2. Physical Characteristics of Study Area

This section is essentially unchanged from the 2004 RI/FS. A few minor updates were made to address activities conducted from 2005 through 2007, including an update on the City of Golden water line (Section 2.1), reference to the 2006 flood plain characterization (Section 2.4.3.1), addition of seven new groundwater monitoring wells in 2007 (Section 2.5), and a 2006 wetlands study in the flood plain (Section 2.7).

2.1 Surface Features and Utilities

In general, the Site slopes gently to the north with a major elevation break above the former settling pond (Figure 2-1). The majority of the buildings located on the eastern side of the main driveway had shallow foundations resulting in relatively uniform topography after the concrete excavation operations had been completed. Buildings on the western side of the Site had fairly deep foundations, and excavation operations resulted in significantly deeper excavations. The 2004 remedial effort created several excavations that remained open until the 2006 Site characterization effort described herein delineated the surrounding material.

Utilities remaining on the Site at the start of the RI included an overhead electrical line, water mains, and a sewer line owned by the City of Golden. All other utilities had been disconnected prior to the concrete/asphalt removal operations.

As reported in the 2004 RI/FS, the City of Golden attempted to locate their utilities on several occasions but encountered difficulty locating the 16-inch water main that traversed the property from north to south. Consequently, remedial investigation activities in the general vicinity of the water main were purposely limited during the New Horizons' work. During late 2005, the City of Golden installed a new section of water line at the base of the slope near the flood plain that tied into existing water lines at manholes near the north fence and next to the football field. During the 2006 field activities performed by Stoller, all water lines were accurately located.

2.2 Meteorology

Information for the local meteorology, gathered by the previous consultant, was obtained from a number of sources. Local weather observation stations in the vicinity of the Site include a National Oceanic and Atmospheric Administration (NOAA) maintained weather station (precipitation) located about 3.5 miles south of the Site (operational record 1975 to present). The RAOA referenced information weather stations in Wheat Ridge (operational record 1981 through 1988), Lakewood Station (operational record 1962 to 2000), and Golden (operational record 1989 to 1995). Average temperatures and precipitation for the area are available from websites such as http://www.weather.com. The RAOA referenced an anemometer that operated during a period from May 1979 to March 1980. The meter was located about 4,000 feet west of the Site in Clear Creek Canyon (Figure 2-2). Wind speeds at the anemometer location are biased by the canyon but provide directional information relevant to the Site.

2.2.1 Precipitation

Average annual precipitation listed for the Golden area is about 17.1 inches (www.weather.com), but there is significant variability along the Front Range. The NOAA weather station located to

the south indicates a precipitation average of 13.4 inches (maximum 18.7 inches, minimum 7.5 inches) over 27 years. For the Front Range area, about 70 percent of the total annual precipitation occurs between April and September due to upslope conditions and thunderstorm activity. The greatest amounts of precipitation typically occur in April, May, and June when the average monthly totals exceed two inches. Precipitation minimums occur in December, January, and February when the average monthly precipitation is generally less than one inch. Front Range evaporation potential exceeds the annual total precipitation. Typical total annual pan-evaporation is about 60 inches, and total annual lake evaporation averages about 41 inches. Approximately 71 percent of the evaporation occurs between May and October.

2.2.2 Temperature

The average annual temperature is about 47.3 degrees Fahrenheit (°F). The highest average monthly temperatures typically occur in July and August and range between 68°F to 70°F. In December and January, the lowest average monthly temperatures are generally observed and range between 28°F to 29°F. Area temperatures can range from –26°F to 104°F.

2.2.3 Wind Direction and Speed

Average wind speed information collected from the three weather stations varied little from month to month. The data indicate, however, that maximum winds and wind gusts are higher in the winter than in the summer. Increased wind speeds in the winter are probably due to the passage of storm fronts causing strong downslope conditions. Average annual wind speed in the Denver area is about 9 miles per hour. However, wind speeds are often higher along the foothills near the Site (no site-specific data were located).

Basically, two major meteorological conditions determine the direction of air movements in the Golden area: synoptic flows and local flows. Synoptic flows are wind patterns that affect areas on the order of several thousands of square miles that are characterized by meteorological systems on the scale of high and low pressure systems as shown on weather maps. In the absence of a dominant synoptic flow, local flows become the prevalent factor in the air movement. These winds typically follow the topography of an area with air flows draining from higher elevations toward the lower elevations.

The Site area is in a unique location relative to wind direction that is best represented by the wind direction information from the meteorological monitoring location shown in Figure 2-2. The wind direction information from that location was evaluated and a wind rose developed for that data (Figure 2-2). Wind data are an incomplete data set collected from May 1979 to March 1980 and were used as part of the RAOA evaluation. The wind rose in Figure 2-2 shows the percentage of time that the wind blew from each of the 16 wind directions monitored. The wind was calm for only about 1.4 percent of the time during the measurement period. Based on a review of Figure 2-2 and area weather data, the predominant wind direction is from the west to east and reflective of drainage flows that are common along the Front Range. On an annual basis, the wind blows from the west approximately 60 percent of the time and from the east approximately 35 percent of the time with minor excursions from the north and south. Midday warming of the plains can generate east to southeast winds, creating an upslope flow along the Front Range. During the night, the cooler air flows down the mountainside across Golden and into the Denver Basin to the east. The night-time flows can start early in the evening and persist into the midmorning and early afternoon.

2.3 Surface-Water Hydrology/Quality

The Site is located immediately south of Clear Creek, the primary surface-water conveyance in the area. Clear Creek is a perennial tributary of the South Platte River with a drainage basin area above the Site of approximately 400 square miles. The headwaters of Clear Creek are located along the Continental Divide near Loveland Basin Ski Area. From the headwaters, the stream drops over 8,000 feet in about 50 miles, passing through steep canyons on its way to the Golden area. East of Golden, Clear Creek flows through the plains for about 14 miles to its confluence with the South Platte River in Denver, Colorado.

Gingery and Associates, Inc. (1979) developed discharge information for flood analysis of Clear Creek. Peak flows calculated for the reach of Clear Creek up to the western edge of the City of Golden are listed below:

Return Period	Peak Flow (cfs)
10-year	3,300
50-year	8,000
100-year	12,500
500-year	25,000

In the vicinity of the Site, the 100-year flood elevation is 5,682 feet (Appendix A). Based on work summarized in Advanced Sciences, Inc. (1989), the 500-year flood level is about 5 feet higher than the 100-year elevation or about 5,687 feet. The elevation at the lowest point of the Site is approximately 5,670 feet (former settling pond area next to Clear Creek), which is in the flood plain. However, the majority of the Site lies between about 5,700 feet to 5,720 feet, which are at least 18 feet above the 100-year elevation and 13 feet above the 500-year elevation.

Chimney Gulch is a small drainage that passes about 100 feet west of the western gate of the Site (Figure 2-2). Chimney Gulch is a tributary of Clear Creek with a drainage basin of approximately 482 acres. This tributary's headwaters begin on Lookout Mountain, and its confluence with Clear Creek is about 200 feet northwest of the Site. During most of the year, Chimney Gulch is dry. However, when the Welch Ditch is being used, excess water in the ditch is routinely drained into Chimney Gulch and back into Clear Creek.

Clear Creek passes through an historic mining region of the Colorado Mineral Belt. Several reaches of Clear Creek have been designated EPA Superfund Sites because of the extensive mining operations. Numerous mine adits along the stream contribute to seasonally elevated concentrations of metals, primarily manganese and zinc.

2.4 Geology

The Site is located along the eastern edge of the Rocky Mountain Front Range foothills. The Front Range is a complexly faulted anticlinal arch of primarily Precambrian crystalline rocks that reach elevations of over 14,000 feet. The foothills include the areas where "older" deposits were folded and pushed aside as the "younger" Rocky Mountains uplifted. The foothills rock types range from unconsolidated sediment deposits (25 thousand to 1 million years old) to sedimentary rocks (primarily sandstone and shale – 300 million to 63 million years old) to igneous and metamorphic rocks (over 1 billion years old). These formations remain as horizontal layers beneath Denver and

the eastern plains. The Clay Pits area is a surface expression of the unconsolidated sediment deposits (Laramie – Fox Hills Sandstone – these deposits have been tilted almost vertical) and the bedrock underlying the Site is a sedimentary rock (Pierre Shale). The Golden fault, a high-angle reverse fault, is present along the eastern edge of the foothills west of the Site.

