.24	3.3	1840	
R-5(S)	4/16/93	227	8.75	74.7	66.6	31.8	5.4							3.4	2050	
R-5(S)	7/14/93	209	7.64	61.8	56.6	25.7	5.1							3.4	1840	
R-5(S)	11/1/93	144	5.49	54.0	46.0	21.4	5.6							3.5	1470	
R-5(S)	1/5/94	148	5.43	46.7	39.0	21.4	5.0				35.5	0	0.28	3.2	1510	
R-5(S)	6/24/94	147	4.89	57.2	46.1	25.2	5.0								1260	
R-5(S)	9/9/94	132	4.16	44.8	37.9	20.4	5.3								1136	
R-5(S)	10/3/94	91.8	3.89	43.2	36.9	19.4	4.8									
R-5(S)	2/14/95	102	3.99	40.7	32.1	20.4	4.8				13		0.92			
R-5(S)	5/11/95	94.1	3.06	33.0	25.8	15.8	4.1									
R-5(S)	8/10/95	66.7	2.69	29.5	23.0	15.8	4.2								694	
R-5(S)	10/4/95	53.3	2.50	30.5	22.2	15.2	4.4								695	
R-5(S)	1/5/96	48.7	1.92	22.5	18.0	14.8	4.0				6.7		0.63		658	

R-5(S)	4/30/96	44.8	1.94	24.5	18.7	17.0	0.1							3.7	594	
R-5(S)	2/6/01										4.26	0.41	0.67			
R-5(S)	2/19/02										11.5	0.73	0.84			
R-5(S)	1/9/03										14	<0.001	1.22			
R-5(S)	1/9/04										6.31	1.24	0.9			
R-5(S)	1/31/07										18.3	0.42	0.75			
R-5(S)	2/28/08										12.9	0.31	1.31			
R-6(S)	6/27/94	108	1.42	110.0	46.7	27.8	6.2								1130	
R-6(S)	9/13/94	109	1.39	102.0	46.7	30.0	7.8								1134	
R-6(S)	10/4/94	91.3	1.26	97.7	46.0	27.3	6.5									
R-6(S)	2/15/95	172	2.48	168.0	76.1	32.7	7.9				3.1		0.6			
R-6(S)	5/30/95	135	1.47	109.0	46.5	25.3	6.9									
R-6(S)	8/14/95	103	1.28	85.5	39.7	23.9	6.0								1018	
R-6(S)	10/4/95	97.3	1.16	78.5	35.4	23.7	5.9								962	
R-6(S)	1/5/96	91.0	1.10	73.1	33.7	23.9	5.9				3.4		0.12		950	
R-6(S)	5/2/96	84.6	0.95	67.6	33.4	23.7	6.1							4.2	924	
R-6(S)	2/5/01										3.61	1.02	0.09			
R-6(S)	2/18/02										0.45	1.06	0.11			
R-6(S)	1/14/03										0.37	<0.001	0.16			
R-6(S)	1/8/04										0.52	1.17	0.23			
R-6(S)	3/3/05										0.42	0.3	0.35			
R-6(S)	2/21/06										0.39	<0.006	0.01			
R-6(S)	1/30/07										0.25	<0.006	0.22			
R-6(S)	2/20/08										0.21	0.76	0.23			
R-6(S)	2/2/09										0.25	<0.006	0.27			
TP-C5	3/23/84	15		2.07	2.01	7.9	1.69	32						6	140	

TP-C5	6/24/84	154	0.4	2.22	2.01	4.6	1.02	56						6	180	-2.9
TP-C5	9/27/84	75	0.3	2.89	1.63	18	1.19	61						6	178	-4.3
TP-C5	1/7/85	25	0.2	9.6	1.43	16	0.85	41						6.1	181	4.0
TP-C5	4/25/85	77	0.3	9.05	1.12	7.1	1.35	7	0.1		0.2		0.03	3.7	110	-5.3
TP-C5	7/20/85	122	0.3	2.03	1.4	4.3	1.11	<5	<0.01	6.6	0.1		0.01	3.6	98	-17
TP-C5	10/13/85	75	0.2	2.04	1.21	4.9	1.01	22	<0.01	21	0.1		0.03	3.7	105	4.3
TP-C5	1/25/86	50	0.3	2.83	1.46	5.3	1.02	29	0.4	16.7	0.1		0.07	5.1	109	4.0
TP-C5	6/29/86	160	0.3			5.1								5.1	130	
TP-C5	9/5/86	128	0.3			4.9								4.7	81	
TP-C5	11/19/86	95	0.2			4								5.3	113	
TP-C5	3/24/87	96	0.2			3.8								5.6	105	
TP-C5	9/20/87					4.1										
TP-C5	11/15/87					3.1										
TP-C5	2/17/88					3.5										
TP-C5	5/11/88					4.2										
TP-C5	8/12/88					2.7										
TP-C5	11/15/88					7										
TP-DG	3/21/84	0.6		12.9	1.21	7.5	2.85	34						6.3	130	
TP-DG	6/24/84	20	0.1	8.05	1.09	6.9	1.31	17						5.5	102	-5.9
TP-DG	9/27/84	19	0.1	2.08	1.04	13	1.68	<1						4.1	90	7.7
TP-DG	1/7/85	33	0.3	10.4	1.36	5.7	1.47	12						5.3	89	12.5
TP-DG	4/24/85	18	0.2	1.93	1.02	4.3	1.22	12	0.2		<0.1		0.05	5.1	82	5.3
TP-DG	7/20/85	8.9	0	2.15	1.12	5.5	1.36	<5	0.4	19.1	0.7		0.04	4.1	60	-9.1
TP-DG	10/13/85	19	0.2	3.32	0.89	7.8	1.04	<5	0.1	33	0.2		0.03	4.5	83	9.1
TP-DG	1/24/86	73	0.4	7.21	0.79	8.5	1.47	20	0.1	21	0.5		0.03	5.7	110	-5.9
TP-DG	7/8/86	7	0			5.3								4.6	82	

TP-DG	9/5/86	19	0.2			4.9								3.9	88	
TP-DG	11/19/86	31	0.1			5.6								4.4	77	
TP-DG	3/24/87	6.1	0.1			4.3								5	81	
TP-DG	9/20/87					**5.6**										
TP-DG	11/15/87					5.2										
TP-DG	2/17/88					4.8										
TP-DG	5/11/88					5										
TP-DG	8/12/88					3.6										
TP-DG	11/15/88					8.3										
TP-UG	3/22/84	1.6		2.22	1.41	8.7	2.76	<1						4.5	90	
TP-UG	6/24/84	8.8	0.1	1.77	1.55	10	1.66	4						4.8	90	-5.9
TP-UG	9/27/84	8	0.1	2.24	1.66	4.9	1.84	5						4.7	82	-6.7
TP-UG	1/7/85	3.7	0.1	2.23	1.41	4.6	1.29	<5						4.3	83	-7.7
TP-UG	4/24/85	2.3	0	2.03	1.39	5.2	1.48	<1	0.2		0.6		0.07	4	93	-7.7
TP-UG	7/20/85	2.7	0	1.45	1.29	4.6	1.61	<5	0	23	0.8		0.05	3.8	114	-9.1
TP-UG	10/13/85	3.8	0.1	1.8	1.41	6.1	1.54	<5	0.1	33	0.7		0.07	3.8	105	-7.7
TP-UG	1/25/86	2.6	0	1.96	1.3	4.3	1.5	<5	0.1	23	0.5		0.08	4.1	79	-9.1
TP-UG	6/29/86	3	0			4.3								3.8	90	
TP-UG	9/5/86	2.3	0.1			4.2								4.1	95	
TP-UG	11/19/86	3.5	0			4.1								3.8	95	
TP-UG	3/24/87	2	0			4.3								4.3	98	
TP-UG	9/20/87					4.5										
TP-UG	11/15/87					4.1										
TP-UG	2/17/88					4.4										
TP-UG	5/11/88					4.7										
TP-UG	8/12/88					6										

TP-UG	11/15/88					9										

APPENDIX E: CBES FOR THE HISTORICAL DATA SET

This appendix contains a copy of the charge balance errors (CBEs) calculated for the historical data set (Chapter 3). For 213 observations (all in the 1984-1986 Permit 22 baseline study), CBEs were calculated by this researcher. A copy of the CBEs reported by the third-party laboratory are included. However, CBEs reported by the lab could not be reproduced using the reported analyte concentrations. Because these CBEs could not be reproduced, CBEs calculated by this researched for reported analyte concentrations are used instead. For 200 additional observations, CBEs were calculated by this researcher (bicarbonate values are not included for all of these observations). For the remaining observations in the historical data set, CBEs could not be calculated as at least one of the major cations (Ca, Mg, or Na) or anions (Cl or SO_4) were not reported.

Well Number	Well ID	Date	Calculated CBE (%)	Reported CBE (%), from lab
11	D-1-Alluv	02/24/84	-3.2	2.0
11	D-1-Alluv	06/23/84	-5.0	-7.7
11	D-1-Alluv	09/30/84	-10.1	-9.1
11	D-1-Alluv	01/07/85	0.7	0.0
11	D-1-Alluv	04/20/85	-18.2	-16.7
11	D-1-Alluv	07/22/85	-13.4	-9.1
11	D-1-Alluv	10/18/85	-11.7	-11.1
11	D-1-Alluv	01/23/86	-13.1	-9.1
12	D-14-OBa	06/20/84	-3.7	-3.2
12	D-14-OBa	09/28/84	9.2	3.2
12	D-14-OBa	01/05/85	1.0	-6.7
12	D-14-OBa	04/23/85	17.3	-4.8
12	D-14-OBa	07/24/85	28.1	0.0
12	D-14-OBa	10/14/85	-0.5	-10.3
12	D-14-OBa	01/23/86	-2.8	-11.1
13	D-14-OBb	06/20/84	0.8	-2.0

13	D-14-OBb	09/28/84	3.9	-2.0
13	D-14-OBb	01/05/85	-1.0	-8.8
13	D-14-OBb	04/23/85	22.0	-5.6
13	D-14-OBb	07/24/85	16.3	-5.0
13	D-14-OBb	10/14/85	3.8	-4.9
13	D-14-OBb	01/23/86	-1.4	-4.2
14	D-14-OBc	06/20/84	-7.2	-5.9
14	D-14-OBc	09/28/84	14.8	0.0
14	D-14-OBc	01/05/85	18.5	0.0
14	D-14-OBc	04/23/85	5.8	0.0
14	D-14-OBc	07/24/85	13.2	0.0
14	D-14-OBc	10/16/85	4.1	-7.7
14	D-14-OBc	01/23/86	10.1	-11.1
16	D-14-UB	06/21/84	-6.2	-1.8
16	D-14-UB	09/28/84	4.5	2.2
16	D-14-UB	01/06/85	3.8	2.9
16	D-14-UB	04/23/85	2.9	4.2
16	D-14-UB	07/25/85	-1.6	-2.4
16	D-14-UB	10/16/85	-3.0	4.2
16	D-14-UB	01/25/86	0.6	1.1
18	D-16-OBal	02/17/84	2.8	0.3
18	D-16-OBal	06/22/84	-6.3	-11.1
18	D-16-OBal	09/28/84	11.4	0.0
18	D-16-OBal	01/06/85	30.1	20.0
18	D-16-OBal	04/23/85	-1.7	-25.0
18	D-16-OBal	07/24/85	2.2	-11.1
18	D-16-OBal	10/16/85	14.9	0.0
18	D-16-OBal	01/23/86	-3.1	-9.1
19	D-16-UB	02/17/84	2.8	2.9
19	D-16-UB	06/22/84	-4.7	5.9
19	D-16-UB	09/28/84	8.3	5.9
19	D-16-UB	01/06/85	0.8	0.0
19	D-16-UB	04/24/85	0.4	0.0
19	D-16-UB	07/24/85	-3.8	-5.6
19	D-16-UB	10/16/85	0.6	0.0
19	D-16-UB	01/26/86	3.0	3.2
20	D-17-OB	02/20/84	-6.2	4.8
20	D-17-OB	06/21/84	-5.3	-5.9

20	D-17-OB	09/29/84	13.3	5.9
20	D-17-OB	01/04/85	9.0	5.3
20	D-17-OB	04/23/85	10.5	-5.9
20	D-17-OB	07/23/85	4.0	-5.3
20	D-17-OB	10/21/85	-0.9	-5.9
20	D-17-OB	01/23/86	13.2	-5.9
21	D-17-UB	03/02/84	31.6	31.4
21	D-17-UB	06/21/84	-3.3	-1.4
21	D-17-UB	09/29/84	3.9	1.8
21	D-17-UB	01/04/85	-2.0	-1.5
21	D-17-UB	04/23/85	-7.0	-5.7
21	D-17-UB	07/23/85	-2.3	-2.9
21	D-17-UB	10/21/85	-0.6	-1.4
21	D-17-UB	01/23/86	2.3	1.4
24	D-2-Alluv	02/18/84	4.0	4.0
24	D-2-Alluv	06/23/84	-1.2	-1.1
24	D-2-Alluv	09/30/84	5.4	2.4
24	D-2-Alluv	01/08/85	1.0	0.0
24	D-2-Alluv	04/20/85	-2.8	-3.6
24	D-2-Alluv	07/23/85	-5.5	-5.1
24	D-2-Alluv	10/14/85	-1.2	-1.2
24	D-2-Alluv	01/23/86	2.8	3.5
26	D-21-OB	02/20/84	1.0	0.2
26	D-21-OB	06/27/84	6.0	0.0
26	D-21-OB	09/29/84	-5.4	0.0
26	D-21-OB	01/07/85	-6.6	-14.3
26	D-21-OB	04/22/85	-21.4	-14.3
26	D-21-OB	07/23/85	-20.4	-14.3
26	D-21-OB	10/13/85	12.1	0.0
26	D-21-OB	01/24/86	-11.6	-14.3
28	D-22-OB	04/14/84	-3.8	20.8
28	D-22-OB	06/22/84	-5.2	-6.7
28	D-22-OB	09/29/84	2.7	-9.1
28	D-22-OB	01/06/85	0.2	0.0
28	D-22-OB	04/22/85	-0.4	0.0
28	D-22-OB	07/25/85	-14.2	-9.1
28	D-22-OB	10/19/85	-3.9	-7.7
28	D-22-OB	01/23/86	-9.3	-7.7

29	D-23-OBa	02/22/84	11.6	11.4
29	D-23-OBa	06/22/84	-2.1	-1.3
29	D-23-OBa	09/29/84	5.6	4.5
29	D-23-OBa	01/08/85	8.0	3.1
29	D-23-OBa	04/24/85	3.2	4.1
29	D-23-OBa	07/21/85	-3.2	-2.8
29	D-23-OBa	10/20/85	1.3	0.0
29	D-23-OBa	01/23/86	-0.7	-1.3
30	D-23-OBb	03/02/84	13.0	10.2
30	D-23-OBb	06/22/84	3.3	0.0
30	D-23-OBb	01/08/85	-9.7	-9.7
30	D-23-OBb	04/24/85	-1.1	-14.3
30	D-23-OBb	07/21/85	22.7	0.0
30	D-23-OBb	10/20/85	-7.7	-14.3
30	D-23-OBb	01/23/86	-7.7	-11.1
31	D-23-UB	02/22/84	-0.1	0.1
31	D-23-UB	06/22/84	-3.6	-3.9
31	D-23-UB	09/29/84	6.2	5.2
31	D-23-UB	01/08/85	-1.9	-1.2
31	D-23-UB	04/24/85	1.2	1.6
31	D-23-UB	07/21/85	-0.8	-0.8
31	D-23-UB	10/20/85	-0.3	-0.4
31	D-23-UB	01/23/86	0.0	0
32	D-24-OB	02/18/84	0.4	0.6
32	D-24-OB	06/22/84	-0.4	0.0
32	D-24-OB	09/29/84	4.9	0.0
32	D-24-OB	01/06/85	15.9	11.1
32	D-24-OB	04/22/85	-29.1	-14.3
32	D-24-OB	07/25/85	-6.3	-20.0
32	D-24-OB	10/19/85	-10.4	0.0
32	D-24-OB	01/23/86	-16.2	-11.1
33	D-25-OB-T	03/13/84	12.0	0.6
33	D-25-OB-T	06/21/84	13.6	0.0
33	D-25-OB-T	09/29/84	3.4	-9.1
33	D-25-OB-T	01/04/85	27.2	11.1
33	D-25-OB-T	04/18/85	-11.5	-25.0
33	D-25-OB-T	07/23/85	7.4	-14.3
33	D-25-OB-T	10/20/85	1.4	-20.0

