Colorado School of Mines Research Institute Site Data Evaluation Report

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1.0 Introduction

This report presents an evaluation of the data available for the Colorado School of Mines Research Institute (CSMRI) site that can be used to demonstrate the extent of compounds of potential concern (COPCs). Data were collected during past site characterization work by a previous consultant and presented in the remedial investigation/feasibility study (RI/FS) (New Horizons 2004). Additional data were collected during a partial remediation of surface and subsurface soils; however, lack of survey control makes these data mostly unusable.

The following sections present a brief history of the site and the site setting. Additional details concerning this information can be found in the RI/FS. The report continues with sections that detail the available data for the site and summarizes data suitable for site characterization. Sources of the data are described along with issues with the usability of the data, if any. All useable data are plotted on a series of plan-view maps depicting soil concentration and the lateral and to a lesser extent the vertical extent of COPCs. The report concludes with findings concerning data gaps that exist making an estimate of the impacted soil volume unreliable at this time.

2.0 Site History

The CSMRI site consisted of 17 buildings that operated from 1912 until 1987 during which time the research institute conducted numerous mineral research projects. These projects involved the mineral extraction and beneficiation of materials that contained naturally occurring levels of radionuclides and metals above the site's background levels. In January 1992, a water main for the City of Golden broke onsite resulting in a large volume of water being discharged into the former settling pond area adjacent to Clear Creek. The U.S. Environmental Protection Agency (EPA) then responded in February 1992, during which time it performed a number of activities, including the excavation of contaminated soil and sediments, stockpiling of material, decontamination of building drains, demolition and removal of several buildings, consolidation of existing drums, water and sediment sampling, disposal of compressed gas cylinders, and closure of the settling pond. In the mid-1990s the remaining buildings onsite were demolished and removed. Following demolition, the remaining pits and basements were backfilled, and the concrete foundations and footers were left in place.

In November and December 2002, the majority of concrete and asphalt slabs were removed in preparation for characterization of the site. New Horizons Environmental Consultants (New Horizons) were contracted to perform groundwater, surface soil, and subsurface soil sampling to generate an RI/FS report. The field investigation began in December 2002 and consisted of a gamma survey, 163 surface soil samples, 34 test pits, 28 borings (68 samples), and four quarters of groundwater sampling from seven monitoring wells. The investigation determined that soils with elevated metals concentrations and radionuclide activities existed around several of the former buildings and in nearby areas. The primary contaminants were found to be arsenic, cadmium, lead, mercury, radium, thorium, and uranium. Elevated concentrations of uranium above the maximum contaminant level (MCL) were detected in the groundwater monitoring wells.

An RI/FS and Proposed Plan was issued on January 21, 2004 by New Horizons to identify, excavate, and dispose of the contaminated soils on the site. Excavation began in April 2004.

The remediation was guided by an In Situ Object Counting System (ISOCS), a hand-held gamma probe and visual observations. Hand-held gamma probe readings and visual observations were the primary methods used to direct the excavation; whereas the ISOCS was used predominantly as confirmation of excavation success. By mid-May 2004, excavated soil volumes far exceeded estimated volumes, which had been previously established in the RI/FS. The Colorado School of Mines (CSM) halted the work and the site was stabilized. Approximately 450 bags (1,870 cubic yards) had been filled and were staged on the south side of the site. The soil bags were covered with a geotextile liner, soil stockpiles were covered with tarps, and safety fencing was placed around excavations. The contract with New Horizons was then terminated in the autumn of 2004.

3.0 Site Setting

The CSMRI site is located on a terrace on the south side of Clear Creek in Golden, Colorado, less than one-half mile east of the eastern extent of the Rocky Mountain Front Range (Figure 1). The Front Range is a complexly faulted anticlinal arch of primarily Precambrian crystalline rocks that reach elevations in excess of 14,000 feet. The Front Range foothills consist of rock types that include unconsolidated to partly indurated surficial deposits (25 thousand to 1 million years old), sedimentary rocks (primarily sandstone and shale – 63 million to 300 million years old), and igneous and metamorphic rocks (over 1 billion years old). The sandstone and shale formations exist as horizontal layers beneath Denver and the eastern plains but are folded into vertical and overturned beds near the Golden fault. The Golden fault is a high-angle reverse fault that strikes roughly north-south along the eastern edge of the foothills and lies just west of the CSMRI site. Surficial deposits in the area consist mainly of Pleistocene alluvial and colluvial deposits. Creek beds contain more recent Holocene alluvial deposits.

Figure 2 presents a bedrock geologic map of the area showing the CSMRI site location and the surrounding features. The geologic strata in the area of the CSMRI site are overturned and steeply dipping. Measurements of the strike of the beds in the area indicate a north-northwest to northwest trend with dips ranging from about 59^{o} to 71^{o} to the west. Further east the beds become vertical, then progressively more horizontal as the distance increases away from the Golden fault. This fault was studied extensively during the construction of the Rocky Flats Plant to the north. The Golden fault was determined to be inactive (i.e., movement has not occurred in the past 35,000 years and multiple movements have not occurred in the past 500,000 years).

The stratigraphic units presented in Figure 2 are described below in order of decreasing age, oldest to youngest.

Idaho Springs Formation (pC) – This formation consists of medium grade metasedimentary gneiss and schist that forms the oldest rocks in the Front Range. The Idaho Springs Formation does not lie on the CSMRI site but is within very close proximity.