2.4.1 Bedrock Structure

Figure 2-3 is a bedrock geologic map of the area showing the Site location and surrounding features. Figure 2-4 shows the surficial geologic deposits found on site. Weimer (1976) developed a geologic cross-section of the Site vicinity. Weimer's cross section is presented in Figure 2-5 and shows that the geologic strata are overturned and steeply dipping. Measurements of the strike of the beds in the Clay Pits area show a North 37° West trend with dips ranging from about 70° to 80° to the west (Grant 1990). Farther east, the beds become vertical and then east dipping. Erosion activity of an earlier Clear Creek along with construction activities appears to have removed the surface expression of the Laramie-Fox Hills sandstone north of the Clay Pits. The Site is located in an area of surficial deposits overlying the Pierre Shale. As shown in Figure 2-5, the Site is located in the Pierre Shale unit, a sequence that is at least 2,000 feet thick at this location.

As evident on Figures 2-3 and 2-4, the Golden fault cuts through the area just west of the Site. Van Horn (1976) characterizes the fault as a moderately to steeply west-dipping reverse fault of large displacement. This fault was extensively evaluated as part of investigations at the Rocky Flats Plant to the north. As a result of these evaluations (summarized in Appendix B of the RAOA), the Golden fault is not an active fault (i.e., movement has not occurred in the past 35,000 years and multiple movements have not occurred in the past 500,000 years).

2.4.2 Bedrock Stratigraphy

The stratigraphic units presented in Figure 2-3 are described below in order of decreasing age, oldest to youngest. These summaries are primarily from Van Horn (1976, 1995 – oral communication for RAOA) and Weimer (1976).

Precambrian (pC) – These metamorphic rocks are resistant but mostly covered by colluvium west of the Site and form the eastern-most slopes of the Front Range. Although outcrops are present, individual units are generally difficult to follow for any distance. Precambrian rocks in this area are believed to be overlain with angular unconformity by the Fountain Formation.

Fountain Formation (PPf) – This sedimentary unit is not exposed in the immediate vicinity of the Site but is believed to be present on the west side of the Golden fault under the alluvial fan materials shown in Figure 2-4. The Fountain is a pink to reddish-orange, coarse- to fine-grained, arkosic conglomeratic sandstone and conglomerate interbedded with lenticular, dark-reddish brown, silty, indurated mudstone and pinkish-gray, fine-grained, quartzose sandstone.

Pierre Shale (Kp) – Small areas of Pierre Shale are evident along the western end of the former settling pond, exposed by the erosion action of Clear Creek. Weimer (1976) characterized the unit as consisting of dark gray shale with minor, thin laminae of tan-weathered limonitic siltstone and silty, very fine-grained sandstone. Pierre Shale underlies much of the Site, including part of the parking area. The Pierre Shale is estimated to be at least 2,000 feet thick beneath the Site.

Fox Hills Sandstone (Kfh) – In the immediate vicinity, exposures of the Fox Hills are limited because of localized faulting. Where exposed, the sandstone is tan to yellow, fine-grained, subrounded, friable, calcareous sandstone with thin beds or laminae of siltstone and gray montmorillonitic claystone. The exposed thickness of the Fox Hills near 12th Street (Figure 2-3) is about 40 feet; however, the exact thickness is questionable because of faulting and could be as much as 75 feet (Weimer 1976). As shown in Figure 2-3, the Fox Hills underlies a part of the eastern-most practice field and some of the former Site buildings and parking area. The outcrop of this formation is visible to the west of the Clay Pits site.

Laramie Formation (Kl) – The Laramie is well exposed in a clay excavation south of Birch and 12th Streets. The thickness of the Laramie is about 350 feet and the formation is subdivided into two stratigraphic units. The lower unit (western-most unit) is about 190 feet thick near 12th Street and consists of four major sandstones that alternate with mineable kaolinitic claystone. The thickness of the individual sandstones and claystones varies from 20 to 40 feet. The sandstones are light gray to buff, fine- to coarse-grained, poorly sorted, subangular, and silty. The kaolinitic claystone units contain light to medium-gray, blocky weathering claystone with lesser amounts of dark gray to black carbonaceous claystone and thin coal streaks. Additionally, the lower Laramie contains a mineable coal seam. A monument over the Old White Ash coal mine is located at the intersection of Birch and 12th Streets. The surface trace of the main worked seam is located to the east of the monument and is 8 feet thick; a second mined seam, 10 to 20 feet to the west of the primary seam, is 3 feet thick (Emmons, *et al.*, 1896). These seams were mined to a distance of about one mile north of Clear Creek and several hundred feet south of 12th Street. The surface trace of the coal mine is presented in Figures 2-3 and 2-4.

The upper Laramie is about 160 feet thick and is similar in lithology to the lower Laramie, except that the sandstones are much thinner and finer grained. Neither coal nor carbonaceous shale is associated with the upper Laramie claystone. As is evident from Figure 2-3, the Laramie underlies the western half of Brooks Field and the eastern portion of the Site.

Arapahoe Formation (Ka) – The Arapahoe overlies the Laramie to the east and is 300 to 500 feet thick. It is composed of discontinuous beds of sandstone and claystone. The exposure in the Clay Pits south of Brooks Field show the lower Arapahoe is predominantly a conglomerate and conglomeratic sandstone with minor intercalations of gray claystone and siltstone. The upper Arapahoe is not exposed in the immediate area. As is evident in Figure 2-3, the Arapahoe underlies the eastern half of Brooks Field and part of the eastern Site access road.

Denver Formation (TKdv) – To the east of the Arapahoe lies the Denver Formation, which is not exposed in the immediate vicinity. The Denver consists of light gray to brown tuffaceous silty claystone, tuffaceous arkose, and esitic conglomerate. The base is marked by the first appearance of volcanic material.

2.4.3 Geologic Characteristics of the Surficial Deposits / Soils

The surficial deposits that overlie the bedrock in the vicinity of the Site include the following (the order presented below does not show the age relationship) and are depicted on Figure 2-4:

- Louviers Alluvium

- Younger Alluvial Fan Colluvium
- Post-Piney Creek Alluvium
- Artificial Fill

More information (e.g., thickness of these surficial deposits) can be found in the test pit and boring logs included in the 2004 RI/FS.

Louviers Alluvium (Qlo) – The Louviers forms a well-defined terrace in the Clear Creek valley and is the oldest of the alluvial deposits present in the area shown in Figure 2-4. The deposit is typically a coarse cobbly sand and gravel that is poorly sorted. Generally, less than 10 percent silt and clay is present. Just east of the area shown in Figure 2-4, the Louviers has sub-round to round pebbles and cobbles of granitic rocks. Boulders as large as one-foot across are present, but the common large size is 6 inches. Based on the subsurface work performed at this location, this unit is about 10 feet thick and extends south under the baseball and practice fields to the approximate location shown where it narrows against the bedrock. The Louviers is overlain by younger alluvial fan, colluvium, and artificial fill deposits. Locally, the post-Piney Creek Alluvium overlies eroded Louviers deposits.

Younger Alluvial Fan (Qyf) – In the location shown in Figure 2-4, this unit is associated with the current Chimney Gulch drainage and overlies the Louviers. This deposit is believed to have formed before the deposition of the post-Piney Creek Alluvium. The materials present in the deposit associated with the Chimney Gulch drainage consist of a poorly sorted, heterogeneous mixture ranging from boulders to clay. The upper few feet are clayey silt grading downward to coarser materials. The thickness of this unit varies but is expected to be as much as 40 feet in the area mapped in Figure 2-4.

Colluvium (Qco) – Colluvium consists of materials that have been moved down steep slopes by creep and sheet wash, and, at a few places, they represent minor alluvial fan deposits. The colluvial deposits grade into, and interfinger with, alluvial terrace deposits and the younger alluvial fan deposits. It is mostly a massive to crudely bedded sandy to clayey silt but locally either sand or clay can predominate. Colluvial deposits generally overlie very irregularly sloping bedrock surfaces. While this may be typical at many locations, they are known to overlie the Louviers deposits over a portion of the area covered in Figure 2-4.