33	D-25-OB-T	01/23/86	0.0	-11.1
53	D-3-OB	03/02/84	-1.7	2.0
53	D-3-OB	06/23/84	1.4	-4.3
53	D-3-OB	09/29/84	11.0	4.8
53	D-3-OB	01/08/85	-0.6	-5.9
53	D-3-OB	04/22/85	10.3	-6.7
53	D-3-OB	07/23/85	5.1	-12.5
53	D-3-OB	10/17/85	3.3	-5.3
53	D-3-OB	01/23/86	3.2	-5.9
59	D-4-UB	02/29/84	5.4	4.0
59	D-4-UB	06/23/84	-1.5	-2.4
59	D-4-UB	09/29/84	4.1	2.8
59	D-4-UB	01/08/85	-2.5	-5.9
59	D-4-UB	04/22/85	1.9	2.6
59	D-4-UB	07/23/85	-0.6	0.0
59	D-4-UB	10/17/85	3.0	2.6
59	D-4-UB	01/23/86	0.1	0.0
61	D-7-OB-T	06/21/84	-0.2	0.0
61	D-7-OB-T	09/28/84	20.2	0.0
61	D-7-OB-T	01/04/85	16.5	5.3
61	D-7-OB-T	04/18/85	-8.0	-20.0
61	D-7-OB-T	07/22/85	4.5	-11.1
61	D-7-OB-T	10/17/85	0.1	-14.3
61	D-7-OB-T	01/23/86	0.0	-9.1
62	D-7-UB	06/21/84	-2.0	-1.3
62	D-7-UB	09/28/84	0.2	0.6
62	D-7-UB	01/05/85	-2.6	-2.1
62	D-7-UB	04/22/85	1.2	1.3
62	D-7-UB	07/22/85	-2.3	-2.6
62	D-7-UB	10/19/85	1.8	1.2
62	D-7-UB	01/23/86	3.5	3.1
63	D-8-OB	03/01/84	8.9	1.0
63	D-8-OB	06/23/84	-0.3	-2.0
63	D-8-OB	09/28/84	3.2	-2.3
63	D-8-OB	01/07/85	-3.4	-5.6
63	D-8-OB	04/22/85	23.4	-5.0
63	D-8-OB	07/20/85	21.9	-5.0
63	D-8-OB	10/17/85	4.4	-13.0

63	D-8-OB	01/23/86	9.1	-6.7
64	D-9-OBa	02/21/84	-3.7	1.0
64	D-9-OBa	06/22/84	-6.8	-6.7
64	D-9-OBa	09/27/84	8.8	6.7
64	D-9-OBa	01/06/85	12.6	9.1
64	D-9-OBa	04/24/85	-10.3	-9.1
64	D-9-OBa	07/21/85	-11.6	-9.1
64	D-9-OBa	10/18/85	-16.7	-11.1
64	D-9-OBa	01/23/86	-7.5	-9.1
65	D-9-OBb	02/21/84	19.5	5.6
65	D-9-OBb	06/22/84	-2.0	-11.1
65	D-9-OBb	01/06/85	27.4	11.1
65	D-9-OBb	04/24/85	5.8	0.0
65	D-9-OBb	07/21/85	4.2	-14.3
65	D-9-OBb	10/18/85	21.5	14.3
65	D-9-OBb	01/22/86	-4.3	-11.1
66	D-9-UB	02/22/84	7.0	6.5
66	D-9-UB	06/22/84	-2.3	-2.2
66	D-9-UB	09/27/84	2.8	2.2
66	D-9-UB	01/06/85	0.5	0.0
66	D-9-UB	04/24/85	0.1	0.0
66	D-9-UB	07/21/85	-0.7	-1.1
66	D-9-UB	10/18/85	2.2	1.1
66	D-9-UB	01/23/86	0.2	0.0
93	TP-C5	03/23/84	15.6	none
93	TP-C5	06/24/84	-8.7	-2.9
93	TP-C5	09/27/84	26.7	-4.3
93	TP-C5	01/07/85	25.9	4.0
93	TP-C5	04/25/85	6.1	-5.3
93	TP-C5	07/20/85	44.3	-16.7
93	TP-C5	10/13/85	15.6	4.3
93	TP-C5	01/25/86	1.6	4.0
94	TP-DG	03/21/84	1.6	none
94	TP-DG	06/24/84	-5.0	-5.9
94	TP-DG	09/27/84	19.1	7.7
94	TP-DG	01/07/85	11.4	12.5
94	TP-DG	04/24/85	-36.6	5.3
94	TP-DG	07/20/85	-0.7	-9.1

94	TP-DG	10/13/85	9.9	9.1
94	TP-DG	01/24/86	1.3	-5.9
95	TP-UG	03/22/84	-5.0	none
95	TP-UG	06/24/84	-1.7	-5.9
95	TP-UG	09/27/84	-10.2	-6.7
95	TP-UG	01/07/85	-7.4	-7.7
95	TP-UG	04/24/85	1.8	-7.7
95	TP-UG	07/20/85	7.8	-9.1
95	TP-UG	10/13/85	5.2	-7.7
95	TP-UG	01/25/86	4.3	-9.1
11	D-1-Alluv	02/20/93	-3.2	none
11	D-1-Alluv	04/15/93	-5.0	none
11	D-1-Alluv	07/13/93	-10.1	none
11	D-1-Alluv	10/26/93	0.7	none
11	D-1-Alluv	01/04/94	-18.2	none
11	D-1-Alluv	06/27/94	-13.4	none
11	D-1-Alluv	09/12/94	-11.7	none
11	D-1-Alluv	10/04/94	-13.1	none
11	D-1-Alluv	02/15/95	-3.7	none
11	D-1-Alluv	05/15/95	9.2	none
11	D-1-Alluv	08/14/95	1.0	none
11	D-1-Alluv	10/04/95	17.3	none
15	D-14-OB-R-95	12/26/95	28.1	none
15	D-14-OB-R-95	01/08/96	-0.5	none
15	D-14-OB-R-95	05/02/96	-2.8	none
15	D-14-OB-R-95	07/10/96	0.8	none
15	D-14-OB-R-95	10/29/96	3.9	none
17	D-14-UB-R-95	12/26/95	-1.0	none
17	D-14-UB-R-95	01/08/96	22.0	none
17	D-14-UB-R-95	05/02/96	16.3	none
17	D-14-UB-R-95	07/10/96	3.8	none

17	D-14-UB-R-95	10/29/96	-1.4	none
18	D-16-OBal	04/15/93	-7.2	none
18	D-16-OBal	06/28/94	14.8	none
18	D-16-OBal	09/13/94	18.5	none
18	D-16-OBal	10/05/94	5.8	none
18	D-16-OBal	02/17/95	13.2	none
18	D-16-OBal	10/04/95	4.1	none
18	D-16-OBal	01/08/96	10.1	none
18	D-16-OBal	05/06/96	-6.2	none
18	D-16-OBal	07/16/96	4.5	none
18	D-16-OBal	10/29/96	3.8	none
19	D-16-UB	02/20/93	2.9	none
19	D-16-UB	04/15/93	-1.6	none
19	D-16-UB	07/14/93	-3.0	none
19	D-16-UB	01/04/94	0.6	none
19	D-16-UB	06/28/94	2.8	none
19	D-16-UB	09/13/94	-6.3	none
19	D-16-UB	10/05/94	11.4	none
19	D-16-UB	02/17/95	30.1	none
19	D-16-UB	05/15/95	-1.7	none
19	D-16-UB	08/14/95	2.2	none
25	D-2-Alluv	02/20/93	14.9	none
25	D-2-Alluv	10/26/93	-3.1	none
25	D-2-Alluv	01/04/94	2.8	none
25	D-2-Alluv	06/27/94	-4.7	none
25	D-2-Alluv	09/13/94	8.3	none
25	D-2-Alluv	10/04/94	0.8	none
25	D-2-Alluv	02/17/95	0.4	none
25	D-2-Alluv	05/16/95	-3.8	none
25	D-2-Alluv	08/14/95	0.6	none
25	D-2-Alluv	10/04/95	3.0	none
25	D-2-Alluv	01/08/96	-6.2	none
27	D-21-OB	02/22/93	-5.3	none
27	D-21-OB	04/15/93	13.3	none
27	D-21-OB	07/13/93	9.0	none
27	D-21-OB	10/26/93	10.5	none
27	D-21-OB	01/04/94	4.0	none
27	D-21-OB	06/27/94	-0.9	none

27	D-21-OB	09/12/94	13.2	none
27	D-21-OB	10/04/94	31.6	none
27	D-21-OB	02/15/95	-3.3	none
27	D-21-OB	05/15/95	3.9	none
27	D-21-OB	08/14/95	-2.0	none
35	D-26-UB	03/05/93	-7.0	none
35	D-26-UB	04/20/93	-2.3	none
35	D-26-UB	07/23/93	-0.6	none
35	D-26-UB	11/02/93	2.3	none
35	D-26-UB	01/06/94	4.0	none
35	D-26-UB	06/23/94	-1.2	none
35	D-26-UB	09/09/94	5.4	none
35	D-26-UB	10/04/94	1.0	none
35	D-26-UB	02/14/95	-2.8	none
35	D-26-UB	05/11/95	-5.5	none
35	D-26-UB	08/09/95	-1.2	none
35	D-26-UB	10/03/95	2.8	none
35	D-26-UB	01/08/96	1.0	none
35	D-26-UB	04/30/96	6.0	none
42	D-30-D	02/18/93	-5.4	none
42	D-30-D	04/20/93	-6.6	none
42	D-30-D	07/15/93	-21.4	none
42	D-30-D	11/03/93	-20.4	none
42	D-30-D	01/05/94	12.1	none
42	D-30-D	06/24/94	-11.6	none
42	D-30-D	09/13/94	-3.8	none
42	D-30-D	10/05/94	-5.2	none
42	D-30-D	02/16/95	2.7	none
42	D-30-D	05/30/95	0.2	none
42	D-30-D	08/10/95	-0.4	none
42	D-30-D	10/04/95	-14.2	none
42	D-30-D	01/04/96	-3.9	none
42	D-30-D	05/01/96	-9.3	none
43	D-30-S	02/17/93	11.6	none
43	D-30-S	04/20/93	-2.1	none
43	D-30-S	07/15/93	5.6	none
43	D-30-S	11/03/93	8.0	none
43	D-30-S	01/06/94	3.2	none

43	D-30-S	06/24/94	-3.2	none
43	D-30-S	09/13/94	1.3	none
43	D-30-S	10/04/94	-0.7	none
43	D-30-S	02/15/95	13.0	none
43	D-30-S	05/30/95	3.3	none
43	D-30-S	08/10/95	-9.7	none
43	D-30-S	10/03/95	-1.1	none
43	D-30-S	01/04/96	22.7	none
43	D-30-S	05/01/96	-7.7	none
48	D-35-OB	02/22/93	-7.7	none
48	D-35-OB	04/17/93	-0.1	none
48	D-35-OB	07/20/93	-3.6	none
48	D-35-OB	11/01/93	6.2	none
48	D-35-OB	01/05/94	-1.9	none
48	D-35-OB	06/27/94	1.2	none
48	D-35-OB	09/07/94	-0.8	none
48	D-35-OB	10/03/94	-0.3	none
48	D-35-OB	02/16/95	0.0	none
48	D-35-OB	05/11/95	0.4	none
48	D-35-OB	08/09/95	-0.4	none
48	D-35-OB	10/03/95	4.9	none
48	D-35-OB	01/05/96	15.9	none
48	D-35-OB	05/02/96	-29.1	none
54	D-41-UB	02/22/93	-6.3	none
54	D-41-UB	04/17/93	-10.4	none
54	D-41-UB	07/20/93	-16.2	none
54	D-41-UB	11/01/93	12.0	none
54	D-41-UB	01/05/94	13.6	none
54	D-41-UB	06/27/94	3.4	none
54	D-41-UB	09/07/94	27.2	none
54	D-41-UB	10/03/94	-11.5	none
54	D-41-UB	02/14/95	7.4	none
54	D-41-UB	05/11/95	1.4	none
54	D-41-UB	08/09/95	0.0	none
54	D-41-UB	10/03/95	-1.7	none
54	D-41-UB	01/04/96	1.4	none
54	D-41-UB	04/30/96	11.0	none
57	D-44-S	08/09/95	-0.6	none

58	D-45-S	12/26/95	10.3	none
58	D-45-S	01/05/96	5.1	none
58	D-45-S	05/01/96	3.3	none
58	D-45-S	07/09/96	3.2	none
58	D-45-S	10/21/96	5.4	none
60	D-6-UB	02/22/93	-1.5	none
60	D-6-UB	04/16/93	4.1	none
60	D-6-UB	07/14/93	-2.5	none
60	D-6-UB	10/27/93	1.9	none
60	D-6-UB	01/04/94	-0.6	none
60	D-6-UB	06/30/94	3.0	none
60	D-6-UB	09/07/94	0.1	none
60	D-6-UB	10/04/94	-0.2	none
60	D-6-UB	02/17/95	20.2	none
60	D-6-UB	05/15/95	16.5	none
61	D-7-OB-T	03/22/84	-8.0	none
62	D-7-UB	03/21/84	4.5	none
68	DII-37-R-91	07/14/93	0.1	none
68	DII-37-R-91	01/04/94	0.0	none
68	DII-37-R-91	06/24/94	-2.0	none
68	DII-37-R-91	09/13/94	0.2	none
68	DII-37-R-91	10/04/94	-2.6	none
68	DII-37-R-91	02/17/95	1.2	none
68	DII-37-R-91	05/30/95	-2.3	none
68	DII-37-R-91	08/10/95	1.8	none
68	DII-37-R-91	10/04/95	3.5	none
68	DII-37-R-91	01/04/96	8.9	none
68	DII-37-R-91	04/30/96	-0.3	none
90	R-2(S)	02/19/93	3.2	none
90	R-2(S)	04/19/93	-3.4	none
90	R-2(S)	07/22/93	23.4	none
90	R-2(S)	11/02/93	21.9	none
90	R-2(S)	01/06/94	4.4	none
90	R-2(S)	06/23/94	9.1	none
90	R-2(S)	09/09/94	-3.7	none
90	R-2(S)	10/03/94	-6.8	none
90	R-2(S)	02/14/95	8.8	none
90	R-2(S)	05/11/95	12.6	none

90	R-2(S)	08/09/95	-10.3	none
91	R-5(S)	02/19/93	-11.6	none
91	R-5(S)	04/16/93	-16.7	none
91	R-5(S)	07/14/93	-7.5	none
91	R-5(S)	11/01/93	19.5	none
91	R-5(S)	01/05/94	-2.0	none
91	R-5(S)	06/24/94	27.4	none
91	R-5(S)	09/09/94	5.8	none
91	R-5(S)	10/03/94	4.2	none
91	R-5(S)	02/14/95	21.5	none
91	R-5(S)	05/11/95	-4.3	none
91	R-5(S)	08/10/95	7.0	none
91	R-5(S)	10/04/95	-2.3	none
91	R-5(S)	01/05/96	2.8	none
91	R-5(S)	04/30/96	0.5	none
92	R-6(S)	06/27/94	0.1	none
92	R-6(S)	09/13/94	-0.7	none
92	R-6(S)	10/04/94	2.2	none
92	R-6(S)	02/15/95	0.2	none
92	R-6(S)	05/30/95	-8.7	none
92	R-6(S)	08/14/95	26.7	none
92	R-6(S)	10/04/95	25.9	none
92	R-6(S)	01/05/96	6.1	none
92	R-6(S)	05/02/96	44.3	none

APPENDIX F: CBES FOR THE HISTORICAL DATA SET

This appendix contains a copy of the charge balance errors (CBEs) calculated for the 2013 data set (Chapter 4). CBEs above +/- 10% are in bold. For the Water Body column, "G" is groundwater, "seep" is a seep (low volume perennial or intermittent spring) on the mine site, and "creek" refers to samples from Mill Creek or a tributary within the mine site. Well and spring categories are overburden pre-disturbance (OP), overburden downgradient (OG), overburden reclamation (OR), underburden pre-disturbance (UP), underburden downgradient (UG), and underburden reclamation (UR).