Fountain Formation (PPf) – The Fountain Formation is a pink to reddish-orange, coarse-grained conglomeratic, arkosic sandstone. While this unit is not exposed on the CSMRI site, it is believed to be present on the extreme west side of the site where it is overlain by alluvial deposits.

Pierre Shale (Kp) – The Pierre Shale is a medium to light gray, noncalcareous shale. It consists primarily of shale but also contains minor siltstone and fine-grained sandstones. This unit underlies much of the site but is only seen in small areas along Clear Creek where it is exposed by erosion.

Fox Hills Sandstone (Kfh) – In the vicinity of Golden, this sandstone consists of about 8 feet of sandstone at the base, 63 feet of shale in the middle, and 23 feet of interbedded sandstone and shale at the top. The sandstone is gray-orange to light gray, fine-grained and weathers to light brown rounded outcrops. The Fox Hills Sandstone is exposed off-site to the south of 12th Street.

Kl – This unit is a steeply dipping, overturned formation that is a light to medium gray, medium to fine-grained quartz sandstone. Locally it contains layers of claystone and coal and is sometimes marked by low hogbacks and open pit clay mines. Economically recoverable coal and clay have been mined in the area of the CSMRI site. Two coal seams running northwest through the site have been mined and subsequently backfilled. An open pit clay excavation is exposed immediately to the south of 12th Street.

Arapahoe Formation (Ka) – The Arapahoe formation is a quartz sandstone and claystone that grades laterally into tuffaceous sediments of the Denver Formation. Near Golden, the Arapahoe is exposed as a narrow belt of steeply dipping, north striking rocks with a prominent basal bed of conglomerate. It is not exposed on the CSMRI site but can be seen to the southeast of 12th Street.

The surficial deposits overlying the bedrock in the vicinity of the CSMRI site are presented in Figure 3 and are described below (the order presented does not represent any age relationship):

Louviers Alluvium (Qlo) – This unit consists of silty, fine-grained sand, which becomes coarser with depth. In the Golden area, it forms deposits that are from 10 to 20 feet thick. Soil investigations indicate the Louviers alluvium is about 10 feet thick at the CSMRI site, gradually decreasing in depth to the south where it pinches out against underlying bedrock.

Younger Alluvial Fan (Qyf) – The material present in this unit is poorly sorted, silty to bouldery gravel. The top 1 to 2 feet is locally very silty grading to coarser materials with depth. These alluvial deposits lie on the western edge of the CSMRI site above the floodplain deposits.

Colluvium (Qco) – Colluvium in the mapped area consists of clay to sand, with minor cobbles to boulders. It is generally thicker on steep slopes, varying from 0 to 20 feet, and thinner on gentle slopes where it reaches a maximum depth of 10 feet. Based on 34 test pits and 28 borings conducted during soil investigations, it was determined that the majority of the subsurface material on the site would be classified as colluvium.

Post-Piney Creek Alluvium (Qpp) – The material found in the Post-Piney Creek unit are cobbley gravels containing some boulders. This deposit forms the flood plains of Clear Creek and is up to 5 feet thick.

Artificial Fill (af) – Artificial fill has been used extensively in and around the CSMRI site, mainly to level football and baseball playing fields adjacent to the CSMRI site. The fill consists of locally excavated material from clay through boulder size, imported materials such as uniform sands and clay and man-made materials such as bricks and building debris.

The CSMRI site is located on a terrace of the south bank of Clear Creek. The terrace was formed by Clear Creek during the uplift of the Rocky Mountains and is cut into the underlying bedrock formations. The terrace is covered by three types of recent (Quaternary) sediments. These include sediments that were deposited by Clear Creek, sediments deposited by erosional processes from Lookout Mountain to the west and anthropogenic fill. These sediments were placed on a terrace cut into the bedrock formations shown on Figure 2. The thickness of the surficial deposits on site ranges from less than ten feet to over 40 feet.

3.1 Current Site Conditions

Figure 4 includes the topography of current site conditions. Building foundations and floor slabs have been mostly removed, and limited soil remediation has been conducted. Approximately 21 test pits exist with excavated soil piled adjacent to the pit as indicated by the hummocky terrain in the topographic map. These test pits are, in general, only 2 to 3 feet deep and were not located in "hot spots" locations. In addition to these pits, six larger excavations remain open from New Horizons' remedial activities and ten open test pits from the previous investigative efforts.

Most of the site has become overgrown with vegetation during the remediation hiatus. A locked, chain-link fence secures the perimeter of the site. A silt fence along the top of the crest of the slope above the former settling pond was installed as a best management practice for stormwater control. Erosion control straw wattles of various lengths have been staked into the ground in areas susceptible to increased stormwater flow, such as road edges.

Stoller has placed two continuous high-volume air samples on the site, one each in the prevailing upwind (AS-West) and downwind (AS-East) directions. The filters in the air monitoring stations are replaced monthly with new filters and the old filters are removed and sent to Paragon Analytics, Inc. of Fort Collins, Colorado for laboratory analyses.

On a weekly basis, Stoller personnel perform a site walk-down. This consists of checking erosion controls, air samplers and soil stockpiles. Four groundwater-monitoring wells and two surface water locations are sampled on a quarterly basis (March, June, September, December). Analytical results of the quarterly monitoring are compiled, compared to existing regulatory guidelines, and provided to CSM. Locations of the site monitoring sample locations are presented in Figure 4.