The 2004 subsurface investigation of the Site included 36 test pits and 28 borings (Section 3.3.4 of the 2004 RI/FS). The majority of the subsurface material would be classified colluvium. The eastern portion of the Site is covered with a clay layer that varies in thickness between 5 to 6 feet. Below the clay is a layer of red, brown sandy clay followed by a layer of orange, red, brown clayey sand. These layers vary in thickness from about 1 foot to 3 feet. These differences reflect the origin of the colluvium. Potentially, the clay materials have been derived from the Pierre Shale; the reddish-brown sand from the Fountain Formation (present on the west side of the Golden fault); and the brown sand from the Fox Hills Formation.

Underlying the colluvial material is an alluvial cobble zone. The cobble zone consists of a small quantity of pinkish, reddish sand intermixed with numerous flat cobbles/boulders (up to 12 inches). See the following description of the Post-Piney Creek Alluvium. Up to 13 feet of this alluvial

material was encountered in the borings. During the 2004 RI, this zone could not be penetrated by the backhoe used for the test pits.

Post-Piney Creek Alluvium (Qpp) – This alluvial unit is present along Clear Creek and the youngest alluvial unit in the area mapped in Figure 2-4. It consists of coarse sand and gravel deposits.

Artificial Fill (af) – Artificial fill areas were identified during the RAOA and are shown in Figure 2-4. The identified fill was used primarily for highway construction and for enhancing the usable area of the athletic fields and the adjacent area. The fills include tan to brown clay, medium to stiff, silty, sandy, and slightly gravelly (athletic field) and the artificial fill consists of silty clay to clayey sand with some gravel and construction debris (softball field area).

A comparative analysis of the topographic changes in the last several decades was performed as part of the RAOA. The analysis revealed that fills in the baseball field and western-most practice field may have been generated from cuts (up to 15 feet) in the infield portion of the baseball field.

Additional artificial fill was identified during the RI including:

- Sandy, silty cobbles for roadbed construction,
- Imported uniform sand used for fill around foundations and under roads,
- Bricks and miscellaneous building debris mixed with varying mixtures of clay and sand, and
- A variety of bricks, clays and sands, and miscellaneous debris used for roadbeds and fill around building foundations.

The topographic evaluation also shows that the channel of Chimney Gulch formerly may have been located about 130 feet east of its current location, which would place the old channel beneath the western access road.

2.4.3.1 Soils

Because of the extensive construction activities on the Site, very little "A" horizon material remained (Figure 2-5). Small areas of an "A" horizon were encountered along the northern side of the eastern and western access road. A treed area located along Clear Creek in the northeastern corner of the Site has a shallow "A" horizon underlain by sandy, silty sub-soils. Subsurface investigation was completed in this area during the 2006 Flood Plain characterization described in Section 3.7. The majority of the Site is covered with "B" or "C" horizon subsoils that were exposed as the buildings and roads were constructed.

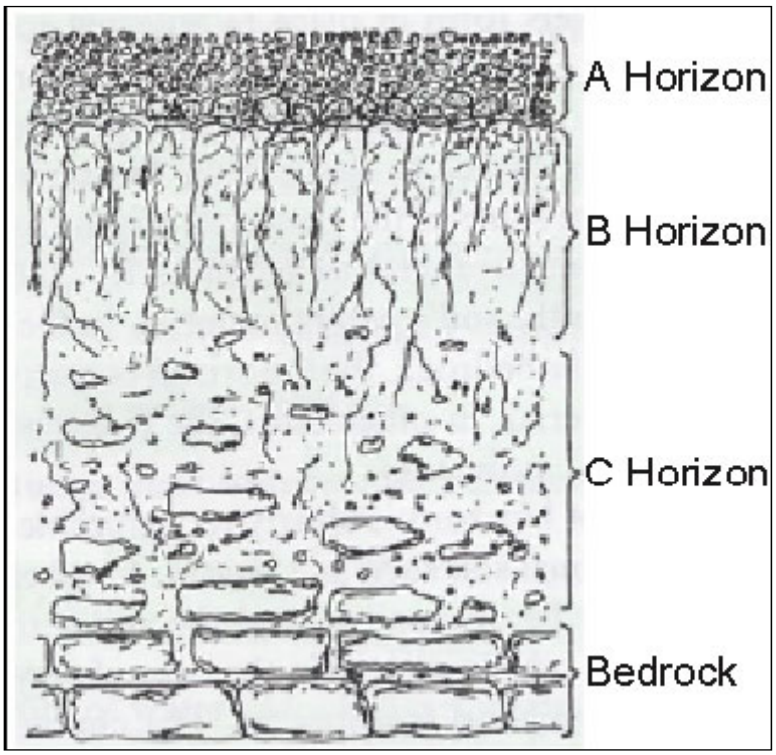

Figure 2-5 Schematic Representation of a Hypothetical Soil Profile with Underlying Parent Rock

2.4.4 Water-Bearing Units

In the area shown in Figure 2-6, groundwater is present in the following bedrock units: the Laramie/Fox Hills units, the Arapahoe, and some of the Denver Formation. Groundwater is also present in the Louviers Alluvium and post-Piney Creek Alluvium. The Laramie/Fox Hills and the Arapahoe are important aquifers of regional significance and the Louviers Alluvium, post-Piney Creek Alluvium, and the Denver Formation can be locally significant. Regional studies by Robson (1983 and 1984) and Robson *et al*., (198la, 1981b) indicate that the outcrop areas for these units in the area covered in Figure 2-6 are part of the recharge area. Recharge is primarily expected to occur from direct rainfall and snowmelt infiltration and by percolation from Clear Creek directly through the alluvium. However, RI observations suggest the reach of Clear Creek along the northern Site border may be a gaining reach because of the artesian nature of Laramie Fox-Hills aquifer in this area (several seeps are visible in the area).

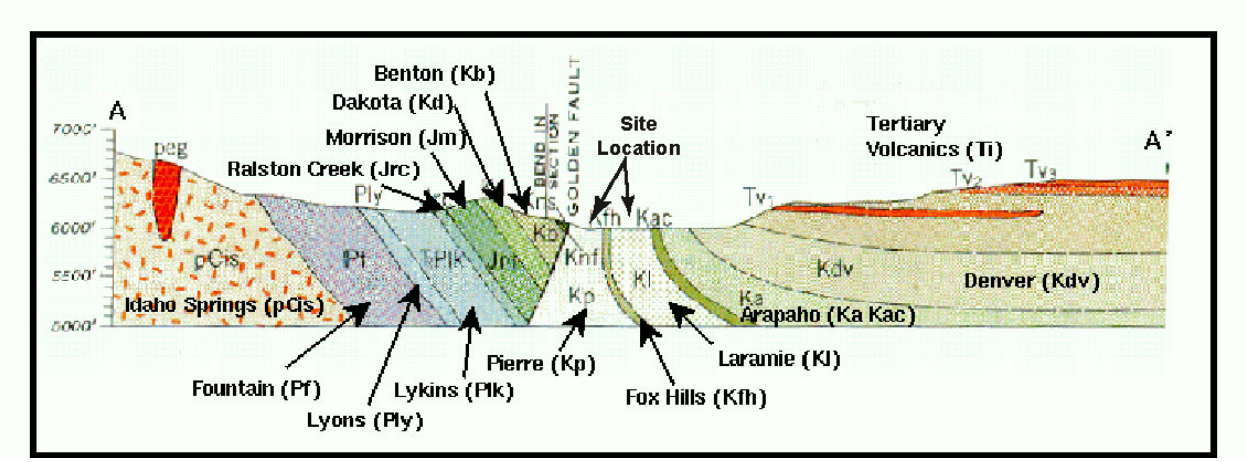

Figure 2-6 Geological Cross Section in the Vicinity of the Site

The most relevant water-bearing unit on the western side of the Site is the alluvial deposit above the weathered Pierre Shale (Figures 2-3 and 2-4). The Pierre Shale acts as an aquitard, allowing water from infiltration and nearby stream losses to move downgradient to Clear Creek. The Pierre Shale was encountered in four of the borings installed as part of the 2004 RI. Depth to the unit varied from about 10 feet below ground surface (bgs) north of the former Building 101N location to about 40 feet bgs near the baseball field. The groundwater-bearing zone above the formation varies between about 1 to 4 feet above the unit near the former Building 101N location and between about 6 to 15 feet near the baseball field. Groundwater was encountered about 30 feet below the baseball field and about 54 feet below the practice fields during the RAOA. More detailed discussions of the subsurface conditions, including groundwater are provided in Section 4.