June 2013 Sampling Event

Water Body	Well/Spring Category	Screen Interval Geology	Location ID	Sample Date	Charge Balance Error (%)
G	OP	Qal	D-1-(Alluv)	6/3/2013	-6.21
G	OR	Spoil	DIII-1-OB2-R-99	6/3/2013	-3.68
G	OP	C/Wi	D-19-OB	6/4/2013	-6.46
G	UP	WUB	D-19-UB	6/4/2013	1.25
G	OG	Qal	D-2-Alluv	6/4/2013	-1.20
G	OG	unk	D-35-OB	6/4/2013	-3.81
G	UG	WUB	D-41-UB	6/4/2013	**48.81**
G	OP	unk	D-45-S	6/4/2013	-4.97
G	OR	Spoil	R-5(S)	6/4/2013	**29.04**
G	OR	Spoil	89-3-OB-R-99	6/5/2013	-1.11
G	OR	Spoil	DII-14-R-08	6/5/2013	-4.88
G	OP	C/Wi	DII-5-OB	6/5/2013	3.67
G	OP	Qal	DII-6(Alluv)-04	6/5/2013	-2.85
Seep	OR	n/a	Seep, north of Pond DI-115	6/5/2013	-7.37
Seep	OR	n/a	Seep, south of Pond DI-79	6/5/2013	-4.83
Seep	OR	n/a	Seep, south end of Pond DI-115	6/6/2013	1.23
Seep	OP	n/a	Seep,by "Ethiopa" field on unnamed tributary to Mill Creek in DIV area	6/6/2013	**16.13**
Creek	n/a	n/a	Mill Creek upstream of mining (near D-1-Alluv well)	6/3/2013	-9.75

Creek	n/a	n/a	Unnamed tributary to Mill Creek within mine	6/5/2013	-4.02
Creek	n/a	n/a	Mill Creek within mine (at Gibbson Bridge)	6/4/2013	-0.04
Creek	n/a	n/a	Mill Creek downstream of mining at USGS 80	6/6/2013	5.22

August 2013 Sampling Event					
Water Body	**Well/Spring Category**	**Screen Interval Geology**	**Location ID**	**Sample Date**	**Charge Balance Error (%)**
G	OR	Spoil	89-2-OB-R-03	8/6/2013	**10.37**
G	OR	Spoil	89-3-OB-R-99	8/6/2013	3.99
G	UR	Dist'd WUB	89-3-UB-R-99	8/6/2013	7.22
G	OG	Qal	D-2-Alluv	8/6/2013	-2.12
G	OG	unk	D-26-OB	8/6/2013	1.40
G	UG	WUB	D-26-UB	8/6/2013	-4.61
G	OR	Spoil	R-16(S)	8/6/2013	-6.12
G	OR	Spoil	R-18(S)	8/6/2013	-3.42
G	OR	Spoil	89-4-OB-R-99	8/7/2013	**34.84**
G	OR	Spoil	89-4-OB-R-99*	8/7/2013	-3.20
G	UR	Dist'd WUB	89-4-UB-R-99	8/7/2013	4.20
G	OP	C/Wi	D-16-OBal	8/7/2013	6.94
G	UP	WUB	D-16-UB	8/7/2013	-4.65
G	UP	WUB	D-19-UB	8/7/2013	-4.40
G	UP	WUB	D-30-D	8/7/2013	**-31.87**
G	OP	unk	D-30-S	8/7/2013	0.19
G	OR	Spoil	DII-14-R-08	8/7/2013	-2.81
G	OR	Spoil	DII-37-R-91	8/7/2013	-1.20
G	OP	C/Wi	DII-5-OB	8/7/2013	**-13.70**
G	UP	WUB	DII-5-UB	8/7/2013	2.49
G	OP	Qal	DII-6(Alluv)-04	8/7/2013	0.17
G	OR	Spoil	R-6(S)	8/7/2013	-3.20
G	UG	unk	50-UB	8/8/2013	9.61
G	OP	unk	53-OB	8/8/2013	5.78
G	OP	unk	53-UB	8/8/2013	-1.73
G	OP	unk	53-UB*	8/8/2013	-1.77

G	OR	Spoil	56-R	8/8/2013	5.22
G	OP	C/Wi	DIII-12-OB	8/8/2013	-0.45
G	OP	C/Wi	DIII-12-OB*	8/8/2013	0.77
G	OP	Qal	DIII-15(Alluv)-04	8/8/2013	-2.76
G	OR	Spoil	DIII-1-OB2-R-99	8/8/2013	-2.46
G	UR	Dist'd WUB	DIII-1-UB-R-99	8/8/2013	**11.14**
G	UR	Dist'd WUB	DIII-1-UB-R-99*	8/8/2013	-1.38
G	OR	Spoil	DIII-5-OB2-R-03	8/8/2013	-6.72
G	OR	Spoil	DIII-6-OB-R	8/8/2013	6.12
G	OP	C/Wi	DIV-1-OB	8/8/2013	-2.07
G	OP	C/Wi	DIV-6-OB	8/8/2013	1.66
Seep	OR	n/a	Seep, north of Pond DI-115	8/7/2013	**-28.35**
Seep	OR	n/a	Seep, south end of Pond DI-115	8/7/2013	-0.66
Seep	OR	n/a	Seep, south end of Pond DI-115*	8/7/2013	-2.45
Seep	OR	n/a	Seep, south of Pond DI-79	8/7/2013	-4.25
Seep	OR	n/a	Seep, south of Pond DI-79*	8/7/2013	-2.69
Creek	n/a	n/a	Mill Creek within mine (at Gibbson Bridge)	8/7/2013	0.71
Creek	n/a	n/a	Mill Creek within mine (at Gibbson Bridge)*	8/7/2013	-1.13
Creek	n/a	n/a	Mill Creek downstream of mining at USGS 80	8/7/2013	**-28.68**
Creek	n/a	n/a	Mill Creek upstream of mining (near D-1-Alluv well)	8/6/2013	-4.12

*Duplicate samples were initially collected as raw water in bulk bottles. Sample preservation (filtration and seperation into cation and anion bottles) was completed within several days of collection to test the effect of this method.

October 2013 Sampling Event

Water Body	Well/Spring Category	Screen Interval Geology	Location ID	Sample Date	Charge Balance Error (%)
G	OR	Spoil	56-R	10/9/2013	-7.25
G	UP	WUB	D-30-D	10/9/2013	6.17
G	OP	unk	D-30-S	10/9/2013	-1.40
G	OR	Spoil	DII-37-R-91	10/9/2013	-0.42
G	OP	C/Wi	DIV-6-OB	10/9/2013	7.92
G	OP	C/Wi	DIV-7-OB	10/9/2013	-3.60

G	UG	unk	50-UB	10/10/2013	6.52
G	OP	unk	53-OB	10/10/2013	**10.83**
G	OP	unk	53-UB	10/10/2013	8.04
G	OR	Spoil	89-4-OB-R-99	10/10/2013	-0.58
G	UR	Dist'd WUB	89-4-UB-R-99	10/10/2013	2.14
G	OP	C/Wi	D-16-OBal	10/10/2013	**64.19**
G	UP	WUB	D-16-UB	10/10/2013	0.44
G	OP	C/Wi	DIII-12-OB	10/10/2013	-0.75
G	OR	Spoil	DIII-6-OB-R	10/10/2013	**28.75**
G	OP	Qal	DIII-15(Alluv)-04	10/11/2013	-0.16
G	OR	Spoil	DIII-1-OB2-R-99	10/11/2013	**13.69**
G	UR	Dist'd WUB	DIII-1-UB-R-99	10/11/2013	-0.11
G	OR	Spoil	DIII-5-OB2-R-03	10/11/2013	**13.54**
Sp	OR	n/a	Seep, north of Pond DI-115	10/10/2013	0.05
Sp	OR	n/a	Seep, south end of Pond DI-115	10/10/2013	-0.01
Sp	OR	n/a	Seep, south of Pond DI-79	10/10/2013	-1.60
Sp	OP	n/a	Seep,by "Ethiopa" field on unnamed tributary to Mill Creek in DIV area	10/10/2013	-2.68

APPENDIX G: 2013 DATA SET

This appendix contains a copy of the 2013 data set for all observations with a charge balance error (CBE) between -10% and +10% (Chapter 4). For the Water Body column, “G” is groundwater, “seep” is a seep (low volume perennial or intermittent spring) on the mine site, and “creek” refers to samples from Mill Creek or a tributary within the mine site. Well and spring categories are overburden pre-disturbance (OP), overburden downgradient (OG), overburden reclamation (OR), underburden pre-disturbance (UP), underburden downgradient (UG), and underburden reclamation (UR). For “Screen Interval Geology”, Carrizo refers to Carrizo Sand, C/Wi refers to undifferentiated Carrizo/Wilcox, Wilcox means Wilcox Group, WUB means Wilcox Group underburden, Dist’d WUB means disturbed Wilcox Group underburden (for UR wells), Qal means Quaternary alluvium, and unk means that the geology is unknown. For “Screen Texture”, SD2 is a clean channel sand unit (high conductivity), “mix” refers to silty sand, clayey sand, or sandy silt, “n/a” refers to spoil wells, which were not logged during installation, and “unk” stands for unknown texture.

Water Body	Well/Spring Category	Screen Interval Geology	Screened Interval Texture	Water Type	Well Number	Location ID	Sample Date	Field EC (uS/cm)	Field pH	Temp
Ck	n/a	n/a	n/a	Na-Cl		Mill Ck by DI-20 surface pond & DI-alluv well	6/3/2013	454	6.86	24.1
G	OP	Qal	unk	Fe-Cl	11	D-1-Alluv	6/3/2013	143	5.51	18.5
G	OR	Spoil	n/a	Fe-SO4	78	DIII-1-OB2-R-99	6/3/2013	543	5.11	22.1
Ck	n/a	n/a	n/a	Ca-SO4		Mill Ck @ Gibbson Bridge	6/4/2013	715	6.89	28.9
G	OP	C/Wi	sand	Mg-Cl	22	D-19-OB	6/4/2013	72	4.65	20.2
G	UP	WUB	mix	Ca-HCO3	23	D-19-UB	6/4/2013	214	6.23	22.8
G	OG	Qal	mix	Ca-HCO3	25	D-2-Alluv	6/4/2013	415	7.71	21.4
G	OG	unk	unk	Mg-SO4	48	D-35-OB	6/4/2013	327	4.44	20
G	OP	unk	unk	Mg-SO4	58	D-45-S	6/4/2013	1311	4.72	23
G	OR	Spoil	n/a	Fe-SO4	4	89-3-OB-R-99	6/5/2013	307	4.48	24.9
Ck	OR	n/a	n/a	Na-Cl		Unnamed Trib. to Mill Ck	6/5/2013	273	6.04	26.3
G	OR	Spoil	n/a	Fe-SO4	67	DII-14-R-08	6/5/2013	560	3.89	24.3
G	OP	C/Wi	SD2	Na-Cl	71	DII-5-OB	6/5/2013	36	5.27	23.1
G	OP	Qal	unk	Na-HCO3	73	DII-6(Alluv)-04	6/5/2013	306	7.44	23.2
Sp	OR	n/a	n/a	Ca-SO4		Seep, N of Pond DI-115	6/5/2013	692	3.58	33.9
Sp	OR	n/a	n/a	Ca-SO4		Seep, S of Pond DI-79	6/5/2013	628	3.44	33.9
Sp	OR	n/a	n/a	Ca-SO4		Seep, S end of DI-115 Pond	6/6/2013	815	6.09	21.0

Ck	n/a	n/a	n/a	Ca-HCO3		Mill Ck downstream of mine @ USGS 80	6/6/2013	312	6.64	24
G	OR	Spoil	n/a	Na-SO4	4	89-3-OB-R-99	8/6/2013	328	4.46	22.1
G	UR	Dist'd WUB	unk	Fe-SO4	6	89-3-UB-R-99	8/6/2013	149	5.62	23.5
Ck	OP	n/a	n/a	Na-Cl		Mill Ck by DI-20 surface pond & DI-alluv well	8/6/2013	474	6.74	27.8
G	OG	Qal	mix	Ca-SO4	25	D-2-Alluv	8/6/2013	398	7.99	19.2
G	OG	unk	unk	Na-NO3	34	D-26-OB	8/6/2013	44	5.64	23.4
G	UG	WUB	mix	Na-HCO3	35	D-26-UB	8/6/2013	444	7.87	21.2
G	OR	Spoil	n/a	Mg-SO4	88	R-16(S)	8/6/2013	1313	3.41	23.5
G	OR	Spoil	n/a	Fe-SO4	89	R-18(S)	8/6/2013	1094	4.74	21.5
G	UR	Dist'd WUB	unk	Na-SO4	10	89-4-UB-R-99	8/7/2013	215	6.17	21.5
Ck	n/a	n/a	n/a	Na-HCO3		Mill Ck @ Gibbson Bridge	8/7/2013	230	6.79	29.9
G	OP	C/Wi	sand	Na-Cl	18	D-16-OBal	8/7/2013	37	4.96	21.3
G	UP	WUB	clay/silt	Na-HCO3	19	D-16-UB	8/7/2013	148	6.17	21.1
G	UP	WUB	mix	Ca-Cl	23	D-19-UB	8/7/2013	98	6.12	20.0
G	OP	unk	unk	Na-Cl	43	D-30-S	8/7/2013	691	6.06	21.0
G	OR	Spoil	n/a	Fe-SO4	67	DII-14-R-08	8/7/2013	450	3.87	21.0
G	OR	Spoil	n/a	Fe-SO4	68	DII-37-R-91	8/7/2013	864	5.60	24.7
G	UP	WUB	unk	Na-SO4	72	DII-5-UB	8/7/2013	89	6.29	21.3
G	OP	Qal	unk	Na-SO4	73	DII-6(Alluv)-04	8/7/2013	297	7.48	20.4

G	OR	Spoil	n/a	Ca-SO4	92	R-6(S)	8/7/2013	1019	4.16	
Sp	OR	n/a	n/a	Ca-SO4		Seep, S end of DI-115 Pond	8/7/2013	798	6.19	27.3
Sp	OR	n/a	n/a	Ca-SO4		Seep, S of Pond DI-79	8/7/2013	609	3.55	35.1
G	UG	unk	unk	Na-SO4		50-UB	8/8/2013	287	6.67	21.4
G	OP	unk	unk	Na-SO4		53-OB	8/8/2013	57	4.29	21.1
G	OP	unk	unk	Na-SO4		53-UB	8/8/2013	296	6.71	23.8
G	OR	Spoil	unk	Mg-SO4		56-R	8/8/2013	114	4.83	21.9
G	OP	C/Wi	SD2	Na-Cl	74	DIII-12-OB	8/8/2013	54	4.29	20.4
G	OP	Qal	unk	Na-Cl	76	DIII-15(Alluv)-04	8/8/2013	650	4.01	22.5
G	OR	Spoil	n/a	Fe-SO4	78	DIII-1-OB2-R-99	8/8/2013	518	5.19	20.8
G	OR	Spoil	n/a	Al-SO4	84	DIII-5-OB2-R-03	8/8/2013	1643	2.70	21.9
G	OR	Spoil	unk	Na-SO4		DIII-6-OB-R	8/8/2013	305	6.45	23.5
G	OP	unk	unk	Mg-SO4		DIV-1-OB	8/8/2013	87	5.38	22.7
G	OP	unk	unk	Na-Cl		DIV-6-OB	8/8/2013	49	4.66	22.3
G	OR	Spoil	unk	Mg-SO4		56-R	10/9/2013	143	4.75	20.4
G	UP	WUB	unk	Ca-Cl	42	D-30-D	10/9/2013	275	6.74	21.3
G	OP	unk	unk	Na-Cl	43	D-30-S	10/9/2013	713	6.08	19.9
G	OR	Spoil	n/a	Ca-SO4	68	DII-37-R-91	10/9/2013	802	5.36	22.8
G	OP	unk	unk	Mg-Cl		DIV-6-OB	10/9/2013	51	4.80	19.8
G	OP	unk	unk	Mg-SO4		DIV-7-OB	10/9/2013	104	5.51	20.1
G	UG	unk	unk	Na-SO4		50-UB	10/10/2013	255	6.15	20.6

G	OP	unk	unk	Na-SO4		53-UB	10/10/2013	56	4.06	22.8
G	OR	Spoil	n/a	Fe-SO4	8	89-4-OB-R-99	10/10/2013	1186	4.19	20.0
G	UR	Dist'd WUB	unk	Na-SO4	10	89-4-UB-R-99	10/10/2013	182	6.20	20.3
G	UP	WUB	clay/silt	Na-Cl	19	D-16-UB	10/10/2013	138	6.15	19.6
G	OP	C/Wi	SD2	Na-SO4	74	DIII-12-OB	10/10/2013	57	4.25	19.4
Sp	OR	n/a	n/a	Ca-SO4		Seep, N of Pond DI-115	10/10/2013	949	3.01	26.6
Sp	OR	n/a	n/a	Ca-SO4		Seep, S end of DI-115 Pond	10/10/2013	799	5.80	24.0
Sp	OR	n/a	n/a	Ca-SO4		Seep, S of Pond DI-79	10/10/2013	505	5.25	25.6
Sp	OP	n/a	n/a	Fe-SO4		Seep, Unnamed trib to MillCk near Ethiopia Field	10/10/2013	91	5.49	21.9
G	OP	Qal	unk	Na-Cl	76	DIII-15(Alluv)-04	10/11/2013	636	3.94	22.0
G	UR	Dist'd WUB	n/a	Na-SO4	80	DIII-1-UB-R-99	10/11/2013	237	5.95	20.6

Location ID	**Sample Date**	**Raw Bicarb. (mg/L)**	**Filtered Bicarb. (mg/L)**	**F- (ppm)**	**Cl- (ppm)**	**NO2 (ppm)**	**Br- (ppm)**	**NO3 (ppm)**	**SO4 (ppm)**	**PO4 (ppm)**
Mill Ck by DI-20 surface pond & DI-alluv well	6/3/2013	50.1	51.0	0.18	71.99	0	0.1647	2.0077	69	5.3228
D-1-Alluv	6/3/2013	31.8	34.7	0.01	22.96	0	0.2116	0	12	0
DIII-1-OB2-R-99	6/3/2013	20.4	18.9	0.04	20.75	0	0.212	0	228	0
Mill Ck @ Gibbson Bridge	6/4/2013	77.7	76.1	0.34	14.07	0	0.2108	0.187	258	0
D-19-OB	6/4/2013	0.0	1.8	0.07	9.42	0	0.0599	12.811	1	0
D-19-UB	6/4/2013	61.6	62.3	0.17	15.08	0	0.0771	0.0667	7	0.1379
D-2-Alluv	6/4/2013	171.3	173.4	0.05	16.27	0	0.1129	0	43	0.2358
D-35-OB	6/4/2013	0.0	1.8	0.47	3.60	0	0	0	155	0
D-45-S	6/4/2013	2.8	3.9	0.56	47.62	0	0.5232	0.0487	691	0
89-3-OB-R-99	6/5/2013	1.7	3.0	0.16	6.24	0	0.1394	0	119	0
Unnamed Trib. to Mill Ck	6/5/2013	9.5	9.6	0.07	26.96	0	0.2861	0.193	14	0.0647
DII-14-R-08	6/5/2013	0.0	0.0	0.89	9.44	0	0.2449	0	224	0
DII-5-OB	6/5/2013	4.5	4.4	0.02	3.17	0	0.0522	2.0226	3	0
DII-6(Alluv)-04	6/5/2013	155.5	155.8	0.09	11.67	0	0.0683	0.0339	19	0.1616
Seep, N of Pond DI-115	6/5/2013	0.0	0.0	0.25	15.80	0	0.2633	0	298	0
Seep, S of Pond DI-79	6/5/2013	0.0	0.0	0.24	8.65	0	0.3233	0	241	0
Seep, S end of DI-115 Pond	6/6/2013	111.7	114.0	0.05	13.64	0	0.37	0	308	0