In December 2005, 447 bags of soil were removed over the course of four days. The soil had been excavated and bagged by a previous consultant as part of the remediation effort of the CSMRI site. The individual bags were picked up by an excavator, placed in an end-dump semi trailer with minimal tearing, and transported to the BFI Foothills Landfill on Highway 93 north of Golden.

3.2 Existing Data

Two sources of data exist to characterize the site. The first source is characterization data collected for the RI/FS and the second source is data collected during the remedial activities. Each of these sources of data is discussed below.

3.2.1 Remedial Investigation/Feasibility Study

During the RI/FS site characterization, data were collected from a surface gamma survey, surface soil samples, test pits, and borings. These data were presented in the RI/FS and are deemed usable to assist in characterizing the site. The surface gamma survey in conjunction with the surface soil samples and samples collected from the surface in the test pits and borings demonstrate the concentrations and extent of surface contamination. The locations of the sample collection points are well documented and the data quality objectives appear adequate. The test pits and borings, however, do only a partial job at characterizing the COPCs in the subsurface. The borings and test pits were installed in areas suspected of highest impacts and were inadequate to delineate extent.

Data from the RI/FS are discussed further in Section 4.0, Data Presentation.

3.2.2 Remedial Action

During the remedial action, six areas were excavated and a seventh area was partially excavated. Excavation of soil was guided by an Eberline ISOCS, a hand-held gamma probe, and visual observations. The ISOCS, a germanium-based spectroscopy system that is designed to provide information on the type and amount of radioactive material, was housed in an onsite trailer and was used predominantly as confirmation of excavation success. The hand-held gamma probe was used to guide the excavation, as were the visual observations. The resulting excavations have not been surveyed and any data removed during the excavation have not been removed from the maps.

Laboratory quality control samples were collected and locations surveyed, but no reliable confirmation sample results have been identified, nor have any laboratory results been identified during the entire remedial activities. No useable data were recovered during the partial remediation of the site. A series of excavations and associated soil stockpiles identified as BFI-1 through BFI-24 have laboratory data consisting of toxicity characteristic leaching profile (TCLP) for lead only. The supposition is that these data were used to characterize the soil for disposal at a landfill and were not used to characterize the site for contamination from metals and/or radionuclides. These data are discussed in Section 4.4, TCLP Lead Data even though it provides little benefit in the understanding of the nature and extent of metals contamination at the site.

4.0 Data Presentation

The site data presented consist of the data collected and presented in the RI/FS. These data are being re-evaluated to determine the data gaps that existed, which resulted in the previous ineffective remedial effort. No raw data were reviewed for completeness and transcription accuracy onto the summary forms. No results were recalculated and verified, and no data were removed from the data set because of the excavations.

Data collected during the RI/FS include data from surface soil samples, a surface gamma survey, test pit soil samples, and soil samples from borings. The surface soil samples were identified as CSM1 through CSM163 and were analyzed for metals (arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, selenium, silver, vanadium, and zinc); alpha-emitting radioisotopes (Th-228, Th-230, Th-232, U-234, U-235, U-238, and gamma-emitting radioisotopes (Ag-110, Al-26, Am-241, Be-7, Bi-212, Bi-214, Cd-109, Ce-139, Ce-144, Co-56, Co-57, Co-58, Co-60, Cr-51, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, Fe-59, I-131, K-40, Mn-54, Na-22, Nb-94, Nb-95, Pa-234, Pb-212, Pb-214, Ra-226, Ra-228, Ru-106, Sb-124, Sb-125, Sc-46, Th-227, Th-234, Tl-208, U-235, and Zn-65). No surface soil samples were tested for alpha-emitting uranium isotopes (U-234 and U-238).

The test pits are identified as CP3 through CP36 and were also analyzed for metals (arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, selenium, silver, vanadium, and zinc); alpha-emitting radioisotopes (Th-228, Th-230, Th-232, U-234, U-235, U-238) and gamma spectroscopy radioisotopes (Ag-110, Al-26, Am-241, Be-7, Bi-212, Bi-214, Cd-109, Ce-139, Ce-144, Co-56, Co-57, Co-58, Co-60, Cr-51, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, Fe-59, I-131, K-40, Mn-54, Na-22, Nb-94, Nb-95, Pa-234, Pb-212, Pb-214, Ra-226, Ra-228, Ru-106, Sb-124, Sb-125, Sc-46, Th-227, Th-234, Tl-208, U-235, and Zn-65).

The borings are identified as CB1 through CB28 and were also analyzed for metals (arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, selenium, silver, vanadium, and zinc); alpha-emitting radioisotopes (Th-228, Th-230, Th-232, U-234, U- 235, U-238) and gamma-emitting radioisotopes (Ag-110, Al-26, Am-241, Be-7, Bi-212, Bi-214, Cd-109, Ce-139, Ce-144, Co-56, Co-57, Co-58, Co-60, Cr-51, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, Fe-59, I-131, K-40, Mn-54, Na-22, Nb-94, Nb-95, Pa-234, Pb-212, Pb-214, Ra-226, Ra-228, Ru-106, Sb-124, Sb-125, Sc-46, Th-227, Th-234, Tl-208, U-235, and Zn-65). Several borings were converted to groundwater monitor wells to assess hydrogeologic and groundwater quality properties of the site.