The most relevant water-bearing unit on the eastern side of the Site is the Laramie Fox-Hills aquifer (Figure 2-6). The outcrop of the Arapahe Formation appears to be located to the east of the Site and does not influence Site hydrology.

2.5 Groundwater Hydrology

A complex groundwater system underlies the Site because of the area geology (Section 2.4). Bedrock in the vicinity is a complicated system of nearly vertical sediment deposits overlying Precambrian, crystalline bedrock (Figure 2-6). Sediment layers that once were located deep under the Denver Basin were pushed up as a result of the uplift of the Rocky Mountains. The Site is located at the western edge of the Denver Basin aquifer system, which includes the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers. These aquifers are unconfined along these uplifted beds and the potentiometric surface (water table) associated with each aquifer is typically closer to the surface than the majority of the aquifer. The aquifers are confined in the deeper portions of the basin, providing the pressure required to raise the groundwater potentiometric surface.

Two groundwater-monitoring wells were installed as part of the 2004 RI, and seven additional wells were installed in February 2007. These wells were used in conjunction with five existing wells to determine groundwater quality and to estimate groundwater flow directions. Because of the very slow recharge rates of several monitoring wells and insufficient information on well

screen conditions, groundwater velocities were not determined. Prior to the start of the halted remedial effort, two wells (CSMRI-6 and CSMRI-7) were abandoned due to their location within the area requiring remediation.

The groundwater flow direction is governed by the underlying weathered Pierre Shale and appears to be flowing north-northeast toward Clear Creek. Figure 2-7 is a potentiometric surface map of the CSMRI Site based on depth to groundwater measurements in early March 2007. Elevation contours in this figure indicate a northerly component of flow for monitor wells that were not dry at the time of field measurement. Monitoring wells CSMRI-1 and CSMRI-2 groundwater elevation data are shown on Figure 2-7 but are not used in developing elevation contours.

The surface expression of the Laramie-Fox Hills sandstone may influence groundwater movement in the vicinity of the Clay Pits causing a northwestern movement. Weathering has removed any surface expression of the sandstone along Clear Creek; therefore, it is difficult to determine if the northwest movement is actually happening.

It appears that the majority of the western Site groundwater comes from surface infiltration from the surrounding foothills and surface irrigation of the baseball/softball fields. Seasonal influence of the nearby Welch Ditch, especially at monitor well CSMRI-2 was eliminated in 2006 with the closure of the Welch Ditch. The eastern Site groundwater appears to be a mixture of the infiltration water and the Laramie Fox-Hills aquifer.

An analysis of the geochemical facies of the groundwater was conducted to determine types of groundwater within the CSMRI site. One round of groundwater from the recently installed and existing monitor wells was collected in late February and early March 2007, and submitted for anions and cations analyses as well as the regularly scheduled, quarterly monitoring sample analytes. Ionic balance results, as a comparison of the sum of the milliequvalants per liter (meq/l) of the anions and cations within each sample, ranged from a low of 0.41 percent (CSMRI-5) to a high of 10.46 percent (CSMRI-11). Ionic balance differences greater than five percent in a sample may be attributed to laboratory procedures or the presence of non-analyzed ions in the groundwater sample. Anion and cation analyses are presented in Table 2-1.

The results of the ionic analysis indicate two distinct types of groundwater within the monitored area of the CSMRI site. Monitor wells located on the upland portion of the CSMRI Site (CSMRI-2, CSMRI-9, CSMRI-10, and CSMRI-11) are a Ca-HCO_3 type water and monitor wells located in the flood plain area (CSMRI-1, CSMRI-4, CSMRI-5 and CSMRI-8), and Clear Creek surface water samples (SW-1 and SW-2) are a Ca-SO_4 type water. An ionic analysis from monitor well CSMRI-1B was not conducted due to insufficient sample volume. The results of the ionic analyses are presented in Figure 2-8 in the Piper trilinear diagram.

The groundwater sample from monitor well CSMRI-2, which is represented in Figure 2-8 as a blue diamond symbol, is distinctly different from the rest of the sample population when plotted in the center of the Piper trilinear diagram. Hydrographs from quarterly groundwater monitoring

Table 2-1
CSMRI Anion-Cation Analytical Results

Analyte	Date	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007
	Units	CSMRI-1	CSMRI-1B	CSMRI-2	CSMRI-4	CSMRI-5	CSMRI-8	CSMRI-9	CSMRI-10	CSMRI-11	SW-1	SW-2
Aluminum	mg/L	0.049	0.051	0.0056	0.0056	0.0056	0.0056	0.045	0.049	0.073	0.076	0.025
Bicarbonate	mg/L	55	NA	310	200	160	240	170	180	160	54	49
Calcium	mg/L	39	130	88	120	80	230	69	79	75	44	39
Carbonate	mg/L	5	NA	50	10	20	20	20	20	20	5	5
Chloride	mg/L	52	NA	19	120	75	54	77	69	74	51	41
Fluoride	mg/L	0.59	NA	1.3	0.65	0.5	1.2	0.5	0.5	0.5	0.63	0.68
Iron	mg/L	0.005	0.004	0.011	0.011	0.011	0.011	0.012	0.0029	0.047	0.0029	0.011
Magnesium	mg/L	12	47	39	49	31	72	31	33	29	11	9.8
Manganese	mg/L	0.0037	0.71	0.023	0.28	0.0029	0.88	1.4	0.93	1.5	0.25	0.25
Nitrogen	mg/L	0.72	NA	0.079	0.073	2.1	0.83	1.5	2.7	2.3	0.53	0.51
Potassium	mg/L	3	52	8.3	11	4.5	23	12	7.3	9.7	4.3	4.2
Sodium	mg/L	26	91	21	47	34	74	33	36	33	26	22
Sulfate	mg/L	77	NA	71	230	130	640	91	110	79	94	80
pH	pH	7.17	NA	7.11	7.03	7.07	7.77	7.46	7.28	7.28	7.76	8.09
Alkalinity	mg CaCO3/kg	55	NA	310	200	160	240	170	180	160	54	49
Anion/Cation Balance RPD	Percent	2.49	NA	5.21	1.18	0.41	7.18	2.88	5.13	10.46	4.19	1.17
Conductivity	umho/cm	424	NA	725	1186	797	1736	678	740	714	515	549

NA = Not Analyzed
RPD= Relative Percent Difference

of the potentiometric surface of monitor well CSMRI-2 indicate a seasonal response to flow and leakage from the adjacent Welch Ditch. During the summer months, the water table at this location typically rises almost 15 feet and then recedes during the winter months. This monitor well is located approximately 600 feet southeast of the CSMRI Site.

The anion triangle on the right lower side of the Piper trilinear diagram shows groundwater from CSMRI-2 is dominated by the $HCO_3 + CO_3$ anion, and the groundwater sample from CSMRI-8 is dominated by the SO_4 anion. The cation triangle on the lower left of the Piper trilinear diagram indicates Ca as the slightly dominant cation.

The Piper diagram also shows the similarity of the groundwater ions for the monitor wells where the symbols representing each of the samples are plotted on top of each other. Specifically this includes monitor wells CSMRI-9, CSMRI-10, and CSMRI-11, which are all co-located at the same position on the Piper diagram and physically are located on the upland portion of the CSMRI Site. Additionally, the CSMRI-1 sample and surface water samples SW-1 and SW-2 are each co-located at the same position within the Piper diagram, which would be expected given the source of the samples and the influence Clear Creek has on CSMRI-1.