Mill Ck downstream of mine @ USGS 80	6/6/2013	103.6	102.7	0.31	20.00	0	0.2437	0.0737	37	0.0441
89-3-OB-R-99	8/6/2013	34.0	35.2	0.08	12.20	< 0.01	0.09	0.35	22	< 0.10
89-3-UB-R-99	8/6/2013	0.0	0.0	0.12	6.00	< 0.01	0.11	< 0.01	112	< 0.10
Mill Ck by DI-20 surface pond & DI-alluv well	8/6/2013	48.1	40.3	0.17	77.80	0.02	0.13	3.95	58	5.85
D-2-Alluv	8/6/2013	168.9	172.9	0.05	17.90	< 0.01	0.03	0.35	42	0.12
D-26-OB	8/6/2013	5.3	5.6	0.03	3.92	< 0.01	< 0.01	7.64	2	< 0.10
D-26-UB	8/6/2013	135.3	134.0	0.18	27.20	< 0.01	0.08	0.35	76	0.25
R-16(S)	8/6/2013	0.0	0.0	1.31	11.30	< 0.04	< 0.04	< 0.04	751	< 0.40
R-18(S)	8/6/2013	0.0	0.0	0.11	7.03	< 0.03	0.10	< 0.03	638	< 0.30
89-4-UB-R-99	8/7/2013	48.1	46.7	0.22	6.05	< 0.01	0.03	< 0.01	44	< 0.10
Mill Ck @ Gibbson Bridge	8/7/2013	64.5	65.5	0.16	27.30	< 0.01	0.08	0.39	14	0.14
D-16-OBal	8/7/2013	0.0	0.0	0.01	4.61	< 0.01	0.01	1.42	4	< 0.10
D-16-UB	8/7/2013	61.6	64.8	0.19	11.70	0.01	0.05	0.73	10	< 0.10
D-19-UB	8/7/2013	32.8	32.8	0.09	11.30	< 0.01	0.03	0.74	7	0.12
D-30-S	8/7/2013	29.0	64.0	0.10	134.00	< 0.02	0.82	0.65	77	< 0.20
DII-14-R-08	8/7/2013	0.0	0.0	0.74	7.42	< 0.01	0.15	< 0.01	200	< 0.10
DII-37-R-91	8/7/2013	50.3	62.5	0.03	13.90	< 0.03	0.15	0.98	384	< 0.30
DII-5-UB	8/7/2013	33.5	33.1	0.09	4.32	< 0.01	0.04	0.34	6	< 0.10

DII-6(Alluv)-04	8/7/2013	157.1	155.1	0.08	8.19	< 0.01	0.01	0.36	16	0.19
R-6(S)	8/7/2013	0.0	0.0	0.04	9.22	< 0.03	0.11	0.96	535	< 0.30
Seep, S end of DI-115 Pond	8/7/2013	88.6	91.5	0.06	9.39	< 0.02	0.30	< 0.02	274	< 0.20
Seep, S of Pond DI-79	8/7/2013	0.0	0.0	0.10	8.84	< 0.02	0.33	0.65	253	< 0.20
50-UB	8/8/2013	126.0	130.8	0.10	7.38	< 0.01	0.03	< 0.01	26	< 0.10
53-OB	8/8/2013	0.0	0.0	< 0.01	3.89	< 0.01	0.03	< 0.01	10	< 0.10
53-UB	8/8/2013	118.9	114.8	0.25	7.58	< 0.01	0.02	< 0.01	42	0.94
56-R	8/8/2013	2.5	2.5	0.07	4.56	< 0.01	0.01	1.10	40	< 0.10
DIII-12-OB	8/8/2013	0.0	0.0	< 0.01	6.61	< 0.01	0.03	1.36	7	< 0.10
DIII-15(Alluv)-04	8/8/2013	0.0	0.0	0.19	129.00	< 0.02	1.88	< 0.02	103	< 0.20
DIII-1-OB2-R-99	8/8/2013	12.4	15.0	0.05	18.60	< 0.01	0.14	< 0.01	225	< 0.10
DIII-5-OB2-R-03	8/8/2013	0.0	0.0	0.70	6.51	< 0.05	0.03	1.92	742	< 0.50
DIII-6-OB-R	8/8/2013	100.5	99.6	0.10	11.10	< 0.01	0.08	< 0.01	28	< 0.10
DIV-1-OB	8/8/2013	10.8	9.7	0.03	10.70	< 0.01	0.04	0.34	20	< 0.10
DIV-6-OB	8/8/2013	0.0	0.0	0.01	8.33	< 0.01	0.03	1.34	4	< 0.10
56-R	10/9/2013	2.4	2.6	0.12	8.46	<0.01	<0.05	0.78	58	<0.05
D-30-D	10/9/2013	153.9	143.0	0.07	3.56	<0.01	<0.05	<0.01	2	<0.05
D-30-S	10/9/2013	74.1	79.8	0.09	135.00	<0.02	0.79	0.39	73	<0.09
DII-37-R-91	10/9/2013	49.1	49.4	0.01	9.00	<0.02	0.17	0.41	357	<0.09

DIV-6-OB	10/9/2013	7.5	0.6	0.02	7.13	<0.01	<0.05	0.96	4	<0.05
DIV-7-OB	10/9/2013	15.0	15.3	0.04	7.20	<0.01	0.05	0.22	23	<0.05
50-UB	10/10/2013	92.6	92.6	0.09	7.03	0.03	<0.05	0.27	37	<0.05
53-UB	10/10/2013	0.0	0.0	0.01	5.12	<0.01	0.05	1.78	7	<0.05
89-4-OB-R-99	10/10/2013	0.0	0.0	0.26	4.81	<0.02	0.21	<0.02	677	<0.11
89-4-UB-R-99	10/10/2013	63.9	62.6	0.19	5.14	0.04	<0.05	0.27	21	<0.05
D-16-UB	10/10/2013	53.6	52.1	0.14	7.96	<0.01	0.07	0.36	10	<0.05
DIII-12-OB	10/10/2013	0.0	0.0	0.01	5.07	<0.01	0.05	1.73	7	<0.05
Seep, N of Pond DI-115	10/10/2013	0.0	0.0	0.15	9.43	<0.02	0.19	0.50	375	<0.10
Seep, S end of DI-115 Pond	10/10/2013	144.9	142.6	0.05	12.90	<0.02	0.32	0.39	282	<0.09
Seep, S of Pond DI-79	10/10/2013	3.4	3.3	0.12	8.44	<0.01	0.29	0.22	224	<0.05
Seep, Unnamed trib to MillCk near Ethiopia Field	10/10/2013	30.7	30.7	0.01	5.54	<0.01	0.06	0.26	12	<0.05
DIII-15(Alluv)-04	10/11/2013	0.0	0.0	0.18	117.00	<0.01	1.67	0.23	98	<0.05
DIII-1-UB-R-99	10/11/2013	79.1	81.8	0.09	9.71	<0.01	0.09	0.25	28	<0.05

Location ID	Sample Date	Li (ppb)	B (ppb)	Na (ppb)	Mg (ppb)	Al (ppb)	Si (ppb)	P (ppb)	K (ppb)	Ca (ppb)	Ti (ppb)	V (ppb)
Mill Ck by DI-20 surface pond & DI-alluv well	6/3/2013	8.0	67.9	50712	5127	5	4718	1601.4	7812	17162	1.9	0.7
D-1-Alluv	6/3/2013	3.7	< 12.7	7967	2259	6	8285	< 24.5	1598	6961	0.8	< 0.44
DIII-1-OB2-R-99	6/3/2013	64.7	53.6	11993	10860	448	5389	< 24.5	8549	19053	0.6	0.7
Mill Ck @ Gibbson Bridge	6/4/2013	5.4	71.3	61407	17694	12	3237	< 24.5	4173	55683	0.4	< 0.44
D-19-OB	6/4/2013	2.8	< 12.7	2899	2316	119	6295	< 24.5	1101	1568	0.5	< 0.44
D-19-UB	6/4/2013	10.8	16.3	10439	4703	7	19484	207.2	9366	9621	2.1	< 0.44
D-2-Alluv	6/4/2013	31.9	107.4	36146	7917	575	7368	< 24.5	4065	33860	14.7	1.3
D-35-OB	6/4/2013	26.7	17.5	4021	16083	5106	15933	< 24.5	2491	15562	1.4	1.4
D-45-S	6/4/2013	40.3	77.7	59170	100416	1219	10148	< 24.5	11928	59562	1.1	< 0.44
89-3-OB-R-99	6/5/2013	19.6	37.2	9707	5242	473	11249	< 24.5	2176	7700	1.1	< 0.44
Unnamed Trib. to Mill Ck	6/5/2013	9.3	18.9	11156	2807	18	7349	< 24.5	2416	5571	0.7	< 0.44
DII-14-R-08	6/5/2013	9.2	108.1	4797	8901	7428	16531	< 24.5	3336	24841	1.7	3.7
DII-5-OB	6/5/2013	1.3	14.5	2233	653	5	6123	< 24.5	1369	1527	0.6	< 0.44
DII-6(Alluv)-04	6/5/2013	8.3	143.6	52655	3073	14	7378	< 24.5	6291	7875	0.8	< 0.44
Seep, N of Pond DI-115	6/5/2013	5.5	103.2	10653	19767	1637	11057	< 24.5	4790	36713	1.2	< 0.44

Seep, S of Pond DI-79	6/5/2013	3.0	114.7	6380	18645	454	5653	< 24.5	3296	43307	0.4	< 0.44
Seep, S end of DI-115 Pond	6/6/2013	2.7	111.8	10142	17871	30	5645	< 24.5	4369	93691	0.5	< 0.44
Mill Ck downstream of mine @ USGS 80	6/6/2013	2.4	47.0	25304	8172	42	6405	< 24.5	2566	24498	4.0	1.9
89-3-OB-R-99	8/6/2013	20.0	47.2	12942	2914	54	18763	< 24.5	6018	7928	3.2	< 0.44
89-3-UB-R-99	8/6/2013	20.6	32.9	11938	5583	613	11718	< 24.5	3219	8397	5.7	< 0.44
Mill Ck by DI-20 surface pond & DI-alluv well	8/6/2013	7.4	86.0	51151	6159	5	4425	1976.7	9968	19687	2.3	0.9
D-2-Alluv	8/6/2013	31.9	103.4	34233	7989	991	8716	51.6	5324	32471	31.5	3.7
D-26-OB	8/6/2013	5.0	< 12.7	4563	817	50	18497	< 24.5	1542	1132	4.3	< 0.44
D-26-UB	8/6/2013	60.8	97.0	45950	9464	37	7679	84.1	3976	25257	1.5	0.3
R-16(S)	8/6/2013	119.9	78.3	29861	57034	18476	32931	< 24.5	9224	78089	3.0	< 0.44
R-18(S)	8/6/2013	33.4	158.3	20356	37975	467	11816	< 24.5	6383	71971	1.5	< 0.44
89-4-UB-R-99	8/7/2013	27.4	43.7	23967	4372	14	23817	471.3	2183	7008	2.9	< 0.44
Mill Ck @ Gibbson Bridge	8/7/2013	2.8	50.1	23193	3664	57	4826	106.3	5876	12575	2.2	0.8
D-16-OBal	8/7/2013	5.9	9.8	2538	610	40	1622	< 7.13	782	1379	0.3	0.2
D-16-UB	8/7/2013	24.4	68.0	14018	3168	4	18542	< 24.5	5480	8791	1.6	< 0.44
D-19-UB	8/7/2013	7.3	13.6	6657	3147	5	3227	40.1	1470	6299	0.4	< 0.13
D-30-S	8/7/2013	73.6	11.4	50559	24199	1	30764	150.3	4013	17133	3.1	< 0.13

DII-14-R-08	8/7/2013	10.2	104.9	5656	8484	6632	20150	8.2	2051	21713	2.0	3.4
DII-37-R-91	8/7/2013	100.6	195.9	12354	29654	17	8911	9.9	12724	55083	1.1	< 0.13
DII-5-UB	8/7/2013	10.3	17.6	7728	2118	8	18230	< 24.5	1745	4636	1.8	< 0.44
DII-6(Alluv)-04	8/7/2013	9.0	142.6	54251	3026	682	9483	77.7	2189	7269	33.2	1.9
R-6(S)	8/7/2013	37.8	316.1	15523	34356	722	11392	< 7.13	7255	68382	2.8	0.3
Seep, S end of DI-115 Pond	8/7/2013	2.2	92.6	6857	11123	18	5587	< 24.5	2518	84831	0.4	< 0.44
Seep, S of Pond DI-79	8/7/2013	3.2	120.8	7018	20400	150	6140	< 7.13	3318	43166	0.9	< 0.13
50-UB	8/8/2013	30.9	104.5	41034	5035	3722	16201	65.7	3294	12774	82.7	16.8
53-OB	8/8/2013	18.7	13.9	2572	596	651	12418	< 7.13	1142	716	17.9	0.8
53-UB	8/8/2013	24.6	105.5	54520	1939	509	16372	342.8	1908	5109	15.0	0.9
56-R	8/8/2013	1.6	23.0	5778	4697	1236	12533	10.7	1670	5631	37.8	2.2
DIII-12-OB	8/8/2013	15.7	11.8	3497	505	130	14528	9.9	2800	417	1.7	0.2
DIII-15(Alluv)-04	8/8/2013	29.4	63.9	48847	19675	3160	18975	< 7.13	2839	24498	1.9	< 0.13
DIII-1-OB2-R-99	8/8/2013	66.1	52.4	12134	11247	285	6144	11.4	6468	18131	1.0	< 0.13
DIII-5-OB2-R-03	8/8/2013	49.1	19.2	4942	16254	52072	38886	< 24.5	2771	77673	14.7	8.7
DIII-6-OB-R	8/8/2013	26.7	80.6	24589	6457	1159	9923	20.3	2738	16333	46.8	4.5
DIV-1-OB	8/8/2013	22.5	17.7	3685	3596	21	11039	< 24.5	5509	4913	0.8	< 0.44

DIV-6-OB	8/8/2013	11.0	9.6	2559	1268	132	14300	< 7.13	1434	1272	1.7	< 0.13
56-R	10/9/2013	1.3	20.8	5745	5880	648	9769	< 10.52	4627	7026	11.1	0.7
D-30-D	10/9/2013	36.3	35.9	21157	9303	< 2.07	18948	225.3	2618	19440	2.4	< 0.05
D-30-S	10/9/2013	74.2	8.6	51980	23757	< 2.07	27104	121.0	4013	17104	3.5	< 0.05
DII-37-R-91	10/9/2013	103.2	203.8	13097	28156	32	8354	11.2	7869	52908	1.2	< 0.05
DIV-6-OB	10/9/2013	10.0	7.8	2581	1389	90	11902	< 10.52	1224	1336	1.7	< 0.05
DIV-7-OB	10/9/2013	24.5	15.8	3876	4215	13	10180	< 10.52	1470	5592	1.2	0.1
50-UB	10/10/2013	28.4	99.2	41925	2968	2741	14215	25.6	2824	6883	115.5	6.8
53-UB	10/10/2013	16.0	9.2	3536	557	170	12461	< 10.52	1123	869	3.2	< 0.05
89-4-OB-R-99	10/10/2013	55.1	90.2	9840	28827	5320	11678	< 10.52	9082	27096	1.4	3.0
89-4-UB-R-99	10/10/2013	25.5	41.1	25690	3244	2	23015	22.2	2135	5018	2.9	< 0.05
D-16-UB	10/10/2013	24.9	61.5	13933	2977	5	17394	72.7	2302	7337	2.1	< 0.05
DIII-12-OB	10/10/2013	16.0	9.6	3468	530	154	12595	< 10.52	977	338	1.6	< 0.05
Seep, N of Pond DI-115	10/10/2013	3.9	81.6	8906	25431	599	8196	< 10.52	3228	45050	1.2	0.1
Seep, S end of DI-115 Pond	10/10/2013	2.9	126.5	10894	16857	34	6599	< 10.52	4230	88582	0.7	< 0.05
Seep, S of Pond DI-79	10/10/2013	2.6	99.0	6993	19260	64	5041	< 10.52	2915	42141	0.4	< 0.05
Seep, Unnamed trib to MillCk near Ethiopia Field	10/10/2013	11.5	14.6	3772	1717	186	10015	44.9	1400	2842	3.8	8.9

DIII-15(Alluv)-04	10/11/2013	30.6	63.3	46950	18947	2923	17425	< 10.52	3156	24420	4.1	0.1
DIII-1-UB-R-99	10/11/2013	26.7	53.3	24958	4346	22	19005	< 10.52	4270	9022	2.1	< 0.05