Results of the laboratory analyses indicate surface soil exceedances for arsenic, lead, mercury, and molybdenum; and subsurface soil exceedances for arsenic, lead, mercury, molybdenum, and vanadium. Surface soil exceedances for alpha radioisotope activity include Th-228, Th-230, and Th-232. Subsurface soil exceedances for radioisotope alpha activity include Th-228, Th-230, Th-232, U-235, and U-238. Both surface and subsurface soil exceedances for gamma radioisotope activity include Ra-226 and Ra-228.

The follow data presentation divides the COPCs data into metals (Section 4.1), alpha activity (Section 4.2), and gamma activity (Section 4.3) for both surface and subsurface soil samples and discusses the nature and the extent of the contamination.

Figures presenting the nature and extent of the COPCs have been combined so that surface and subsurface action level metals exceedances are shown on Figure 5, surface and subsurface revised metals exceedances are shown on Figure 6, surface and subsurface alpha activity radioisotope exceedances are shown on Figure 7, and surface and subsurface gamma activity radioisotope exceedances are shown on Figure 8.

4.1 Metals

The following sections discuss the nature and extent of both surface and subsurface soil samples for metals analyses. Action levels for arsenic and mercury as COPCs were re-evaluated after discussions with the Colorado Department of Public Health and Environment (CDPHE). The action level for arsenic was changed from 11.6 milligrams per kilogram (mg/kg), as presented in the New Horizons RI/FS, to 39 mg/kg after a re-evaluation of the background concentration of arsenic in the Colorado Front Range was conducted.

The action level for mercury was changed from 1.1 mg/kg to 23 mg/kg. The Record of Decision (ROD) for the CSMRI site indicates that the proposed standard for "mercury (compounds)" is 23 mg/kg and this value is interpreted as the sum of all available mercury compounds (i.e., elemental, metallic, inorganic [mercury salts] as total mercury and as detected by EPA method SW7471 [cold vapor atomic absorption]). The re-evaluation of metals as COPCs is discussed in Section 4.1.2.

The metals' nature and extent maps are presented twice: the first time with the action levels for arsenic and mercury as presented in the RI/FS by New Horizons and the second time with the revised action levels for arsenic and mercury.

4.1.1 Soil Metals Exceedances (Former Cleanup Goals)

A total of 163 surface soil sample locations (CSM series samples) were sampled and analyzed for metals. A total of 68 subsurface soil samples were collected from 28 boreholes (CB series samples) at depths ranging from 1 to 42 feet below ground surface (bgs). A total of 54 subsurface soil samples were collected from 34 test pits (CP series samples) at depths ranging from 0.25 feet to 11 feet bgs. All samples were submitted to Paragon Analytics, Inc. of Fort Collins, Colorado for analyses. Five metal compounds (arsenic, lead, mercury, molybdenum, and vanadium) were detected at concentrations above their respective soil action levels and were retained as COPCs. Table 4-1 presents a summary of surface and subsurface soil exceedances and identifies the locations of the maximum exceedance(s) and the deepest exceedance(s).

Table 4-1
Data Summary for Soil Metals Exceedances

Metal Compound	Action Level (mg/kg)	Number of Sample Exceedances	Maximum Detected Value in Soil (mg/kg)	Maximum Detected Value Location(s)	Deepest Exceedance (ft bgs)	Deepest Exceedance Location
Arsenic	11.60	134	330	CB13, CB27, CP21	3.5	CB4, CP14
Lead	400	55	14,000	CP21	6	CP27
Mercury	1.10	98	400	CP21	8	CP20
Molybdenum	390	5	980	CP25	1.5	CP22, CP24
Vanadium	550	1	1,000	CB6	1	CB6

mg/kg = milligrams per kilogram

Figure 5 presents the site-wide extent of metals in surface and subsurface soils above the tentative cleanup goals. The solid lines in the figure indicate lateral extent has been defined by

concentration of metals at the surface and subsurface soil data points below the tentative cleanup goals. Dashed lines indicate the lateral extent of the metals exceedances in soil have not been defined at the surface and in the subsurface. Review of Figure 5 indicates approximately 30 percent of the extent lines are defined and 70 percent of the extent lines remain undefined. The extent of surface soil and subsurface soil metal exceedances encompasses most of the area of the site where former buildings associated with CSMRI were located. The extent of surface soil and subsurface soil metal exceedances also extends into the area immediately east of the former settling pond.

4.1.2 Soil Metals Exceedances (Revised Cleanup Goals)

As discussed in Section 4.1, a re-evaluation of the action levels as identified in the RI/FS for arsenic and mercury was conducted. To accurately assess the potential impact on the nature and extent of the COPCs with the revised action levels, the data summary metals table was compiled with the new action levels. Table 4-2 presents the revised metals surface and subsurface soil sample exceedances and identifies the maximum exceedance and the locations of the deepest exceedance(s).

Table 4-2
Data Summary for Soil Metals Exceedances Using Revised Cleanup Goals

Metal Compound	Action Level (mg/kg)	Number of Sample Exceedances	Maximum Detected Value in Soil (mg/kg)	Maximum Detected Value Location(s)	Deepest Exceedance (ft bgs)	Deepest Exceedance Location
Arsenic	39	54	330	CSM97	3	CB13, CP13
Lead	400	55	14,000	CSM113	6	CP27
Mercury	23	9	400	CSM30	1.5	CP21
Molybdenum	390	5	980	CSM136	1.5	CP24, CP22
Vanadium	550	1	1,000	CB6	1	CB6

mg/kg = milligrams per kilogram

Figure 6 presents the site-wide revised extent of metals in surface and subsurface soils and defines the extent to the tentative cleanup goals. The solid lines in the figure indicate lateral extent has been defined by below the tentative concentration goal of metals at surface and subsurface soil data points. Dashed lines indicate the lateral extent of the metals exceedances in soil have not been defined at the surface and in the subsurface. Review of Figure 6 indicates approximately 40 percent of the extent lines are defined and 60 percent of the extent lines remain undefined.