In conclusion, the groundwater underlying the Site has two distinct geochemical facies: one on the upland portion of the Site where recharge from is precipitation and irrigation, and a second facies on the flood plain area of the Site where the influence is from Clear Creek.

2.6 Demography, Land Use, and Water Use

The demographics and potential resource utilization of the Site and surrounding area are important in furthering the understanding of the remedial objectives. Remediation will focus on reducing, or if possible, eliminating impacts to resources and health effects to the surrounding population.

2.6.1 Demography

In 2000, the population of the City of Golden was 17,159 based on the U.S. Census. The Golden city limits extend approximately 1.7 miles to the north of the Site, 1.5 miles to the east of the Site, and 3.2 miles south of the Site.

2.6.2 Land Use

Land usage in the vicinity of the Site includes residential, commercial, and rangeland. A large portion of the surrounding area is owned by the State of Colorado and has a variety of university-related uses, including athletic fields, classrooms, recreational facilities, maintenance, and administration. Additionally, the City of Golden has offices and a water treatment plant on the north side of Clear Creek across from the Site. The residential, commercial, municipal, and agricultural facilities and their distances from the Site as obtained by direct field reconnaissance and map measurements are as follows:

- West - condominiums along Clear Creek are located about 1,500 feet west of the Site.
- South - a housing area along Parfet Estates Drive. The closest house is about 1,300 feet from the Site.

- North - a public campground is located about 50 feet from the Site on the north side of Clear Creek. Ponds associated with the City of Golden's water treatment plant are about 200 feet northwest of the Site. The City of Golden's offices are about 100 feet to the north. A recreation center is located about 300 feet to the north with a 40-unit apartment building about 300 feet north of the recreation center (600 feet north of the Site). The dairy originally located 3.6 miles north of the Site is no longer in business.
- East - the School's football stadium shares the eastern boundary with the Site. There are condominiums on the west side of Maple Drive within 150 feet of the eastern gate. The closest house on 12th Street is about 600 feet from the Site. The closest School building is 700 feet to the southeast.

2.6.3 Surface-Water Uses

Surface water diverted from Clear Creek is primarily used for water supply and secondarily for recreation and irrigation purposes. Diversions present within approximately one mile of the Site are shown on Figure 2-9 and are described in the following sections.

2.6.3.1 Welch Ditch Diversion

This ditch originates on the south side of Clear Creek about 1.8 miles upstream of the Site (west). The Welch Ditch passes approximately 900 feet south of the south end of the Site (about 650 feet south of the Clay Pits) near monitor well CSMRI-2. The water from the ditch is used for irrigation and is not used for domestic purposes. The ditch is unlined and flows along the side of the hill above the Site to the east, through a tunnel and culverts in the vicinity of the School student housing and the Clay Pits. From here, it flows around the southern perimeter of Golden, along the north side of South Table Mountain above the Coors brewery, and then to the east into the Federal Center. The ditch is a major source of groundwater recharge for the Site drainage when it is in operation. Overflow from the ditch is diverted down the Chimney Gulch drainage. The Welch Ditch was permanently closed in 2006.

2.6.3.2 Church Ditch/City of Golden Diversions

This ditch originates on the north side of Clear Creek about 0.9 mile upstream of the Site (west). The major water users served by the Church Ditch include the cities of Broomfield, Northglenn, Thornton, Westminster, and Arvada. Water is used for municipal purposes, including drinking water. The City of Golden also diverts some of its municipal water at the Church Ditch headgate and that water is incorporated into the city's drinking water supply. Treatment facilities for Golden are located on the northern side of Clear Creek near the Site.

2.6.3.3 Agricultural Ditch Diversion

This diversion originates on the south side of Clear Creek about 3,000 feet downstream (east) of the Site. The Agricultural Ditch is the first surface-water diversion downstream of the Site. The major water users served by the Agricultural Ditch include a major municipal supplier to the cities of Lakewood and Wheat Ridge. Some of the water is also used by Arvada, Golden, and unincorporated areas of Jefferson County, in additional to a number of other smaller industrial and agricultural users.

2.6.3.4 Farmers' Highline Canal and Ditch

This diversion originates on the north side of Clear Creek about 3,500 feet downstream (east) of the Site. The major water users served by the Farmers' Highline diversion include the cities of Westminster, Thornton, Northglenn, and Arvada. Water is used for municipal purposes, including drinking water. Coors and several small irrigation users also divert from the ditch.

2.6.4 Groundwater Uses

Groundwater wells, applications, and permits were identified for a one-mile radius around the Site from information provided by the Colorado Division of Water Resources. A copy of that information is included in Appendix B of the New Horizons' 2004 RI/FS. An evaluation of that information shows that as many as 20 wells may be in use within a 1-mile radius of the Site. The identified uses include nine for industrial, ten for domestic, and one for household purposes. Yields range from 1 gallon per minute to as much as 85 gallons per minute. The nearest wells are located on the north side of Clear Creek within 500 to 1,000 feet of the Site. The nearest well on the south side of Clear Creek is over 2,000 feet away. The nine industrial use wells are alluvial wells owned by Coors Brewing Company are to the northeast of the Site at distances in excess of about 2,000 feet in locations near Clear Creek. Water taken from the industrial use wells, as well as the domestic and household wells, may be used for drinking water purposes according to the Colorado Division of Water Resources use classification.

2.6.5 National Historic Preservation Act Considerations

Potential historical and archeological resources were previously evaluated during preparation of the RAOA. The Colorado Historical Society advised that no significant historical or archeological resources are known in the immediate vicinity of the Site. Additionally, the City of Golden's Planning Department also advised that no known historical or archeological resources would affect the FS alternatives evaluation or selection process.

2.7 Ecology

The ecosystem of the area surrounding Golden is a diverse habitat influenced by a range in elevations that encompasses the plains, foothills, and mountains. The channelization of Clear Creek, construction of artificial ponds, grading projects, changes in vegetation, and other works of man have created new habitats by altering the natural habitat in the vicinity. Extensive residential development also has occurred over the years, and new development is continuing to the north and south of the Site.

The U.S. Fish and Wildlife Service was previously contacted during preparation of the RAOA to determine if sensitive ecosystems or species are present in the area. They indicated that a federally threatened plant species, the Ute Ladies' Tresses Orchid (*Spiranthes diluvialis*) is present in the Clear Creek area in the vicinity of the Site. The RAOA includes a survey performed by a local botanical expert, recommended by the U.S. Fish and Wildlife Service, in an area adjacent to the Site for potential Ute Ladies' Tresses Orchid habitat. The surveyed areas included Chimney Gulch below U.S. Highway 6 and a tributary of Chimney Gulch that runs parallel to U.S. Highway 6 on the north. The results of that survey showed that neither Chimney Gulch nor its tributary provide adequate habitat for *Spiranthes diluvialis* and that both drainage courses are in poor condition relative to natural habitats. The only portion of the Site that could

potentially have suitable habitat would be the lower area along Clear Creek. This area has significant disturbance because of the excavation of the prior settling pond and the installation of the monitoring wells. A wooded area east of the settling pond area is unsuitable habitat for the Ute Ladies' Tresses Orchid because the plant prefers wet meadows. Using published habitat descriptions and the results of the previous investigation it was determined that onsite habitats were unsuitable for Ute Ladies' Tresses.

A wetlands delineation was completed in 2006 on the portion of the site adjacent to the former settling pond, within the flood plain of Clear Creek. The study was completed to determine if wetlands existed on the flood plain of Clear Creek immediately adjacent to the Site. The study determined a limited area with wetland characteristics does exist in the vicinity of the former pond area. The work plan addressing the impacted soil adjacent to the wetlands was designed to eliminate impacts to the wetlands. The U.S. Army Corps of Engineers reviewed and approved the work plan. The complete wetlands delineation report is attached as Appendix B.