Location ID	**Sample Date**	**Cr (ppb)**	**Mn (ppb)**	**Fe (ppb)**	**Co (ppb)**	**Ni (ppb)**	**Cu (ppb)**	**Zn (ppb)**	**As (ppb)**	**Se (ppb)**	**Rb (ppb)**	**Sr (ppb)**
Mill Ck by DI-20 surface pond & DI-alluv well	6/3/2013	< 0.55	178	519	0.5	1.4	< 1.09	17.6	1.0	< 0.21	9.7	186.8
D-1-Alluv	6/3/2013	< 0.55	309	10216	5.6	1.3	< 1.09	28.5	5.2	< 0.21	1.1	96.7
DIII-1-OB2-R-99	6/3/2013	0.7	646	71547	30.4	34.3	< 1.09	320.2	2.7	< 0.21	21.8	238.0
Mill Ck @ Gibbson Bridge	6/4/2013	< 0.55	432	325	1.3	2.5	< 1.09	30.1	0.7	< 0.21	6.6	427.4
D-19-OB	6/4/2013	< 0.55	12	24	1.7	1.1	< 1.09	52.6	< 0.59	< 0.21	1.1	31.8
D-19-UB	6/4/2013	< 0.55	146	2327	0.7	1.7	< 1.09	34.9	< 0.59	< 0.21	3.0	332.9
D-2-Alluv	6/4/2013	2.0	127	421	0.1	1.0	< 1.09	25.7	1.0	< 0.21	3.1	1212.9
D-35-OB	6/4/2013	0.9	1751	3480	75.9	77.1	< 1.09	236.4	3.2	< 0.21	3.2	244.0
D-45-S	6/4/2013	1.3	444	1193	58.2	110.2	< 1.09	182.0	0.7	0.2	8.3	1181.8
89-3-OB-R-99	6/5/2013	1.3	256	35344	23.5	26.2	< 1.09	377.4	< 0.59	< 0.21	8.0	116.8
Unnamed Trib. to Mill Ck	6/5/2013	< 0.55	194	1575	2.8	2.6	< 1.09	52.7	< 0.59	< 0.21	3.9	111.0
DII-14-R-08	6/5/2013	0.9	465	35734	28.0	36.5	< 1.09	353.0	4.0	< 0.21	7.0	571.8
DII-5-OB	6/5/2013	1.6	3	20	< 0.13	0.3	< 1.09	62.6	< 0.59	0.3	1.1	13.0
DII-6(Alluv)-04	6/5/2013	0.8	20	60	< 0.13	0.3	< 1.09	89.8	< 0.59	< 0.21	2.3	282.9
Seep, N of Pond DI-115	6/5/2013	< 0.55	762	34267	33.7	29.9	< 1.09	197.3	1.2	< 0.21	11.7	386.8

Seep, S of Pond DI-79	6/5/2013	1.9	1934	6928	23.6	18.6	< 1.09	130.6	0.9	< 0.21	8.6	463.6
Seep, S end of DI-115 Pond	6/6/2013	< 0.55	1022	60041	27.1	34.1	< 1.09	120.8	3.4	< 0.21	9.3	489.6
Mill Ck downstream of mine @ USGS 80	6/6/2013	1.0	543	7963	2.8	2.4	< 1.09	27.2	4.2	0.6	5.8	231.8
89-3-OB-R-99	8/6/2013	< 0.55	214	2866	2.4	4.6	< 1.09	37.7	< 0.59	< 0.21	5.1	183.7
89-3-UB-R-99	8/6/2013	< 0.55	275	37289	25.4	30.1	< 1.09	425.0	0.9	< 0.21	8.1	125.4
Mill Ck by DI-20 surface pond & DI-alluv well	8/6/2013	< 0.20	161	300	0.6	2.0	3.4	50.7	1.8	0.3	10.5	209.8
D-2-Alluv	8/6/2013	1.2	117	690	0.3	0.9	3.6	9.2	1.0	< 0.09	3.6	1185.0
D-26-OB	8/6/2013	1.7	5	22	0.2	1.5	< 1.09	13.1	< 0.59	< 0.21	2.2	19.3
D-26-UB	8/6/2013	< 0.20	92	55	0.1	0.4	1.0	30.9	< 0.29	0.1	2.4	664.8
R-16(S)	8/6/2013	2.1	7384	36903	264.1	301.2	7.0	2333.1	6.2	< 0.21	29.9	1837.6
R-18(S)	8/6/2013	< 0.55	2373	130392	85.3	129.1	< 1.09	661.0	2.6	< 0.21	16.1	1538.4
89-4-UB-R-99	8/7/2013	< 0.55	205	6033	4.3	6.4	< 1.09	25.9	< 0.59	< 0.21	5.3	165.7
Mill Ck @ Gibbson Bridge	8/7/2013	0.2	711	1822	2.0	2.5	1.6	43.3	5.5	0.2	7.9	129.9
D-16-OBal	8/7/2013	0.5	9	192	0.6	1.0	2.4	22.3	< 0.29	0.5	1.7	13.4
D-16-UB	8/7/2013	< 0.55	43	487	0.5	0.9	< 1.09	28.2	< 0.59	< 0.21	3.7	276.2
D-19-UB	8/7/2013	< 0.20	102	668	1.1	2.3	1.2	37.9	< 0.29	< 0.09	2.0	186.9
D-30-S	8/7/2013	< 0.20	1833	35107	44.5	69.4	1.0	76.4	0.6	< 0.09	11.5	174.1
DII-14-R-08	8/7/2013	0.7	386	33647	25.4	33.5	1.4	248.8	4.5	0.2	5.6	480.0

DII-37-R-91	8/7/2013	< 0.20	1184	86368	30.3	19.1	1.0	67.3	2.2	< 0.09	14.4	1190.4
DII-5-UB	8/7/2013	< 0.55	121	1434	0.2	0.9	< 1.09	14.7	< 0.59	< 0.21	2.1	117.4
DII-6(Alluv)-04	8/7/2013	1.2	29	840	0.5	5.2	1.9	7.8	0.6	< 0.09	2.5	251.7
R-6(S)	8/7/2013	0.2	2084	94326	147.5	120.2	3.2	728.0	6.2	< 0.09	15.0	1585.3
Seep, S end of DI-115 Pond	8/7/2013	< 0.55	734	51291	19.6	26.2	< 1.09	42.6	2.9	< 0.21	7.9	457.8
Seep, S of Pond DI-79	8/7/2013	< 0.20	1956	13748	21.0	15.6	< 0.71	39.5	0.7	0.1	8.4	467.4
50-UB	8/8/2013	8.8	161	4671	3.1	8.1	< 1.09	25.5	2.6	< 0.21	9.5	235.9
53-OB	8/8/2013	0.6	8	268	2.9	4.0	2.0	40.7	< 0.29	< 0.09	3.9	11.2
53-UB	8/8/2013	0.7	19	642	0.2	0.7	< 1.09	3.4	< 0.59	< 0.21	2.9	129.1
56-R	8/8/2013	1.1	15	549	1.6	2.1	1.7	13.8	0.4	1.1	1.8	59.4
DIII-12-OB	8/8/2013	0.3	12	87	2.1	2.8	2.7	25.3	< 0.29	1.0	3.8	8.9
DIII-15(Alluv)-04	8/8/2013	1.6	159	179	10.5	15.2	3.4	77.2	1.0	4.1	9.0	303.3
DIII-1-OB2-R-99	8/8/2013	< 0.20	617	72691	30.0	34.7	0.8	311.5	0.8	< 0.09	20.0	226.6
DIII-5-OB2-R-03	8/8/2013	25.3	630	11436	199.7	193.2	17.1	591.3	6.0	0.5	19.8	195.4
DIII-6-OB-R	8/8/2013	1.9	155	6437	0.3	1.1	0.8	62.1	3.5	0.2	4.0	178.7
DIV-1-OB	8/8/2013	< 0.55	24	6	2.8	4.8	< 1.09	24.5	< 0.59	< 0.21	3.4	44.6
DIV-6-OB	8/8/2013	0.5	6	81	1.8	3.2	0.8	18.1	< 0.29	0.2	2.2	13.3
56-R	10/9/2013	0.5	10	189	1.4	1.6	-4.1	24.7	0.2	1.0	1.3	75.5
D-30-D	10/9/2013	< 0.10	74	2462	< 0.11	0.2	-4.9	4.1	< 0.22	< 0.17	2.2	423.0

D-30-S	10/9/2013	< 0.10	1811	34227	44.4	71.1	-4.4	70.0	0.8	< 0.17	11.0	171.4
DII-37-R-91	10/9/2013	< 0.10	1203	73685	31.5	23.4	-4.8	63.3	2.7	< 0.17	14.8	1143.5
DIV-6-OB	10/9/2013	0.6	5	49	1.5	2.7	-4.6	17.6	< 0.22	< 0.17	1.9	13.9
DIV-7-OB	10/9/2013	< 0.10	22	773	2.1	3.5	-4.8	14.6	0.3	< 0.17	2.8	47.6
50-UB	10/10/2013	3.0	75	1248	2.2	4.9	-3.9	9.6	4.6	< 0.17	5.3	153.7
53-UB	10/10/2013	< 0.10	13	188	2.2	2.8	-4.1	35.1	0.2	1.5	3.3	8.3
89-4-OB-R-99	10/10/2013	0.4	1658	250567	235.9	362.1	-4.8	2387.3	3.7	< 0.17	31.6	235.6
89-4-UB-R-99	10/10/2013	< 0.10	128	165	2.2	3.7	-4.5	24.1	< 0.22	< 0.17	4.4	116.5
D-16-UB	10/10/2013	< 0.10	53	725	0.8	0.6	-4.4	14.9	0.2	< 0.17	2.8	233.6
DIII-12-OB	10/10/2013	< 0.10	12	109	2.0	2.6	-4.5	26.9	< 0.22	1.7	3.3	7.7
Seep, N of Pond DI-115	10/10/2013	0.2	1279	61379	42.8	40.7	-4.8	104.6	1.5	< 0.17	8.0	646.0
Seep, S end of DI-115 Pond	10/10/2013	< 0.10	932	60121	26.5	35.7	-5.0	62.3	4.9	< 0.17	9.5	462.5
Seep, S of Pond DI-79	10/10/2013	< 0.10	1855	18559	22.8	17.8	-5.1	45.4	0.2	< 0.17	6.4	437.3
Seep, Unnamed trib to MillCk near Ethiopia Field	10/10/2013	0.3	49	10134	0.7	1.0	-4.8	3.7	11.1	< 0.17	3.0	32.0
DIII-15(Alluv)-04	10/11/2013	0.8	157	189	9.8	13.4	-3.2	102.3	1.0	3.8	8.8	286.2
DIII-1-UB-R-99	10/11/2013	< 0.10	205	4940	1.7	4.0	-4.6	49.4	0.2	< 0.17	6.0	280.1

Location ID	Sample Date	Zr (ppb)	Mo (ppb)	Ag (ppb)	Cd (ppb)	Sn (ppb)	Zn (ppb)	Sb (ppb)	Cs (ppb)	Ba (ppb)	Tl (ppb)	Pb (ppb)
Mill Ck by DI-20 surface pond & DI-alluv well	6/3/2013	< 0.12	0.5	< 0.96	0.2	< 0.14	17.6	0.2	< 0.12	42.0	< 0.17	< 0.10
D-1-Alluv	6/3/2013	< 0.12	< 0.39	< 0.96	0.3	< 0.14	28.5	< 0.12	< 0.12	96.2	< 0.17	0.5
DIII-1-OB2-R-99	6/3/2013	< 0.12	< 0.39	< 0.96	1.2	< 0.14	320.2	< 0.12	0.3	24.6	< 0.17	2.0
Mill Ck @ Gibbson Bridge	6/4/2013	< 0.12	< 0.39	< 0.96	< 0.12	< 0.14	30.1	< 0.12	< 0.12	79.0	< 0.17	< 0.10
D-19-OB	6/4/2013	< 0.12	< 0.39	< 0.96	0.5	< 0.14	52.6	< 0.12	< 0.12	47.4	< 0.17	0.2
D-19-UB	6/4/2013	< 0.12	< 0.39	< 0.96	0.6	< 0.14	34.9	< 0.12	< 0.12	109.6	< 0.17	< 0.10
D-2-Alluv	6/4/2013	0.4	< 0.39	< 0.96	< 0.12	< 0.14	25.7	< 0.12	0.1	55.8	< 0.17	0.6
D-35-OB	6/4/2013	< 0.12	< 0.39	< 0.96	1.0	< 0.14	236.4	< 0.12	< 0.12	59.4	< 0.17	1.7
D-45-S	6/4/2013	0.4	< 0.39	< 0.96	4.6	< 0.14	182.0	< 0.12	< 0.12	49.5	0.2	1.1
89-3-OB-R-99	6/5/2013	< 0.12	< 0.39	< 0.96	1.0	< 0.14	377.4	< 0.12	< 0.12	57.5	< 0.17	0.6
Unnamed Trib. to Mill Ck	6/5/2013	< 0.12	< 0.39	< 0.96	< 0.12	< 0.14	52.7	< 0.12	< 0.12	81.1	< 0.17	< 0.10
DII-14-R-08	6/5/2013	0.1	< 0.39	< 0.96	2.4	< 0.14	353.0	< 0.12	0.4	32.1	< 0.17	2.7
DII-5-OB	6/5/2013	< 0.12	< 0.39	< 0.96	0.5	< 0.14	62.6	< 0.12	< 0.12	16.5	< 0.17	< 0.10
DII-6(Alluv)-04	6/5/2013	< 0.12	< 0.39	< 0.96	0.3	< 0.14	89.8	< 0.12	< 0.12	100.1	< 0.17	0.1
Seep, N of Pond DI-115	6/5/2013	< 0.12	< 0.39	< 0.96	< 0.12	3.6	197.3	< 0.12	< 0.12	42.9	< 0.17	0.5

Seep, S of Pond DI-79	6/5/2013	< 0.12	< 0.39	< 0.96	0.2	< 0.14	130.6	< 0.12	< 0.12	55.8	< 0.17	0.1
Seep, S end of DI-115 Pond	6/6/2013	< 0.12	< 0.39	< 0.96	0.5	< 0.14	120.8	< 0.12	0.2	30.7	< 0.17	< 0.10
Mill Ck downstream of mine @ USGS 80	6/6/2013	0.2	0.5	< 0.96	0.3	< 0.14	27.2	< 0.12	< 0.12	139.5	< 0.17	0.2
89-3-OB-R-99	8/6/2013	< 0.12	< 0.39	< 0.96	0.3	< 0.14	37.7	< 0.12	< 0.12	71.0	< 0.17	< 0.10
89-3-UB-R-99	8/6/2013	< 0.12	< 0.39	< 0.96	0.4	< 0.14	425.0	< 0.12	< 0.12	46.5	< 0.17	0.3
Mill Ck by DI-20 surface pond & DI-alluv well	8/6/2013	0.0	0.6	< 4.71	0.3	< 0.15	50.7	0.2	< 0.05	42.9	< 0.13	< 0.06
D-2-Alluv	8/6/2013	2.3	< 0.31	< 4.71	< 0.05	< 0.15	9.2	< 0.07	0.2	72.3	< 0.13	1.2
D-26-OB	8/6/2013	< 0.12	< 0.39	< 0.96	< 0.12	< 0.14	13.1	0.1	< 0.12	55.3	< 0.17	< 0.10
D-26-UB	8/6/2013	0.1	< 0.31	< 4.71	0.8	< 0.15	30.9	0.3	0.1	100.1	< 0.13	0.2
R-16(S)	8/6/2013	< 0.12	< 0.39	< 0.96	6.0	< 0.14	2333.1	0.1	0.5	48.6	0.4	4.5
R-18(S)	8/6/2013	< 0.12	< 0.39	< 0.96	0.4	< 0.14	661.0	< 0.12	0.3	15.8	< 0.17	0.2
89-4-UB-R-99	8/7/2013	< 0.12	< 0.39	< 0.96	0.1	< 0.14	25.9	0.4	< 0.12	48.4	< 0.17	< 0.10
Mill Ck @ Gibbson Bridge	8/7/2013	0.1	0.4	< 4.71	0.2	< 0.15	43.3	0.1	< 0.05	56.2	< 0.13	0.2
D-16-OBal	8/7/2013	< 0.03	< 0.31	< 4.71	0.4	< 0.15	22.3	< 0.07	0.1	30.1	< 0.13	< 0.06
D-16-UB	8/7/2013	< 0.12	< 0.39	< 0.96	0.2	< 0.14	28.2	0.2	< 0.12	87.0	< 0.17	< 0.10
D-19-UB	8/7/2013	< 0.03	< 0.31	< 4.71	0.4	< 0.15	37.9	< 0.07	< 0.05	74.5	< 0.13	< 0.06
D-30-S	8/7/2013	< 0.03	< 0.31	< 4.71	0.1	< 0.15	76.4	0.1	0.1	151.5	< 0.13	< 0.06