The extent of surface soil and subsurface soil metal exceedances encompasses most of the area of the site where former buildings associated with CSMRI were located.

4.2 Alpha Activity Soil Radioisotopes

A total of 163 surface soil sample locations (CSM series samples) were collected and submitted for alpha spectroscopy. A total of 68 subsurface soil samples were collected from 28 boreholes (CB series samples) at depths ranging from 1 to 42 feet bgs. A total of 54 subsurface soil samples were collected from 34 test pits (CP series) at depths ranging from 0.25 feet to 11 feet

bgs. All samples were submitted to Paragon Analytics, Inc. of Fort Collins, Colorado for analysis. Five alpha-emitting radionuclide isotopes (Th-228, Th-230, Th-232, U-235, and U-238) were detected at activities exceeding their respective action levels and were retained as COPCs. A total of 10 soil borings and 10 test pit locations were identified having alpha activity exceedances for Ra-226 and Ra-228. Table 4-3 presents a summary of surface soil and subsurface soil exceedances and identifies the maximum exceedance and the locations of the deepest exceedance(s).

Table 4-3
Data Summary for Alpha Activity Soil Exceedances

Radioisotope Group Spectroscopy	Radio-isotope Compound	Activity Action Level (pCi/g)	Number of Sample Exceed-ances	Maximum Detected Value in Soil (pCi/g)	Deepest Exceedance (ft bgs)	Deepest Exceedance Location
Alpha	Th-228	6.57	6	109	1.5	CP24
Alpha	Th-230	11.53	38	270	16	CB28
Alpha	Th-232	3.98	19	7.9	11	CP4
Alpha	U-235	4.97	2	110	7	CB27
Alpha	U-238	21.80	12	110	7	CB27

pCi/g – picoCuries per gram

Figure 7 presents the surface soil and subsurface soil site-wide extent of alpha activity. The solid lines in the figures indicate lateral and vertical extent has been defined by radioisotope activity below the action level at surface soil and subsurface soil data points. Dashed lines indicate the lateral extent of the radioisotopes exceedances have not been defined. Review of Figure 7 indicates approximately 22 percent of the extent lines are defined and 78 percent of the extent lines remain undefined.

As presented in Figure 7, the extent of the surface and subsurface soil alpha activity exceedances are generally in the central area of the CSMRI site with several isolated "hot-spot" exceedances to the east and west of the center of the site. No alpha activity exceedances have been identified in surface and subsurface soils in the area of the former settling pond area located adjacent to and north of the CSMRI site. This area was investigated, remediated, and closed under an EPA action in February 1992.

4.3 Gamma Activity Soil Radioisotopes

A total of 163 surface soil sample locations (CSM series samples) were collected and submitted for gamma activity spectroscopy analyses. A total of 68 subsurface soil samples were collected from 28 boreholes (CB series samples) at depths ranging from 1 to 42 feet bgs. A total of 54 subsurface soil samples were collected from 34 test pits (CP series) at depths ranging from 0.25 feet to 11 feet bgs. All samples were submitted to Paragon Analytics, Inc. of Fort Collins, Colorado for analysis. Two gamma-emitting radionuclide isotopes (Ra-226 and Ra-228) were detected at activities exceeding their respective action levels and were retained as COPCs. A total of 11 soil borings and 15 test pit locations were identified having gamma activity exceedances for Ra-226 and Ra-228. Table 4-4 presents a summary of surface and subsurface

soil exceedances and identifies the maximum exceedance(s) and the locations of the deepest exceedance(s).

Table 4-4
Data Summary for Gamma Activity Soil Exceedances

Radioisotope Group Spectroscopy	Radioisotope Compound	Activity Action Level (pCi/g)	Number of Sample Exceedances	Maximum Detected Value in Soil (pCi/g)	Deepest Exceedance (ft bgs)	Deepest Exceedance Location
Gamma	Ra-226	4.04	112	610	3.5	CB4, CP14
Gamma	Ra-228	4.60	8	9.4	2	CB5

pCi/g – picoCuries per gram

Figure 8 presents the surface soil and subsurface soil site-wide extent of gamma activity. The solid lines in the figure indicate lateral and vertical extent has been defined by radioisotope activity below the action level at surface soil and subsurface soil data points. Dashed lines indicate the lateral extent of the radioisotopes exceedances has not been defined. Review of Figure 8 indicates approximately 40 percent of the extent lines are defined and 60 percent of the extent lines remain undefined.

As presented in Figure 8, the extent of the surface and subsurface soil gamma activity exceedances encompasses a larger area of the center of the site when compared to the extent of the alpha exceedances. Several smaller, isolated "hot-spot" gamma activity exceedances have been identified to the east and west of the center of the site and also an undefined island of exceedance immediately east of the former settling pond.

4.4 TCLP Lead Data

During the excavation remediation process, a series of 24 pits were constructed and excavated soil was placed adjacent to the pits. Soil samples (BFI series data) were collected and tested for the presence of lead through TCLP analyses. The results of the TCLP testing indicate all samples were below the regulatory limit of 5.0 milligrams per liter (mg/l) lead in leachate to be considered hazardous. The highest detectable concentration of leachable lead is 1.3 mg/l with six samples indicating concentrations of leachable lead at or below the detection limit.