Figure 2-1

CSMRI Site Map with Topography

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Former Settling Pond

N
W E
S

Scale: 1" = 100'

Feet
0 50 100 200

CSMRI
Remedial Investigation /
Feasibility Study

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Former Settling Pond
Clear Creek
Job Trailer
Stockpile A
Stockpile B
Clay Pits
12th Street
5675
5680
5685
5690
5695
5700
5705
5710
5715
5720
5725
5730
5740
5745

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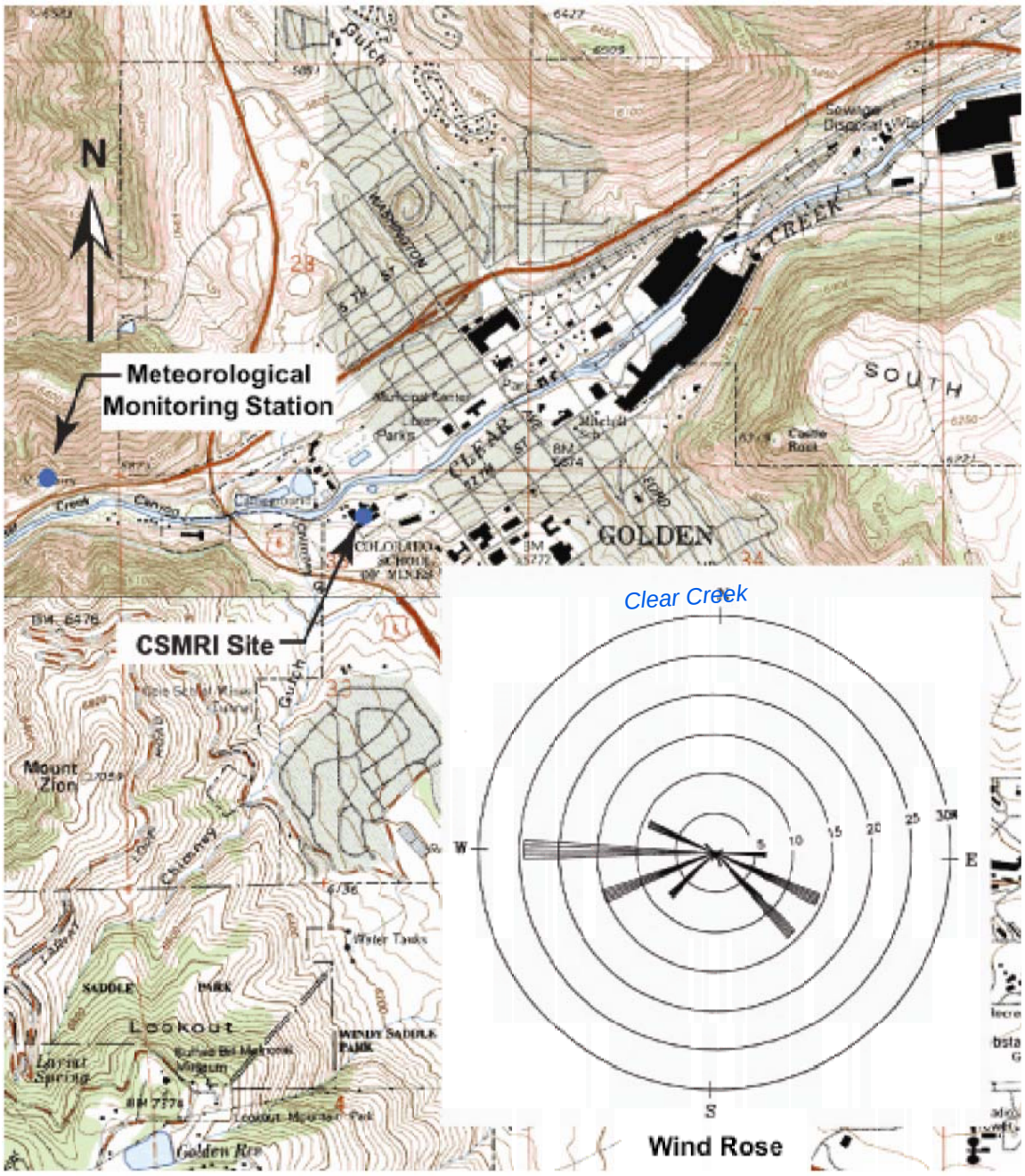

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Figure 2-2

Meteorological Monitoring Location in Clear Creek Canyon

CSMRI
2007 Revised
Remedial Investigation / Feasibility Study

Stoller

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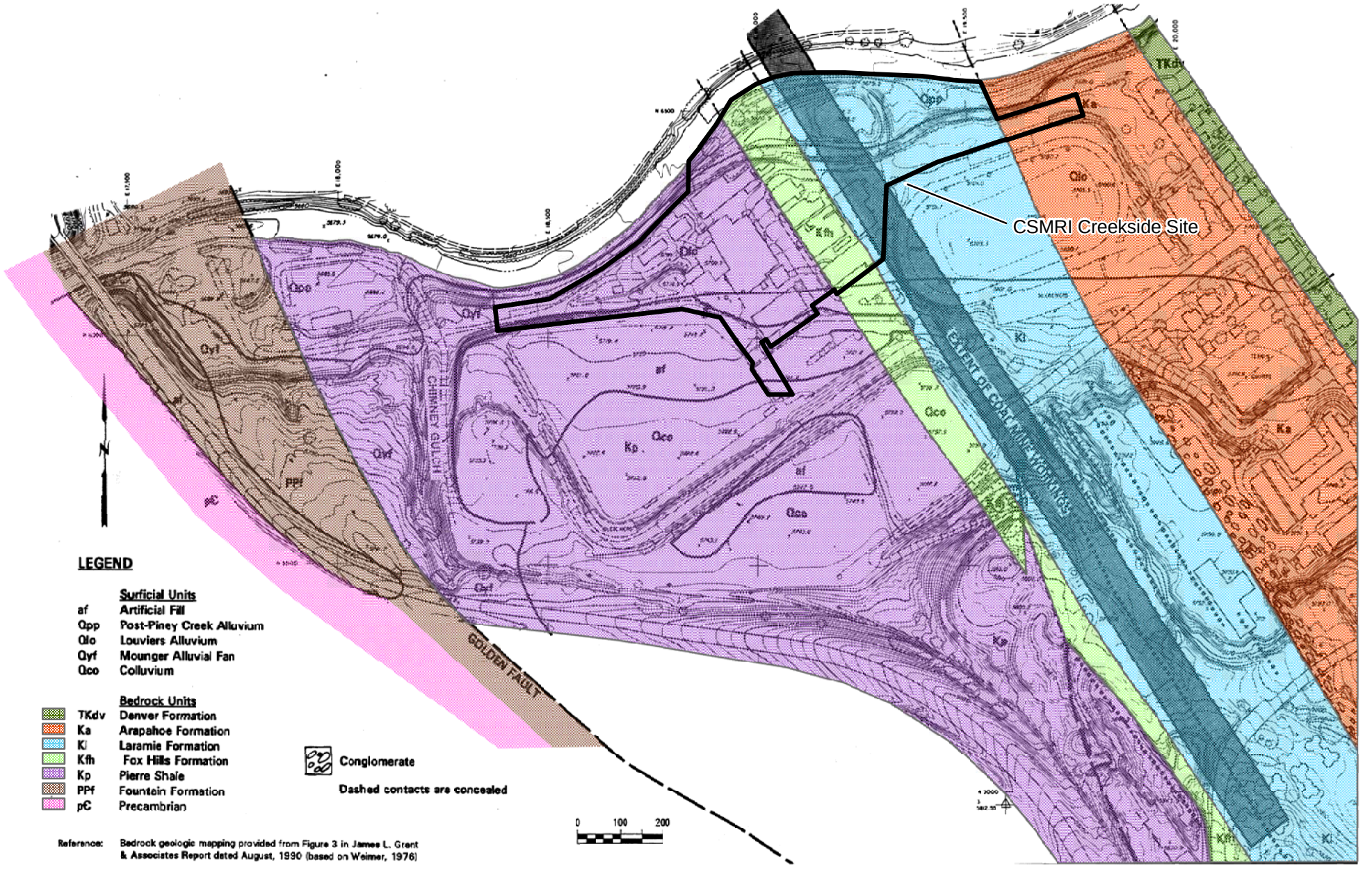