DII-14-R-08	8/7/2013	0.1	< 0.31	< 4.71	1.8	< 0.15	248.8	< 0.07	0.3	30.4	< 0.13	1.7
DII-37-R-91	8/7/2013	0.0	< 0.31	< 4.71	0.1	< 0.15	67.3	< 0.07	0.1	26.8	< 0.13	< 0.06
DII-5-UB	8/7/2013	< 0.12	< 0.39	< 0.96	0.4	< 0.14	14.7	0.8	< 0.12	79.3	< 0.17	< 0.10
DII-6(Alluv)-04	8/7/2013	0.6	< 0.31	< 4.71	0.1	< 0.15	7.8	0.1	0.1	102.5	< 0.13	0.4
R-6(S)	8/7/2013	0.2	< 0.31	< 4.71	2.3	< 0.15	728.0	0.1	0.1	23.0	0.2	1.0
Seep, S end of DI-115 Pond	8/7/2013	< 0.12	< 0.39	< 0.96	< 0.12	< 0.14	42.6	< 0.12	0.1	33.0	< 0.17	< 0.10
Seep, S of Pond DI-79	8/7/2013	< 0.03	< 0.31	< 4.71	0.2	< 0.15	39.5	< 0.07	0.1	57.9	< 0.13	< 0.06
50-UB	8/8/2013	4.5	0.6	< 0.96	< 0.12	< 0.14	25.5	0.2	1.1	123.4	< 0.17	7.9
53-OB	8/8/2013	0.3	< 0.31	< 4.71	0.3	< 0.15	40.7	< 0.07	0.1	138.1	< 0.13	0.5
53-UB	8/8/2013	0.6	0.6	< 0.96	0.2	< 0.14	3.4	< 0.12	< 0.12	49.4	< 0.17	0.2
56-R	8/8/2013	0.9	< 0.31	< 4.71	0.1	< 0.15	13.8	< 0.07	0.1	65.8	< 0.13	0.4
DIII-12-OB	8/8/2013	< 0.03	< 0.31	< 4.71	0.6	< 0.15	25.3	< 0.07	0.1	87.1	< 0.13	0.1
DIII-15(Alluv)-04	8/8/2013	0.1	< 0.31	< 4.71	1.1	< 0.15	77.2	< 0.07	0.3	212.0	0.2	1.5
DIII-1-OB2-R-99	8/8/2013	< 0.03	< 0.31	< 4.71	0.7	< 0.15	311.5	< 0.07	0.3	24.4	< 0.13	0.2
DIII-5-OB2-R-03	8/8/2013	0.6	< 0.39	< 0.96	3.5	< 0.14	591.3	< 0.12	2.0	19.8	0.2	44.3
DIII-6-OB-R	8/8/2013	1.8	0.9	< 4.71	0.2	< 0.15	62.1	0.1	0.2	89.5	< 0.13	0.6
DIV-1-OB	8/8/2013	< 0.12	< 0.39	< 0.96	0.2	< 0.14	24.5	< 0.12	< 0.12	60.5	< 0.17	< 0.10

DIV-6-OB	8/8/2013	< 0.03	< 0.31	< 4.71	0.1	< 0.15	18.1	< 0.07	< 0.05	84.3	< 0.13	< 0.06
56-R	10/9/2013	0.3	< 0.19	< 0.44	< 0.12	< 0.15	24.7	< 0.13	< 0.08	69.4	< 0.10	0.1
D-30-D	10/9/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	4.1	< 0.13	< 0.08	260.5	< 0.10	< 0.12
D-30-S	10/9/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	70.0	< 0.13	< 0.08	144.7	< 0.10	< 0.12
DII-37-R-91	10/9/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	63.3	< 0.13	0.1	27.3	< 0.10	< 0.12
DIV-6-OB	10/9/2013	0.2	< 0.19	< 0.44	< 0.12	< 0.15	17.6	< 0.13	< 0.08	74.6	< 0.10	< 0.12
DIV-7-OB	10/9/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	14.6	< 0.13	< 0.08	57.9	< 0.10	< 0.12
50-UB	10/10/2013	2.3	0.3	< 0.44	< 0.12	< 0.15	9.6	< 0.13	0.2	69.2	< 0.10	1.6
53-UB	10/10/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	35.1	< 0.13	< 0.08	78.1	< 0.10	0.2
89-4-OB-R-99	10/10/2013	< 0.06	< 0.19	1.4	2.2	< 0.15	2387.3	0.2	0.6	13.4	< 0.10	1.0
89-4-UB-R-99	10/10/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	24.1	0.6	< 0.08	29.3	< 0.10	< 0.12
D-16-UB	10/10/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	14.9	< 0.13	< 0.08	80.7	< 0.10	< 0.12
DIII-12-OB	10/10/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	26.9	< 0.13	< 0.08	77.2	< 0.10	< 0.12
Seep, N of Pond DI-115	10/10/2013	0.1	< 0.19	< 0.44	< 0.12	0.2	104.6	< 0.13	0.2	24.3	< 0.10	0.2
Seep, S end of DI-115 Pond	10/10/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	62.3	< 0.13	0.1	33.4	< 0.10	< 0.12
Seep, S of Pond DI-79	10/10/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	45.4	< 0.13	< 0.08	54.2	< 0.10	< 0.12
Seep, Unnamed trib to MillCk near Ethiopia Field	10/10/2013	0.2	0.4	< 0.44	< 0.12	< 0.15	3.7	< 0.13	< 0.08	50.2	< 0.10	0.5

DIII-15(Alluv)-04	10/11/2013	0.1	< 0.19	< 0.44	< 0.12	< 0.15	102.3	< 0.13	0.3	164.2	0.1	1.1
DIII-1-UB-R-99	10/11/2013	< 0.06	< 0.19	< 0.44	< 0.12	< 0.15	49.4	0.3	< 0.08	106.6	< 0.10	< 0.12

APPENDIX H: POST COLLECTION PH VARIABILITY

This appendix discusses the complication of post-collection pH variability in water samples. This issue was discovered during the collection of the 2013 data set (Chapter 4) but also applies to the historic data set.

Overview of Post-Collection pH Variability

The difference field pH and on-site pH by mine personnel for 20 wells sampled during the August (Q3) 2013 sampling event and 19 wells sampled during the October (Q4) sampling event were compared. The paired pH measurements are shown in Figure

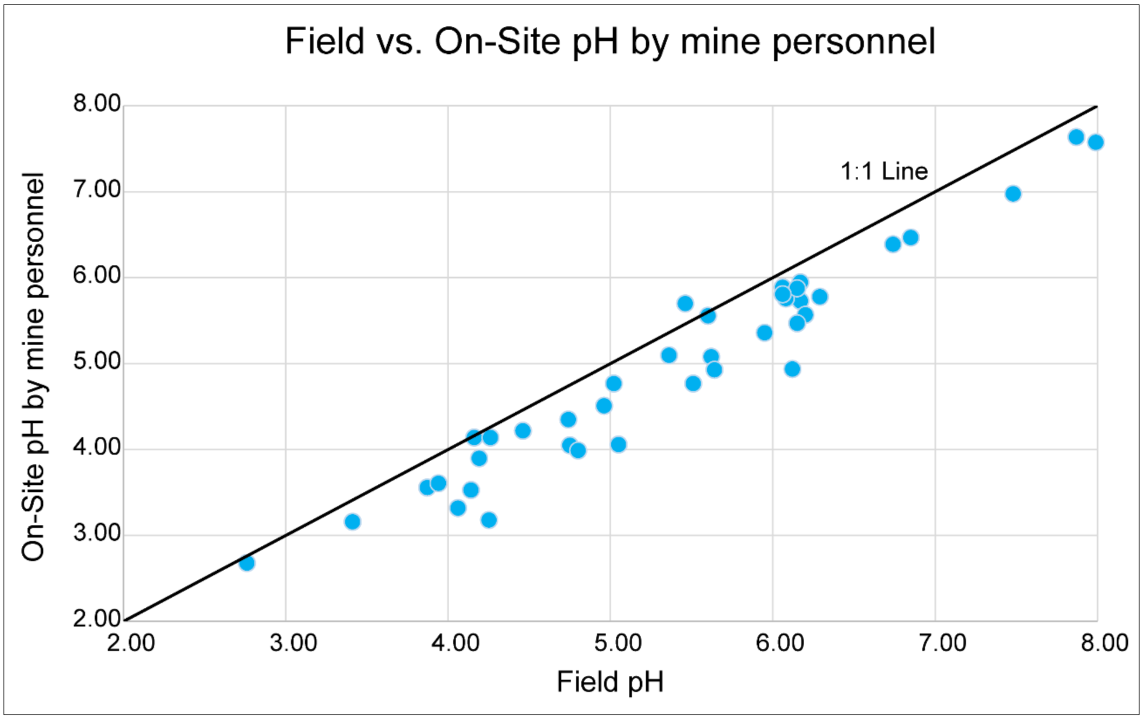


Figure H.1: Graph of field pH versus and on-site pH (as measured by mine personnel) for 20 wells sampled during the August (Q3) 2013 sampling event and 19 wells sampled during the October (Q4) sampling event. Most points plot below the 1:1 line, showing that the on-site pH is typically lower than the field pH (measured by this researcher).

H.1. Most points plot below the 1:1 line, showing that the on-site pH measured by mine personnel is typically lower than the field pH (measured by this researcher). The minimum and maximum differences are -0.24 and 1.18, respectively. The mean difference is 0.43 and the median difference is 0.38. If the on-site pH measured by mine personnel is greater than the field pH measured by this researcher, then the difference is negative. If the former is smaller than the latter, then the difference is positive.

To investigate the evolution of pH over time, the pH of 21 samples collected during the June sampling event and 39 samples collected in August. These samples were collected with minimal headspace and cooled during storage. pH was measured 2-9 day after collection with an average delay of 5.7 days and a median delay of 6 days. The minimum and maximum pH differences are -0.87 and 2.24, respectively. The mean and

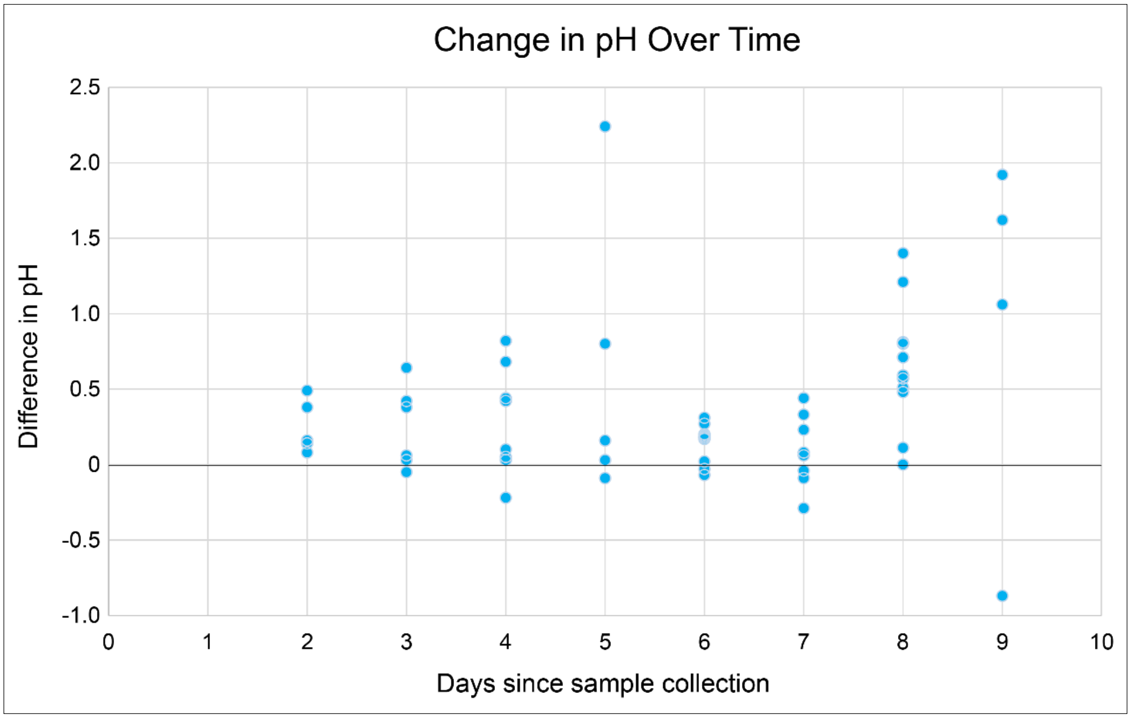


Figure H.2: Graph of pH change in samples stored between 2 to 9 days. For most stored samples, pH decreased over time (positive difference).

median pH differences are 0.38 and 0.22. If the pH measurement after storage is higher than the field pH, then the difference is negative. If the pH measurement after storage is lower than the field pH, then the difference is positive. These results are shown in Figure H.2. For most stored samples, pH decreased over time (positive difference).

To evaluate the extent of pH changes within the first few hours of collection, the difference between field pH and pH from sample bottles a few (2-6) hours after collection, 23 October (Q4) samples are compared. The paired pH measurements are shown in Figure H.3. Most points plot slightly above the 1:1 line, showing that the on-site pH re-measurements are typically slightly higher than the field pH (both measured by this researcher). The minimum and maximum differences are -0.33 and 0.12,

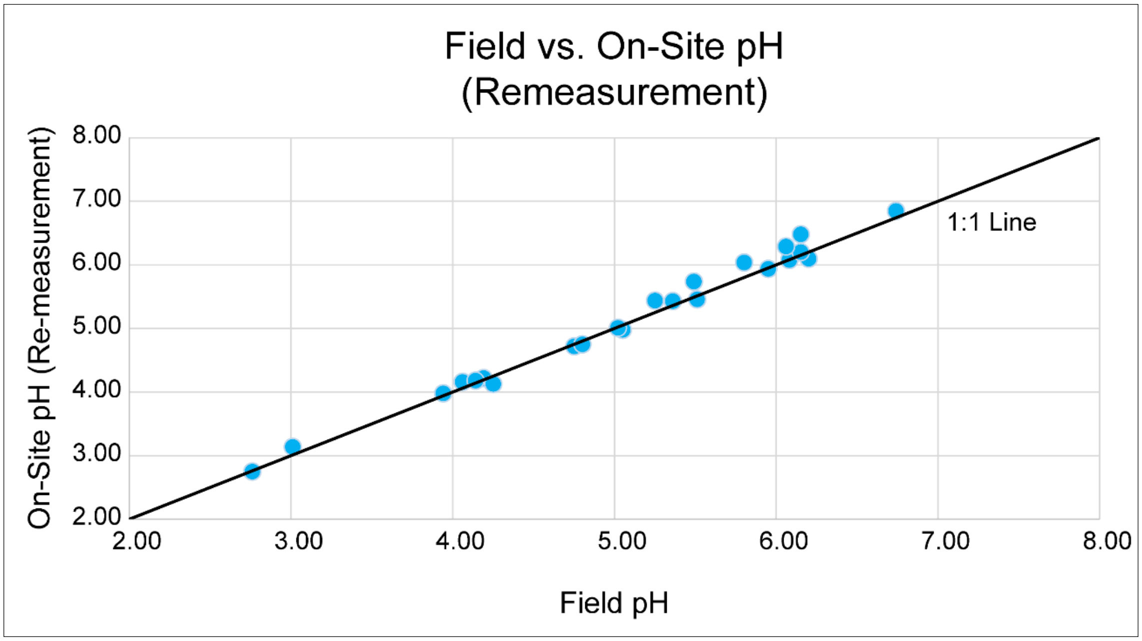


Figure H.3: Graph comparing field pH versus re-measurements of pH from sample bottles a few (2-6) hours after collection for 23 samples October (Q4) samples. Most points plot slightly above the 1:1 line, showing that the on-site pH re-measurements are typically slightly higher than the field pH (both measured by this researcher).

respectively. The mean difference is -0.06 and the median difference is -0.04. If the on-site pH re-measurement is greater than the field pH, then the difference is negative. If the former is smaller than the latter, then the difference is positive.

These observations about pH variability indicate that groundwater pH at Oak Hill Mine is not stable over time. Post collection, groundwater pH tends to decrease over time (Figures H.2 and H.3) and the variance (spread) of the change tends to increase over time (Figure H.2). It is hypothesized that these changes are due to oxygen-driven redox reactions within the sample, resulting in a drop of pH over time as oxygen is consumed and H^+ released (e.g., Chapter 2, Equations 11-13). However, strict sampling protocols – including the elimination of headspace in sample bottles – can largely delay post-collection pH evolution for several hours after sampling (Figure H.3).

It should be noted, however, that the pH differences observed in Figure H.1 were measured on different instruments: one instrument was used by this researcher in the field and the other was used by mine personnel where on-site parameters and sample preservation measures are completed. Both instruments are calibrated to the standard three calibration points (pH 4, 7, 10). However, the Accumet AP125 portable pH meter used by this researcher was also calibrated with an additional acidic pH point (pH 2), and calibration accuracy was checked against a pH 6 buffer (as well as the 4 calibration standards). The addition of a pH 2 calibration point for the Accumet AP125 portable pH meter allows for greater accuracy of acidic groundwater measurements as interpolation of measurements between calibration standards is more accurate than extrapolation of measurements outside the calibration range. Some difference in pH measurements in Figure H.1 may therefore be attributed to the differences in instrument calibration procedures but as most samples have a pH > 4, most of the differences in pH are believed to be due to real differences in sample pH due to post-collection pH evolution.