5.0 Conclusions

Results of laboratory analyses of 163 surface soil samples, 28 boreholes, and 34 test pits for subsurface soil samples have been evaluated to identify COPCs. Soil samples were submitted for metals, alpha activity radioisotope, and gamma activity radioisotope identification. The data evaluation report has identified four metals (arsenic, lead, mercury, and molybdenum) as surface soil COPCs and five metals (arsenic, lead, mercury, molybdenum, and vanadium) as subsurface soil COPCs. A re-evaluation of the action levels of arsenic and mercury was conducted after the background level for arsenic was adjusted and the mercury action level was applied correctly to the analytical results. Alpha activity radioisotope analyses identified Th-228, Th-230, Th-232, U-235, and U-238 as exceeding activity action levels in surface and subsurface soils. Gamma activity radioisotope analyses identified Ra-226 and Ra-228 as exceeding activity action levels in surface and subsurface soils.

Data were compiled to summarize the nature of the exceedances, and plan-view maps were generated to determine the extent of the exceedances.

The extent on the plan view nature and extent figures for each compound group exceedance that has been defined range from 20 percent to 40 percent. Dashed lines on the nature and extent maps indicate the extent remains undefined. As such, the extent of the select COPCs that remain undefined should be closed to determine the extent and volume of soil above the cleanup goal. Additional surface and subsurface soil sampling and laboratory analyses in the area outside of the dashed lines will aid in determining the nature and extent of the COPCs exceedances. Soil volume estimates for the amount of soil that will be removed, as part of the remediation effort can then be better defined.

6.0 References

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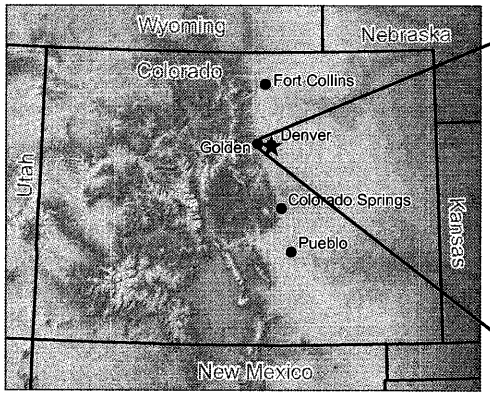