Figure 2-3

Bedrock Geologic Map of Site

CSMRI
Remedial Investigation / Feasibility Study

Stoller

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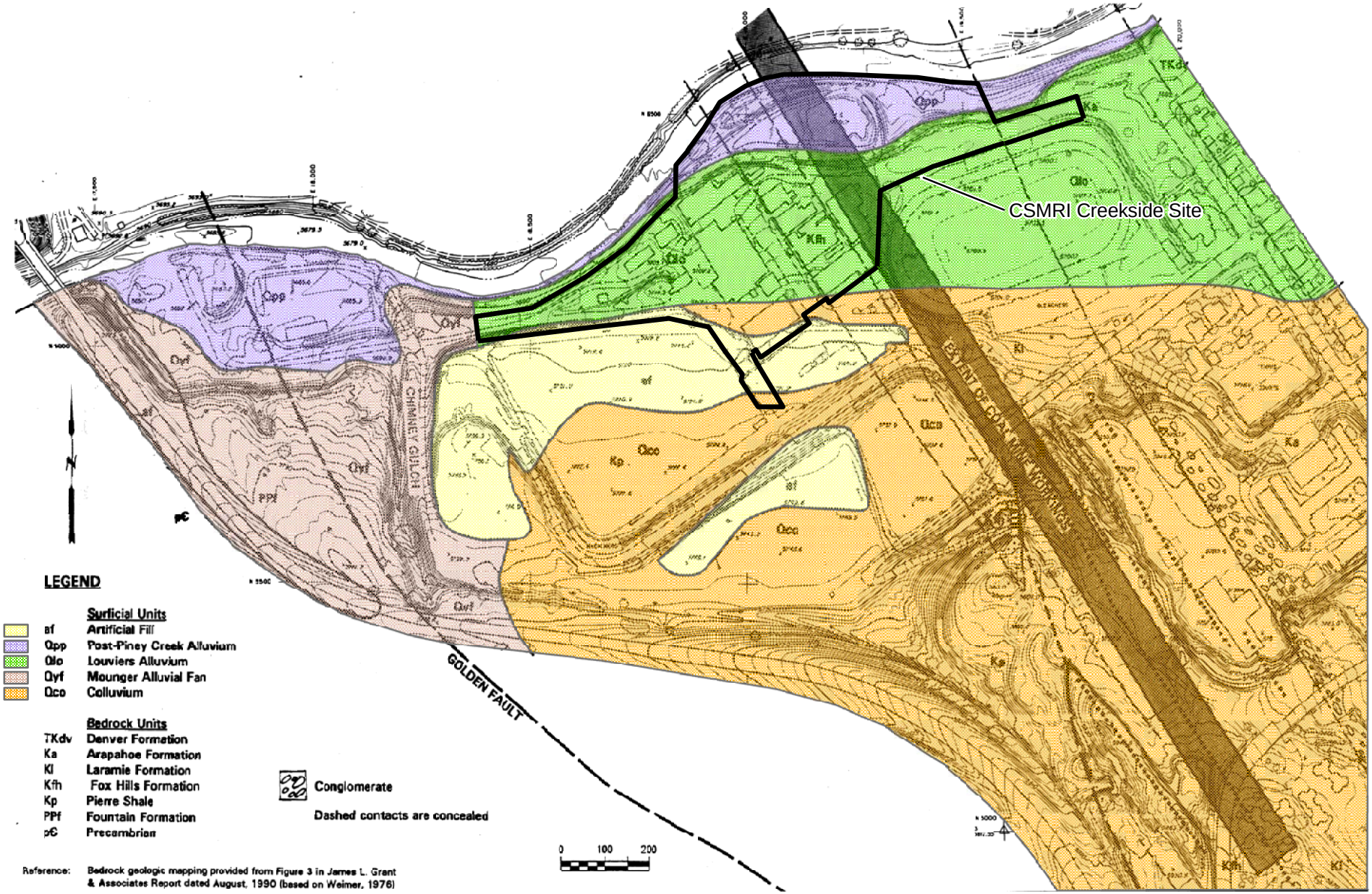

Figure 2-4

Surficial Geologic Map of Site

CSMRI
Remedial Investigation / Feasibility Study

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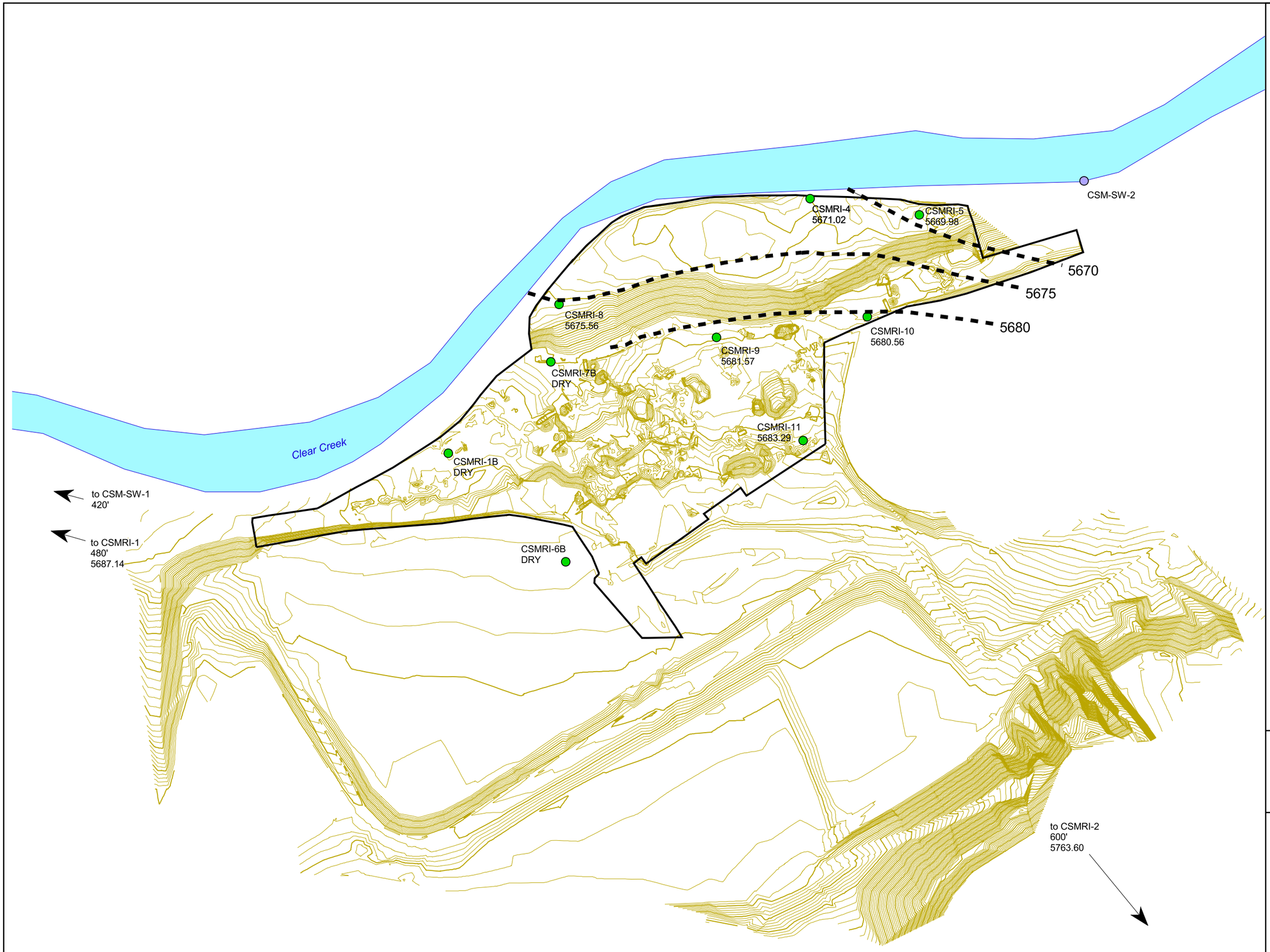

Explanation

- Wells
- Surface Water Sample Locations
- Ghost Wells
- 1 Foot Contours
- 5 Foot Index Contour
- Property Boundary
- Clear Creek
- 5669.98 Potentionmetric Surface Elevation (Feb 27 and Mar 1, 2007)
- Elevation Contour