Suggested Changes to Sampling Protocol

To control post-collection pH evolution in groundwater samples, the following adjustments to sample collection procedures are suggested:

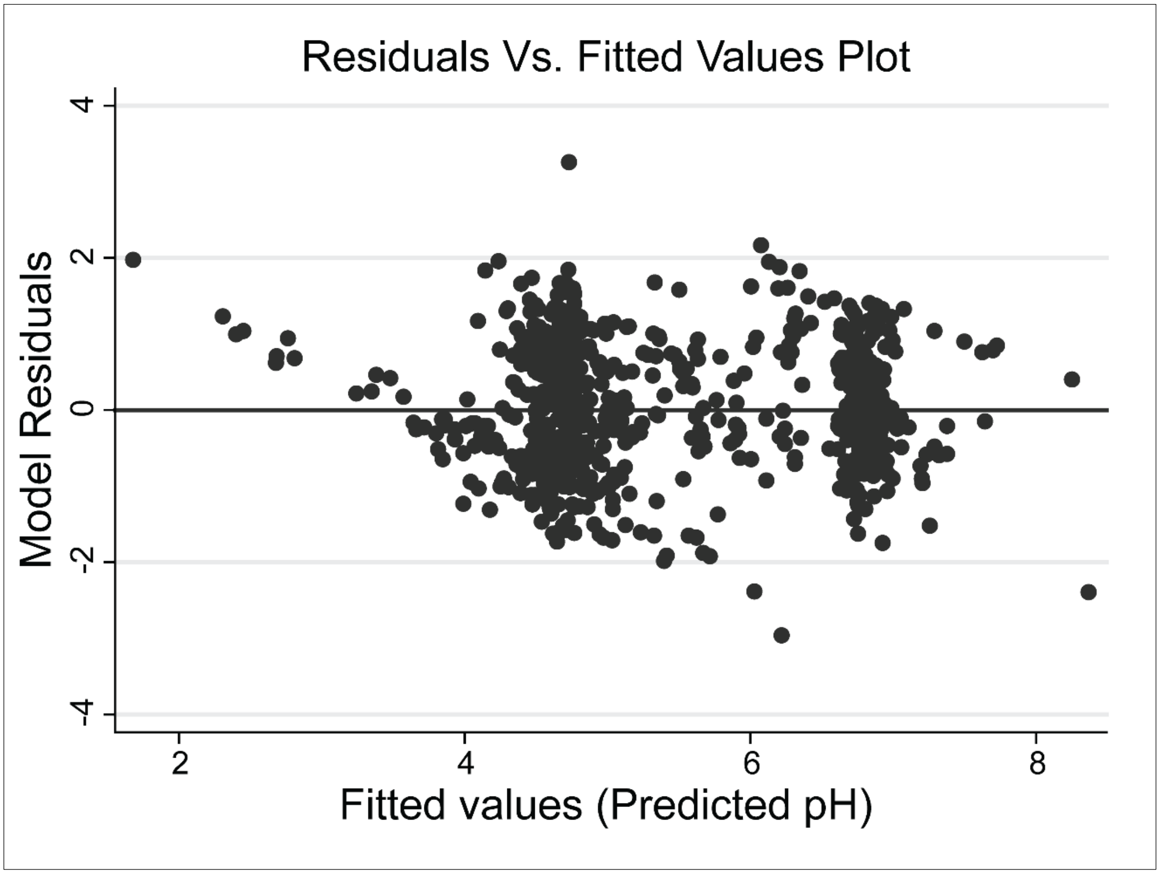
1. Elimination of headspace in cubitainers used to collect groundwater from wells as prolonged exposure to oxygen-rich air drives redox reactions.
2. Collection of field pH measurements in a subset of randomly selected wells during each sampling event to provide a method for assessing the magnitude of post-collection pH evolution for each sampling event. If pH changes remain large, the sampling procedure can be re-assessed or field pH can be measured for all well samples.

To provide overall metrics of the accuracy and precision of sampling procedures, the following methods are suggested:

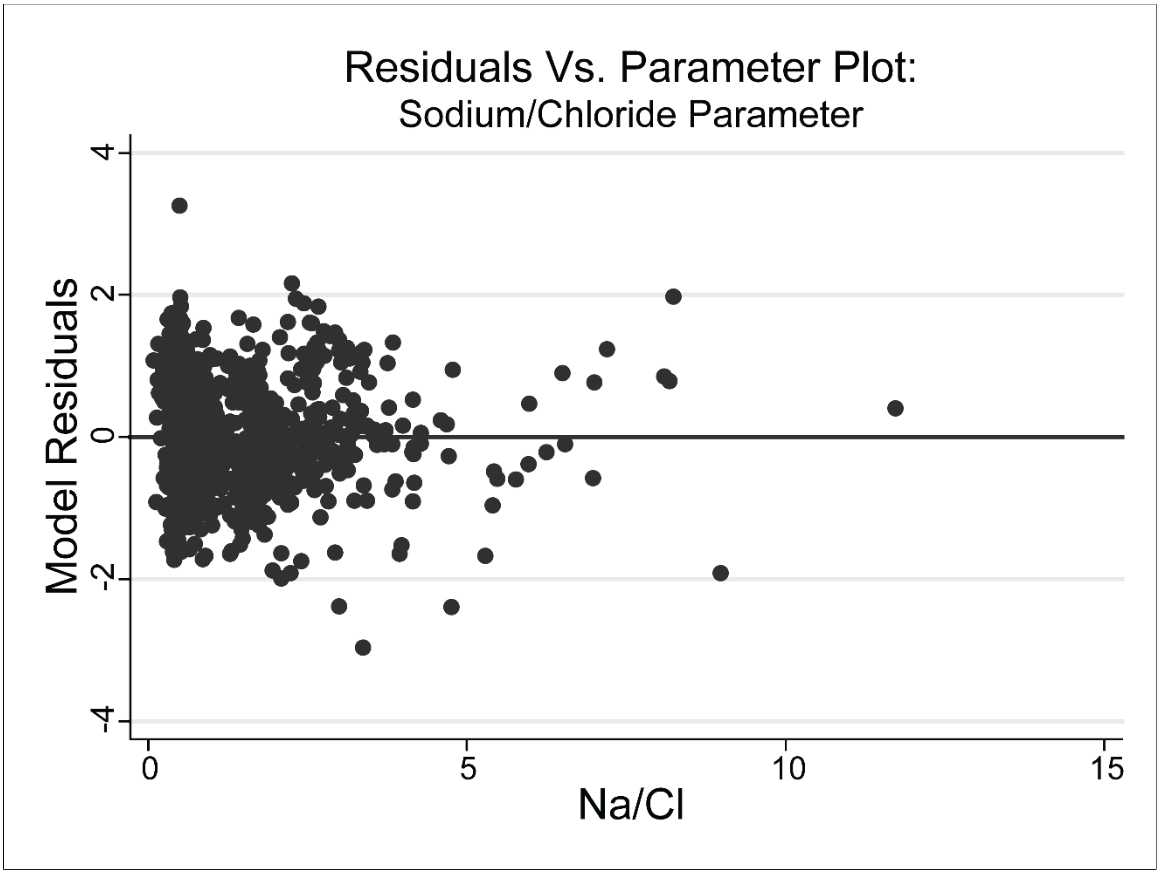
3. Measurement of major cations (Na, Mg, Ca) and anions (Cl, SO_4, and HCO_3 when $pH > 5$) every quarter so that charge balance errors (CBEs) can be computed. To reduce cost, these additional measurements could be ordered for a randomly selected subset of the wells sampled each quarter.
4. Collection of at least one duplicate sample from a randomly chosen well each quarter, to provide an estimate of the precision.
5. Collection of at least one field blank once a quarter (or perhaps once a year to reduce costs), to provide an estimate of cross-sample contamination.

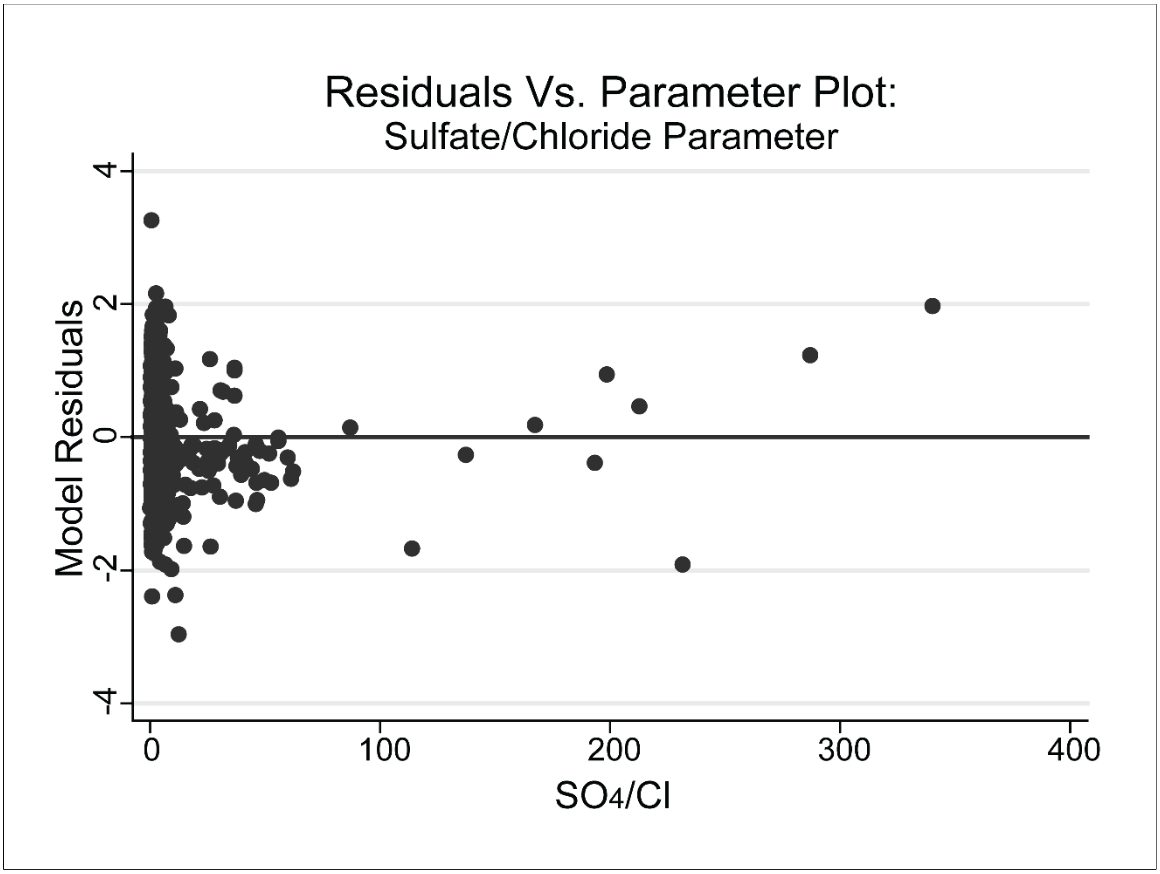
APPENDIX I: DIAGNOSTIC PLOTS FOR FINAL MLR MODEL

This appendix presents three diagnostic plots for the final statistical model discussed in Chapter 5 in "Part Three: Multiple Linear Regression." These plots compare model residuals to model output (fitted value, predicted pH) and the continuous variables of the model input (Na/Cl and SO_4/Cl ratios). Residuals are the difference between the predicted pH for each observations and the actual pH value. If the assumptions of the multiple linear regression (MLR) model have been satisfied, then the residuals will plot randomly. Trends indicate at least one assumption of the MLR model has been violated.



Problematic trends can include a moving average (increasing, decreasing, or cyclic) and heteroscedasticity, a systematic increase or decrease in variance as a function of some variable. In this plots, heteroscedasticity would manifest as a "funnel shape" pattern. For additional information, see Kleinbaum et al. (1988). Visual inspection of these diagnostic plots indicate that the residuals are independent and homoscedastic (constant variance), as required by model assumptions.




Residuals Vs. Parameter Plot:
Sulfate/Chloride Parameter
Model Residuals
4
2
0
-2
-4
0
100
200
300
400
SO4/Cl

References

Appelo, C.A.J. and Postma, D., 2005, Geochemistry, groundwater, and pollution (second edition): Boca Raton, Louisiana, CRC Press, 649 p.

Arora, H.S., Dixon, J.B., Hossner, L.R., and Senkayi, A.L., 1984, Mineralogy of selected lignitic coal overburdens of the Wilcox Group in east Texas: Soil Science, v. 137, p. 207-215.

Ayers, W.B., Jr., and Lewis, A.H., 1985, The Wilcox Group and Carrizo Sand (Paleogene) in east-central Texas: depositional systems and deep-basin lignite: The University of Texas at Austin, Bureau of Economic Geology Special Publication, 19 p., 30 pls.

Ayers, Jr., W.B., 1987, Sedimentologic controls on lignite quality and mining, Sandow Lignite Mine, lower Calvert Bluff Formation, east-central Texas, *in* Finkelman, R.B., Casagrande, D.J., and Benson, S.A., eds., Gulf Coast lignite geology: Prepared for the Fourteenth Biennial Lignite Symposium on the Technology and Utilization of Low-Rank Coals May, 1987, Dallas, Texas: Reston, Virgina, Environmental and Coal Associates, p. 55-68.

Ayers, W.B., and Kaiser, W.R., 1987, Regional depositional detting, resources, and auality of lignite in the Wilcox Group of east Texas and the Jackson Group of east and south Texas, *in* Finkelman, R.B., Casagrande, D.J., and Benson, S.A., eds., Gulf Coast lignite geology: Prepared for the Fourteenth Biennial Lignite Symposium on the Technology and Utilization of Low-Rank Coals May, 1987, Dallas, Texas: Reston, Virgina, Environmental and Coal Associates, p. 83-128.

Barnes, V.E., Eaton, R.W., Wright, A.C., McCallum, H.D., Wendlandt, E.A., Burford, S.O., Gibson, D.T., Pieper, M.K., Haenggi, W.T., Owen, D.E., and Shelby, C.A., 1965, Tyler sheet: Geologic Atlas of Texas Series, The University of Texas at Austin, Bureau of Economic Geology, Geologic Atlas of Texas, scale 1:250,000, 1 sheet. Reprinted 1975. http://ngmdb.usgs.gov/Prodesc/proddesc_19388.htm (accessed June 2014).

Benson, S.A., 1987, Inorganic constituents in selected Texas and North Dakota lignites, *in* Finkelman, R.B., Casagrande, D.J., and Benson, S.A., eds., Gulf Coast lignite geology: Prepared for the Fourteenth Biennial Lignite Symposium on the Technology and Utilization of Low-Rank Coals May, 1987, Dallas, Texas: Reston, Virginia, Environmental and Coal Associates, p. 224-230.

Breyer, J.A., 1987, A tidal origin for coarsening-upward sequences above two Wilcox lignites in East Texas, *in* Finkelman, R.B., Casagrande, D.J., and Benson, S.A., eds., Gulf Coast lignite geology: Prepared for the Fourteenth Biennial Lignite Symposium on the Technology and Utilization of Low-Rank Coals May, 1987, Dallas, Texas: Reston, Virginia, Environmental and Coal Associates, p. 33-54. *Reproduced from* 1987, Journal of the Geological Society, v. 144.

Cagle, M.F., 2007, Temporal and spatial sulfate variability in groundwater at a lignite min, northeast Texas [unpub. M.S. thesis]: Austin, The University of Texas at Austin, 269 p.

Carson, C.D., Fanning, D.S., and Dixon, J.B., 1982, Alfisols and ultisols with acid sulfate weathering features in Texas, *in* Kral, D.M., ed., Acid Sulfate Weathering: Madison, Wisconsin, Soil Science Society of America, Special Publication 10, p. 127-146.

Clarke, L.B., 1995, Coal mining and water quality: International Energy Agency (IEA) Coal Research Report, 99 p.

Conover, W.J., 1999, Practical nonparametric statistics (third edition): New York, John Wiley & Sons, 584 p.

Corder, G.W. and Foreman, D.I., 2009, Nonparametric statistics for non-statisticians: A step-by-step approach: Hoboken, New Jersey, John Wiley & Sons, 247 p.

Daniel, W.W., 1990, Applied nonparametric statistics (second edition): Boston, PWS-Kent Publishing Company, 635 p.

Dent, D., 1986. Acid sulphate soils: A baseline for research and development: Wageningen, The Netherlands, International Institute for Land Reclamation and Improvement, ILRI Publication No. 39, 204 p.

Dixon, J.B., Hossner, L.R., Senkayi, A.L., and Egashira, K., 1982, Mineralogical properties of lignite overburden as they relate to mine spoil reclamation, *in* Kral, D.M., ed., Acid Sulfate Weathering: Madison, Wisconsin, Soil Science Society of America, Special Publication 10, p. 169-192.

Dutton, 1982, Hydrogeochemistry of the unsaturated zone at Big Brown Lignite Mine, east Texas [unpub. Ph.D thesis]: Austin, The University of Texas at Austin, 239 p.

Dutton, A.R., 1990, Vadose-zone recharge and weathering in an Eocene sand deposit, East Texas, U.S.A: Journal of Hydrology, v. 114, p. 93-108.

East Texas Regional Water Planning Group (ETRWPG), 2010, Regional Water Planning Area, 2011 Update of the Regional Water Plan Final Plan, September 1, 2010: http://www.twdb.texas.gov/waterplanning/rwp/plans/2011/I/Region_I_2011_RWP.pdf (accessed June 2014).

Edmunds, W.M. and Shand, P., eds., 2008, Natural groundwater quality: Singapore, Blackwell Publishing Ltd., 469 p.

Edwards, K.J., Bond, P.L., Druschel, G.K., McGuire, M.M., Hamers, R.J., and Banfield, J.F., 2000, Geochemical and biological aspects of sulfide mineral dissolution: lessons from Iron Mountain, California: Chemical Geology, v. 169, p. 383-397.

Espey, Huston and Associates, 1983, Impacts of lignite development in Texas: An environmental primer: Texas Energy and Natural Resources Advisory Council Report TENRAC/EDF-091, 89 p.

Field, C.W., 1972, Sulfur: Element and geochemistry, *in* Fairbridge, R.W., ed., The Encyclopedia of Geochemistry and Environmental Sciences: New York, Van Nostrand Reinhold, p. 1142-1148.