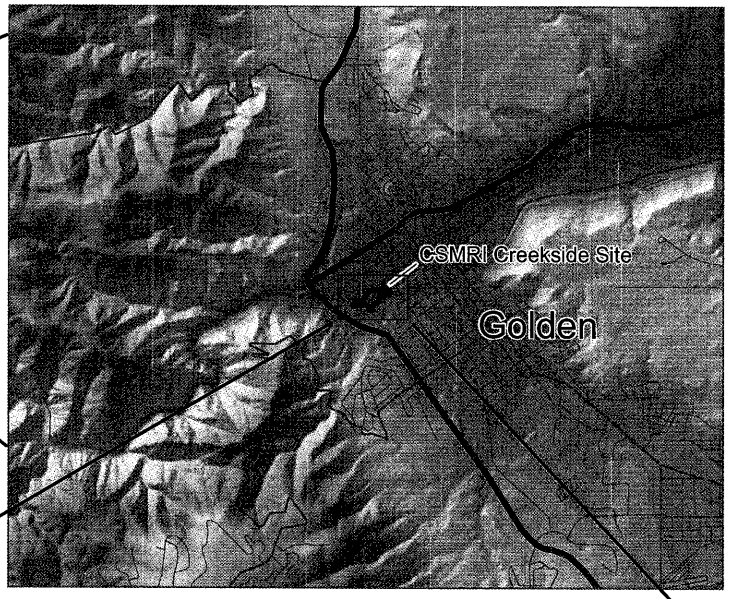

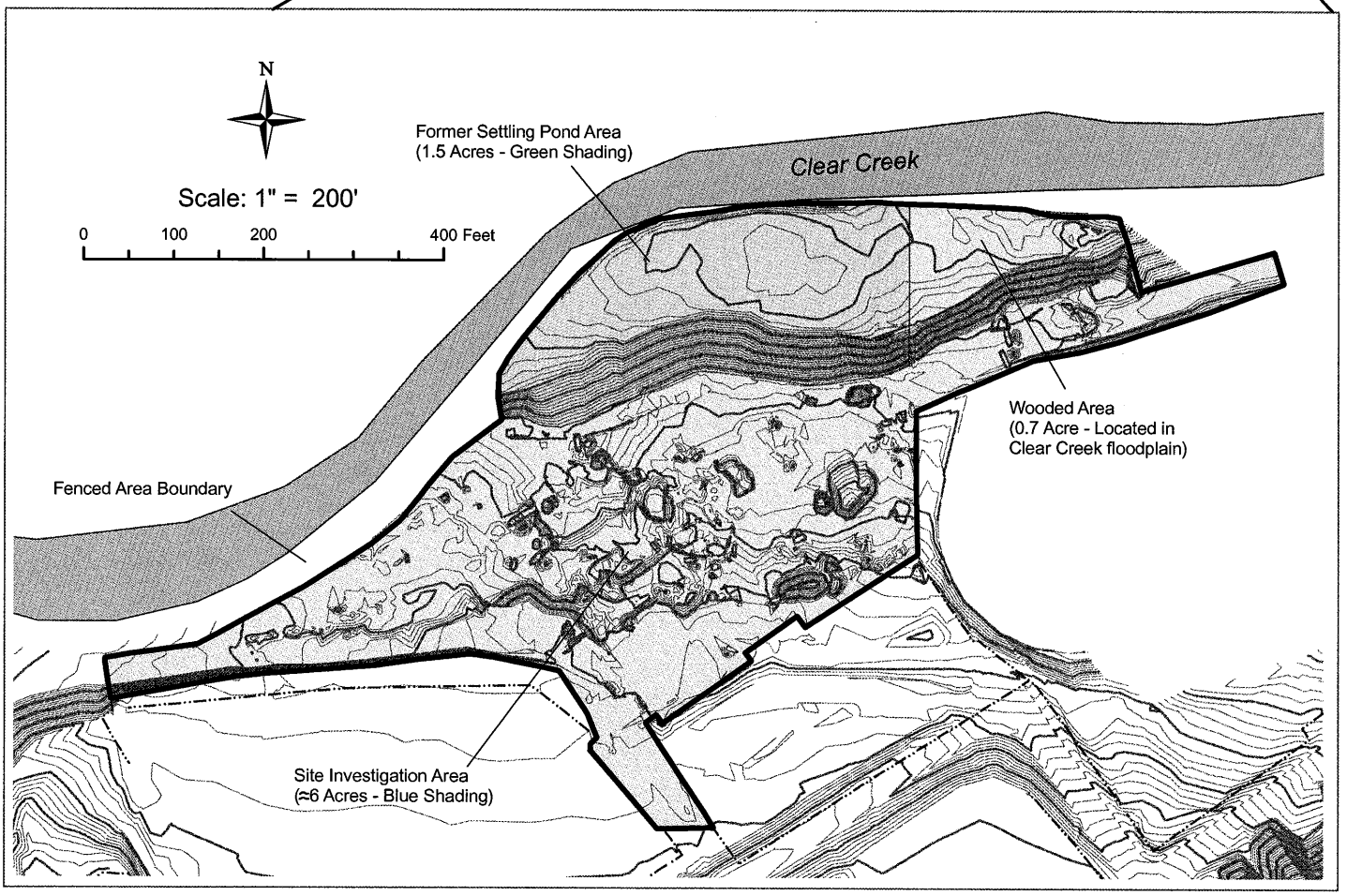

Figure 1

CSMRI
Site Location Map

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)