N

100 0 100 200 Feet

1 inch = 150 feet

Figure 2-7
Groundwater Potentiometric Surface Map - March 2007

CSMRI
Remedial Investigation / Feasibility Study

Stoller

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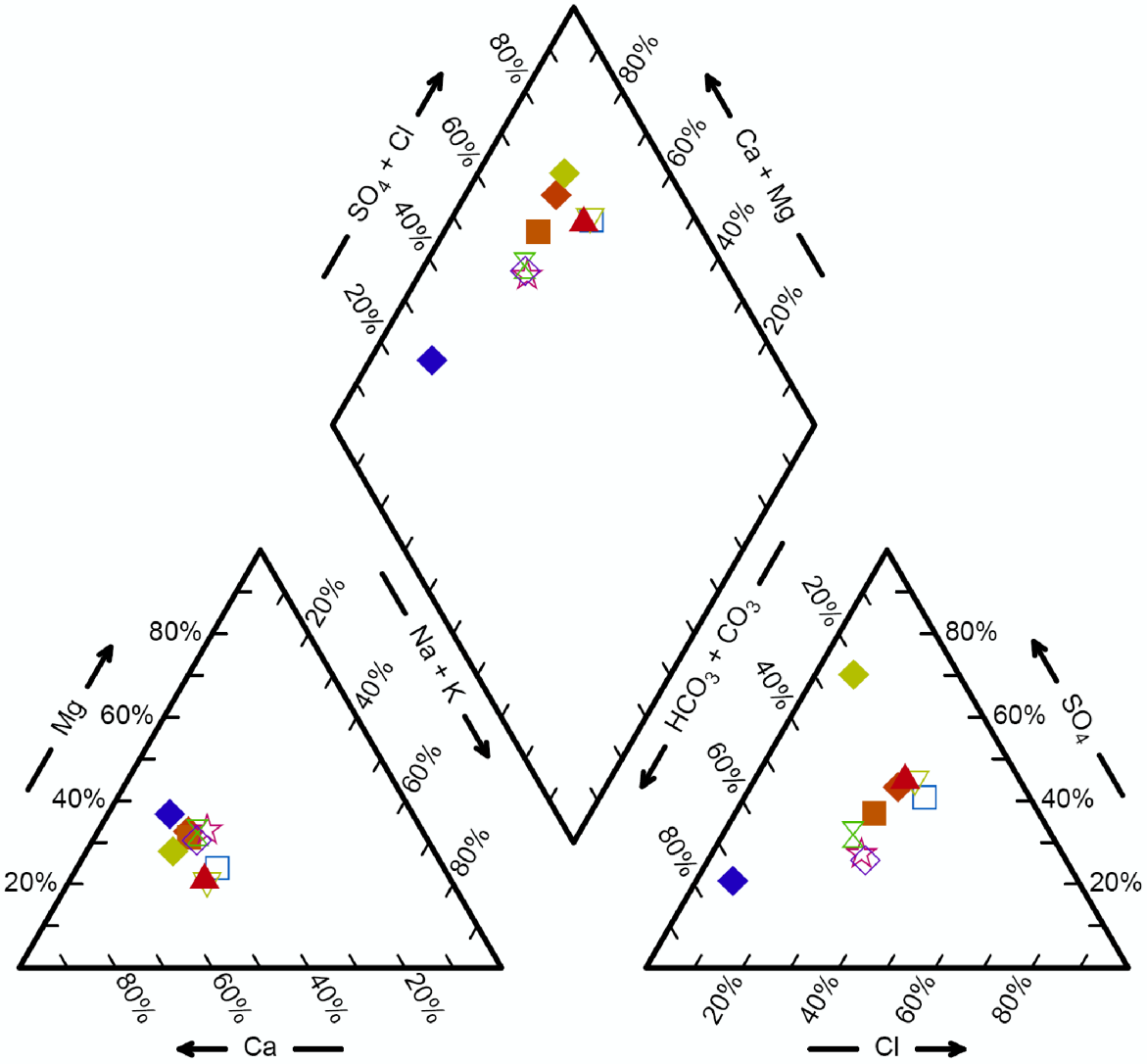

Figure 2-8

Piper Trilinear Diagram

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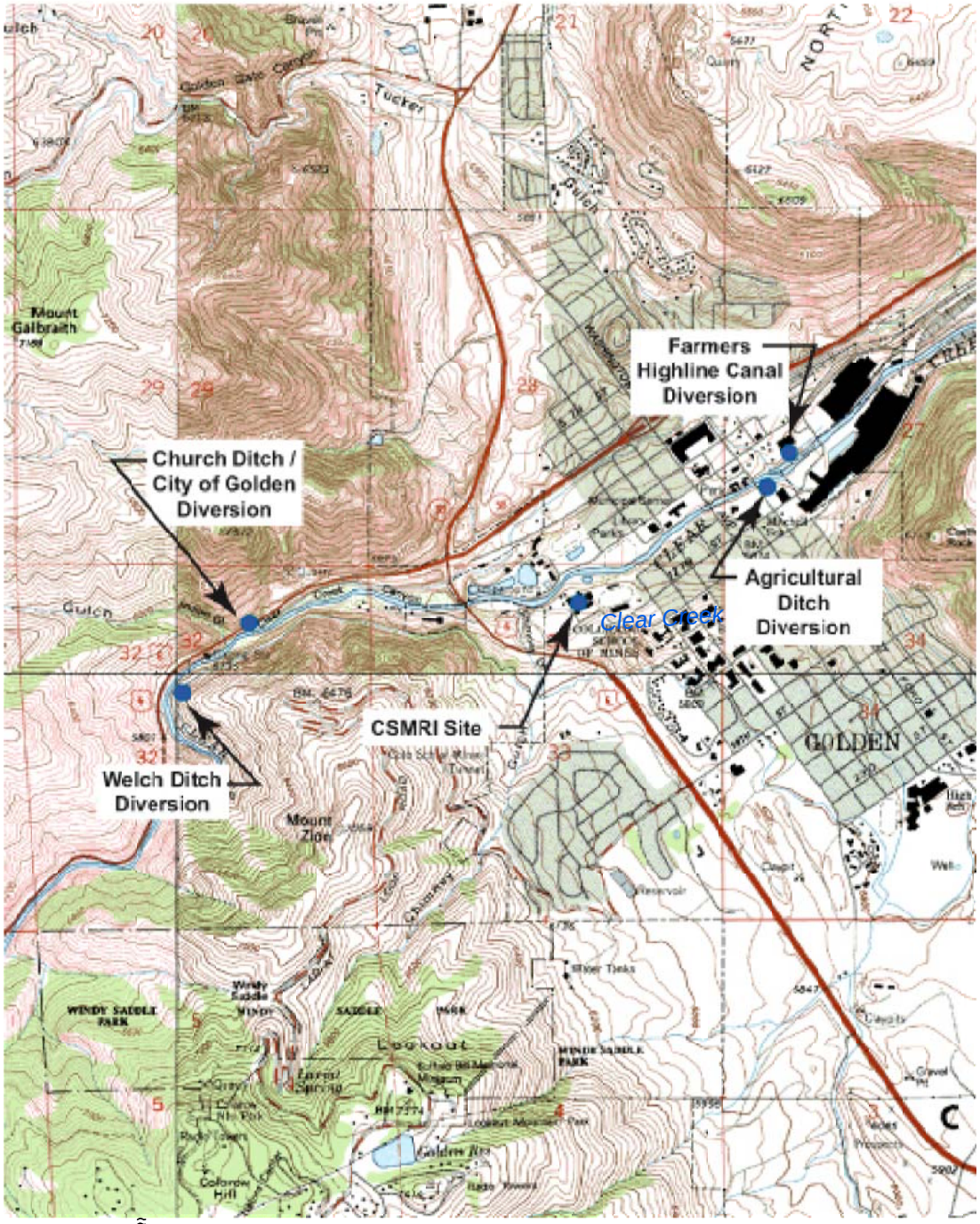

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Figure 2-9

Surface Water Diversion

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