Fisher, W.L., 1963, Lignites of the Texas Gulf Coastal Plain: Austin, Texas, The University of Texas at Austin, Bureau of Economic Report of Investigations No. 50, 164 p., http://www.lib.utexas.edu/books/landscapes/publications/txu-oclc-2660154/txu-oclc-2660154.pdf.

Fisher, W.L. and McGowen, J.H, 1967, Depositional systems in the Wilcox Group of Texas and their relationship to occurrence of oil and gas: Gulf Coast Association of Geological Societies Transactions., v.17, p.105-125.

Fisher, W.L., Brown, L.F., Jr., Scott, A.J., and McGowen, J.H., 1969, Delta systems in the exploration for oil and gas: a research colloquium: Austin, Texas, The University of Texas at Austin, Bureau of Economic Geology, 212 p.

Fogg, G.E., Kaiser, W.R., and Ambrose, M.L., 1991, The Wilcox Group and Carrizo Sand (Paleogene) in the Sabine Uplift area, Texas: Ground-water hydraulics and hydrochemistry: The University of Texas at Austin, Bureau of Economic Geology Special Publication, 70 p., 18 pls.

French, L.N., 1979, Hydrogeologic aspects of lignite strip mines near Fairfield, Texas [unpub. M.A. thesis]: Austin, The University of Texas at Austin, 147 p.

Gentry, Robert, 2000. TXU employee. Personal communication, *in* Barth, A.K., 2002, Land capability classification of minesoils in east Texas [unpub. M.S. thesis]: Austin, The University of Texas at Austin, 99 p.

George, P.G., Mace, R.E., and Petrossian, R., 2011, Aquifers of Texas: Texas Water Development Board Report 380, 172 p., https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R380_AquifersofTexas.pdf

Hall Southwest Corp. (HSW), 1990, Section .146: Probable hydrologic consequences determination, Oak Hill permit area, Rusk County, Texas [Report prepared for Texas Utilities Mining Company] *in* Texas Utilities Mining Company, Oak Hill Mine Permit 22 Renewal/Revision.

Hall Southwest Corp. (HSW), 1991, Section .146: Probable hydrologic consequences determination, Oak Hill 2280 acre study area, Rusk County, Texas [Report prepared for Texas Utilities Mining Company] *in* Texas Utilities Mining Company, Oak Hill Mine Permit 40 Renewal/Revision.

Hangen, E., Gerke, H.H., Schaaf, W., and Hüttl, R.F., 2005, Assessment of preferential flow processes in a forest-reclaimed lignitic mine soil by multicell sampling of drainage water and three tracers: Journal of Hydrology, v. 303, p. 16-37, DOI:10.1016/j.jhydrol.2004.07.009.

Hirsch, A., 1977, Chapter 9: Environmental aspects of lignite mining in the south-central United States, *in* Finkelman, R.B., Casagrande, D.J., and Benson, E.H., eds., Gulf Coast lignite geology: Prepared for the Fourteenth Biennial Lignite Symposium on the Technology and Utilization of Low-Rank Coals May, 1987, Dallas, Texas: Reston, Virginia, Environmental and Coal Associates, p. 193-202.

Hewitt, C.D., 1990, Hydraulic properties of a reclaimed lignite surface mine, east Texas [unpub. M.A. thesis]: Austin, The University of Texas at Austin, 151 p.

Holzmer, F.J., 1992, Redevelopment of the groundwater system at a reclaimed lignite surface mine, east Texas [unpub. M.A. thesis]: Austin, The University of Texas at Austin, 193 p.

Horbaczewski, J.K., personal communication, 2007, Mine-related and natural acid seeps at Gibbons Creek Lignite Mine, Texas: presented at the 28th Annual Surface Mine Reclamation Workshop, College Station, Texas, October 4-5, 2007. Workshop sponsored by the Texas Cooperative Extension Service and the Texas Agricultural Experiment Station, http://www.texasmpa.org/publications/research/mine-related%20and%20natural%20acid%20seeps%20at%20gibbons%20creek%20lignite%20mine%20texas.pdf (accessed July 2014).

Horbaczewski, J.K., personal communication, 2009, Peach Creek – A naturally acidic drainage near Gibbons Creek Lignite Mine, Texas: presented at the 30th Annual Surface Mine Reclamation Workshop, College Station, Texas, October 1-2, 2009. Workshop sponsored by the Texas Cooperative Extension Service and the Texas Agricultural Experiment Station, http://www.texasmpa.org/publications/research/peach%20creek%20a%20naturally%20acidic%20drainage%20near%20gibbons%20creek%20lignite%20mine%20texas.pdf (accessed July 2014).

Jarocki, K.E., 1994, Properties of and factors influencing infiltration rates at a reclaimed lignite min, Freestone County, Texas [unpub. M.A. thesis]: Austin, The University of Texas at Austin, 141 p.

Kaiser, W.R., 1978a, Electric power generation from Texas lignite: The University of Texas at Austin, Bureau of Economic Geology Geological Circular 78-3, 18 p.

Kaiser, W.R., 1978b, Depositional systems in the Wilcox Group (Eocene) of east-central Texas and the occurrence of lignite, *in* Kaiser, W.R., ed., Proceedings of the Gulf Coast Lignite Conference: Geology, Utilization, and Environmental Aspects: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 90, p. 33-53.

Kaiser, W.R., Johnston, J.E., and Bach, W.N., 1978c, Sand-body geometry and the occurrence of lignite in the Eocene of Texas: Lignite resources in Texas: The University of Texas at Austin, Bureau of Economic Geological Circular No. 78-4, 19 p.

Kaiser, W.R., Ayers, W.B., Jr., and LaBrie, L.W., 1980, Lignite resources in Texas: Austin, Texas, The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 104, 52 p.

Kaiser, W.R., 1982, Lignite depositional models, Texas Eocene: A regional approach to coal geology, *in* Shobert, H.H., ed., Proceedings of the Basic Coal Science Workshop, Houston, Texas, 1981: U.S. Department of Energy, Grand Forks Technology Center, p. 9-67.

Kaiser, W.R., 1986, Geology and ground-water hydrology of deep-basin lignite in the Wilcox Group of east Texas: A summary, *in* Kaiser, W.R., ed., Geology and ground-water hydrology of deep-basin lignite in the Wilcox Group of east Texas: Austin, Texas, University of Texas at Austin, Bureau of Economic Geology, p. 3-10.

Kaiser, W.R., Jackson, M.L.W., and Collins, G.F., 1986, Geology of deep-basin lignite in the Wilcox Group, Sabine Uplift area, *in* Kaiser, W.R., ed., Geology and ground-water hydrology of deep-basin lignite in the Wilcox Group of east Texas: University of Texas at Austin, Bureau of Economic Geology, Special Publication, p. 11-20.

Keller, W.D., 1969, Chemistry in introductory geology (fourth edition): Columbia, Missouri, Lucas Brothers Publishers, 108 p.

Kennedy, J.L. and Pepper, G.L., 1980, Hydraulic properties and hydrogeologic mapping of reclaimed Gulf Coast lignite mines, *in* Mathewson, C.C., ed., Proceedings, Texas A&M University Lignite Symposium: Texas A&M Center for Energy and Mineral Resources, p. 17.1-17.13.

Kersey, D.G., 1980, Stratigraphy of selected lignite deposits in Texas, *in* Lignite: Texas A&M University Lignite Symposium: College Station, Texas, Texas A&M University, Center for Energy and Mineral Resources, p. 2.1-2.14.

Kleinbaum, D.G., Kupper, L.L., and Muller, K.E., 1988, Applied regression analysis and other multivariable methods (second edition): Boston, PWS-Kent Publishing Company, 718 p.

Konhauser, K., 2007, Introduction to geomicrobiology: Singapore, Blackwell Science Ltd., 425 p.

Kresse, T.M. and Hay, P.D., 2009 (revised February 2011), Geochemistry, comparative analysis, and physical and chemical characteristics of the thermal waters east of the Hot Springs National Park, Arkansas, 2006-09: U.S. Geological Survey

Scientific Investigations Report 2009-5263, 48 p. http://pubs.usgs.gov/sir/2009/5263/ (accessed July 2014).

Kresse, T.M., Warner, N.R., Hays, P.D., Down, A., Vengosh, A., and Jackson, R.B., 2012, Shallow groundwater quality and geochemistry in the Fayetteville Shale gas-production area, north-central Arkansas, 2011: U.S. Geological Survey Scientific Investigations Report 2012-5273, 31 p. http://pubs.usgs.gov/sir/2012/5273/ (accessed July 2014).

Kruskal, W.H., and Wallis, W.A., 1952, Use of ranks in one-criterion variance analysis: Journal of the American Statistical Association, v. 47, p. 583-621.

Kruskal, and Wallis, 1953, Errata: Use of ranks in one-criterion variance analysis: Journal of the American Statistical Association, v. 48, p. 907-911.

Lentz, R.C., 1975, Relation of Eocene depositional environments to sulfur content and quality of surface waters at lignite strip mines near Fairfield, Texas [unpub. M.A. thesis]: Austin, The University of Texas at Austin, 147 p.

Maidment, D.R., ed., 1993, Handbook of hydrology: New York, McGraw-Hill, Inc., 1424 p.

McBride, G.B., 2005, Using statistical methods for water quality management: Issues, problems, and solutions: Hoboken, New Jersey, John Wiley & Sons, 313 p.

Pastor, Behling, and Wheeler, LLC (PBW), 2008a, Section .127: Geology Information, Oak Hill Mine Study Area, Rusk County, Texas [Report prepared for Luminant Mining Company, LLC] *in* Luminant Mining Company, LLC, Oak Hill Mine Permit 46C [Permit approved May 13, 2014].

Pastor, Behling, and Wheeler, LLC (PBW), 2008b, Section .128: Groundwater Information, Oak Hill Mine Study Area, Rusk County, Texas [Report prepared for Luminant Mining Company, LLC] *in* Luminant Mining Company, LLC, Oak Hill Mine Permit 46C [Permit approved May 13, 2014].

Pastor, Behling, and Wheeler, LLC (PBW), 2008c, Section .146: Probable hydrologic consequences determination, Oak Hill Mine, Permit 46B renewal/revision, Rusk County, Texas [Report prepared for Luminant Mining Company, LLC] *in* Luminant Mining Company, LLC, Oak Hill Mine Permit 46C [Permit approved May 13, 2014].

Puls, R.W. and Barcelona, M.J., 1995, Low-flow (minimal drawdown) ground-water sampling procedures: U.S. Environmental Protection Agency, Office of Research and Development Report EPA/540/S-95/504, 12 p, http://www.epa.gov/superfund/remedytech/tsp/download/lwflw2a.pdf.

Murray, G.E., 1948, Geology of De Soto and Red River Parishes: Baton Rogue, Louisiana Geological Survey Geological Bulletin No. 25, 312 p., 17 plates.

Murray, G.E., 1961. Geology of the Atlantic and Gulf Coastal Province of North America: New York, Harper and Brothers, 692 p.

Nichols, D.J., and Traverse, A., 1971, Palynology, petrology, and depositional environments of some early Tertiary lignites in Texas: Geoscience and Man, v.3, p. 37-48.

Office of Surface Mining (OSM), 1985, Technical evaluation of topsoil substitution practices and handling of potential acid/toxic-forming materials in Texas: A draft final special study report: Denver, Colorado, U.S. Department of Interior, 147 p.

Palmquist, M.P., 1987, Geology of the Jewett Lignite Mine, *in* Finkelman, R.B., Casagrande, D.J., and Benson, S.A., eds., Gulf Coast lignite geology: Prepared for the Fourteenth Biennial Lignite Symposium on the Technology and Utilization of Low-Rank Coals May, 1987, Dallas, Texas: Reston, Virginia, Environmental and Coal Associates, p. 4-16.

Railroad Commission of Texas (RRC), 2014, Annual Coal Production: Surface Coal Mining & Exploration Program database: http://www.rrc.state.tx.us/media/19487/coalprodthru2013.pdf and http://www.rrc.state.tx.us/media/19550/coalprod2013_web.xlsx (last revised May 15, 2014, accessed June 2014).

Samborska, K. and Halas, S., 2010, ^{34}S and ^{18}O in dissolved sulfate as tracers of hydrogeochemical evolution of the Triassic carbonate aquifer exposed to intense groundwater exploitation: Applied Geochemistry, v. 25, p.1397-1414.

Sandeen, W.M., 1987, Ground-water resources in Rusk County, Texas: Texas Water Development Board Report 297, 106 p., https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R297/Report297.asp

Schaumburg & Polk, Inc., 2006, 2006 Water Plan, East Texas Region: http://www.twdb.texas.gov/waterplanning/rwp/plans/2006/I/Region_I_2006_RWP.pdf (accessed June 2014).

Schweinfurth, S.P., 2009, Chapter C: An introduction to coal quality *in* Pierce, B.S. and Dennen, K.O., eds., The National Coal Resource Assessment Overview, Reston, Virginia: U.S. Geological Survey Professional Paper 1625-F, 402 p., http://pubs.usgs.gov/pp/1625f/downloads/Front.pdf

Shaw, M.G., 2006, Geologic control of stream water composition in Cherokee, Smith, and Rusk Counties, Texas [unpub. M.S. thesis]: Nacogdoches, Stephen F. Austin State University, 193 p.

Singer, P.C. and Stumm, W., 1970, Acidic Mine Drainage: The Rate-Determining Step: Science, v. 167, p. 1121-1123.

Stevens, J.P., Pituch, K.A., Whittaker, T.A., 2007, Intermediate Statistics: A modern approach (third edition): New York, Taylor & Francis Group, 460 p.

Stumm, W. and Morgan, J.J., 1995, Aquatic chemistry: Chemical equilibria and rates in natural waters (third edition): New York, John Wiley & Sons, Inc., 1022 p.

Sukhija, B.S., Reddy, D.V., Nagabhushanam, P., Hussain, S., and Giri, V.Y., 1996, The use of environmental isotopes and chloride as natural tracers to investigate the effects of depressurization of a coastal aquifer for lignite mining, India: Hydrogeology Journal, v. 4, p. 70-89.

Tewalt, S.J., 1986, Chemical characterization of Texas lignites: The University of Texas at Austin, Bureau of Economic Geology Geological Circular 86-1, 52 p.

Tewalt, S.J., 1987, Chemical characteristics of Gulf Coast lignites, *in* Finkelman, R.B., Casagrande, D.J., and Benson, S.A., eds., Gulf Coast lignite geology: Prepared for the Fourteenth Biennial Lignite Symposium on the Technology and Utilization of Low-Rank Coals May, 1987, Dallas, Texas: Reston, Virginia, Environmental and Coal Associates, p. 201-210.

Texas Water Development Board, 2011, Texas Aquifers: http://www.twdb.state.tx.us/groundwater/aquifer/index.asp (accessed June 2014).

TXU Corporation, 1984, Oak Hill Mine: Application for Surface Mine Permit, Appendix II of IV, §4.6: Ground-Water Chemistry. Submitted to Railroad Commission of Texas on June 1, 1984.

United States, 1983, Martin Lake D Area Lignite Surface Mine, Henderson, Rusk County Texas: Final Environmental Impact Statement: Dallas, Texas, U.S. Environmental Protection Agency, Region 6, EPA 906/9-83-012, 178 p.

United States, 2011, U.S. Code: Chapter 25, § 1201 – 1202, http://www.osmre.gov/lrg/docs/USCODE-2011-title30-chap25.pdf (accessed July 2014).

Venburg, L.C., 1983, Monitoring the effect of surface mining operations on the hydrologic regime: *Ground Water Monitoring Review*, v. 3, p. 86-91.

Wielchowsky, C.C., Collins, G.F., Gerahian, L.K., and Calhoun, E.J., 1977, Chapter 6: Frontier lignite exploration in the south- central United States, *in* Campbell, M.D., ed., Geology of alternate energy sources in the south-central United States: Houston, Texas, Houston Geological Society, pp. 125-159.

Wilcoxon, F., 1945, Individual comparisons by ranking methods, Biometrics, v. 1, p. 80-83.

Williamson, D.R., 1987, Lignites of northwest Louisiana and the Dolet Hills Lignite Mine, *in* Finkelman, R.B., Casagrande, D.J., and Benson, E.H., eds., Gulf Coast lignite geology: Prepared for the Fourteenth Biennial Lignite Symposium on the

Technology and Utilization of Low-Rank Coals May, 1987, Dallas, Texas: Reston, Virginia, Environmental and Coal Associates, p. 4-16.

Woessner, W.W., Andrews, C.B., and Osborne, T.J., 1979, The impacts of coal strip mining on the hydrogeologic system of the Northern Great Plains: case study of potential impacts on the Northern Cheyenne Reservation: Journal of hydrology, v. 43, p.445-467.

Vita

Lilith Joy Mercier graduated from Bowling Green State University in Ohio with a Bachelor of Liberal Studies in 2006. In 2008, she received an M.A. in Philosophy from The University of Texas at Austin. Subsequently, she studied under the supervision of Dr. John M. Sharp, Jr. at the Jackson School of Geosciences, The University of Texas at Austin. Her research was funded by the Luminant Environmental Research Fellowship. She is a member of The Geological Society of America, the Austin Geological Society, and the International Association of Hydrogeologists, as well as Phi Kappa Phi and Phi Beta Kappa. In her spare time, Ms. Mercier instructs beginner- and intermediate-level dog agility classes in Austin and competes in USDAA and UKI dog agility in the central Texas area.

Permanent email: LJoyMercier@utexas.edu

This thesis was typed by Lilith Joy Mercier.