CSMRI
Data Evaluation Report

Stoller

J:\projects\CSMRI\de_basemap.mxd

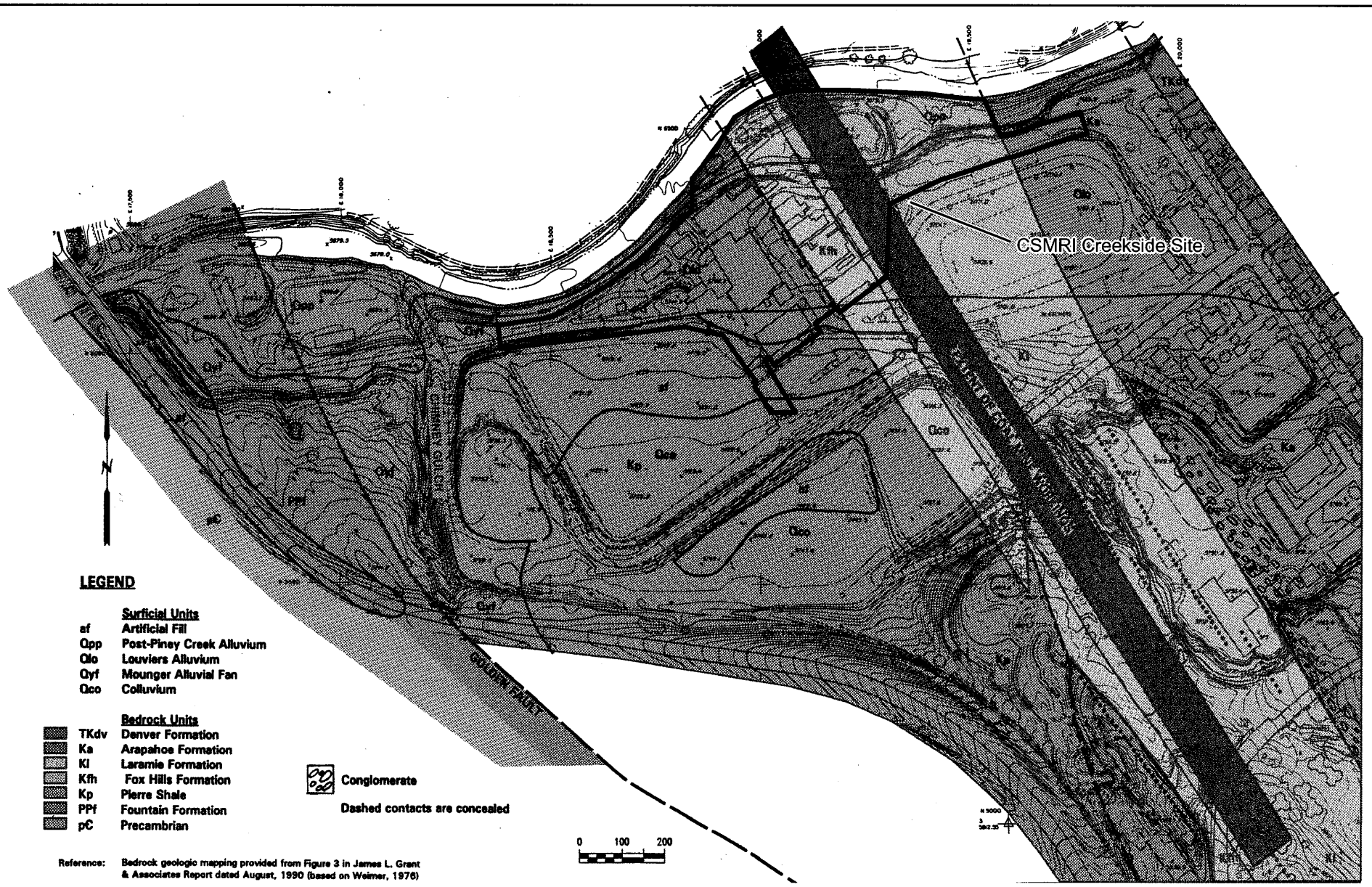

Figure 2

CSMRI
Bedrock Geologic Map

CSMRI
Data Evaluation Report

Stoller

J:\projects\CSMRI\de_bedrock_geology.mxd

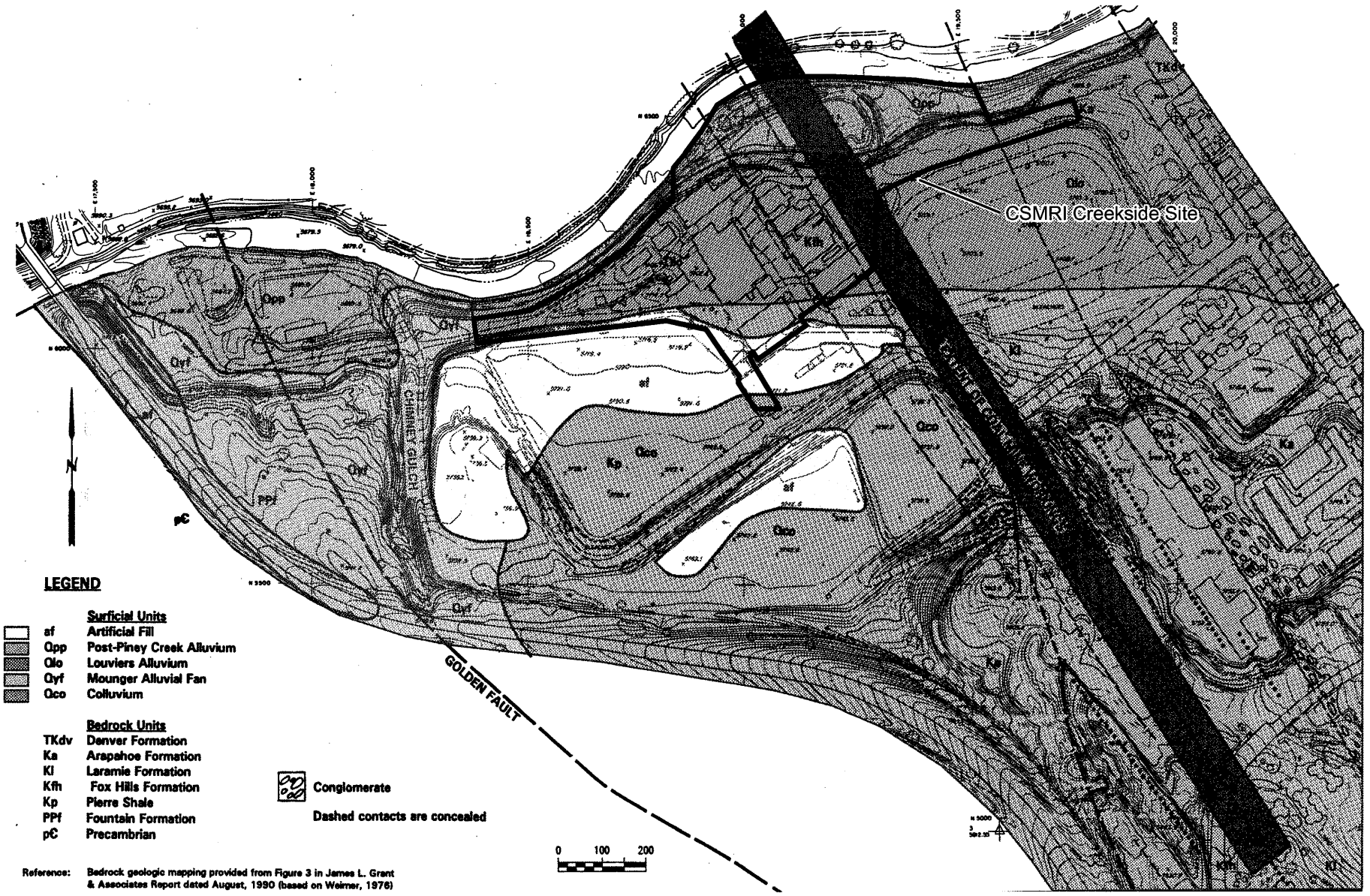

Figure 3

CSMRI
Surface Geologic Map

CSMRI
Data Evaluation Report

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J:\projects\CSMRI\de_surficial_geology.mxd

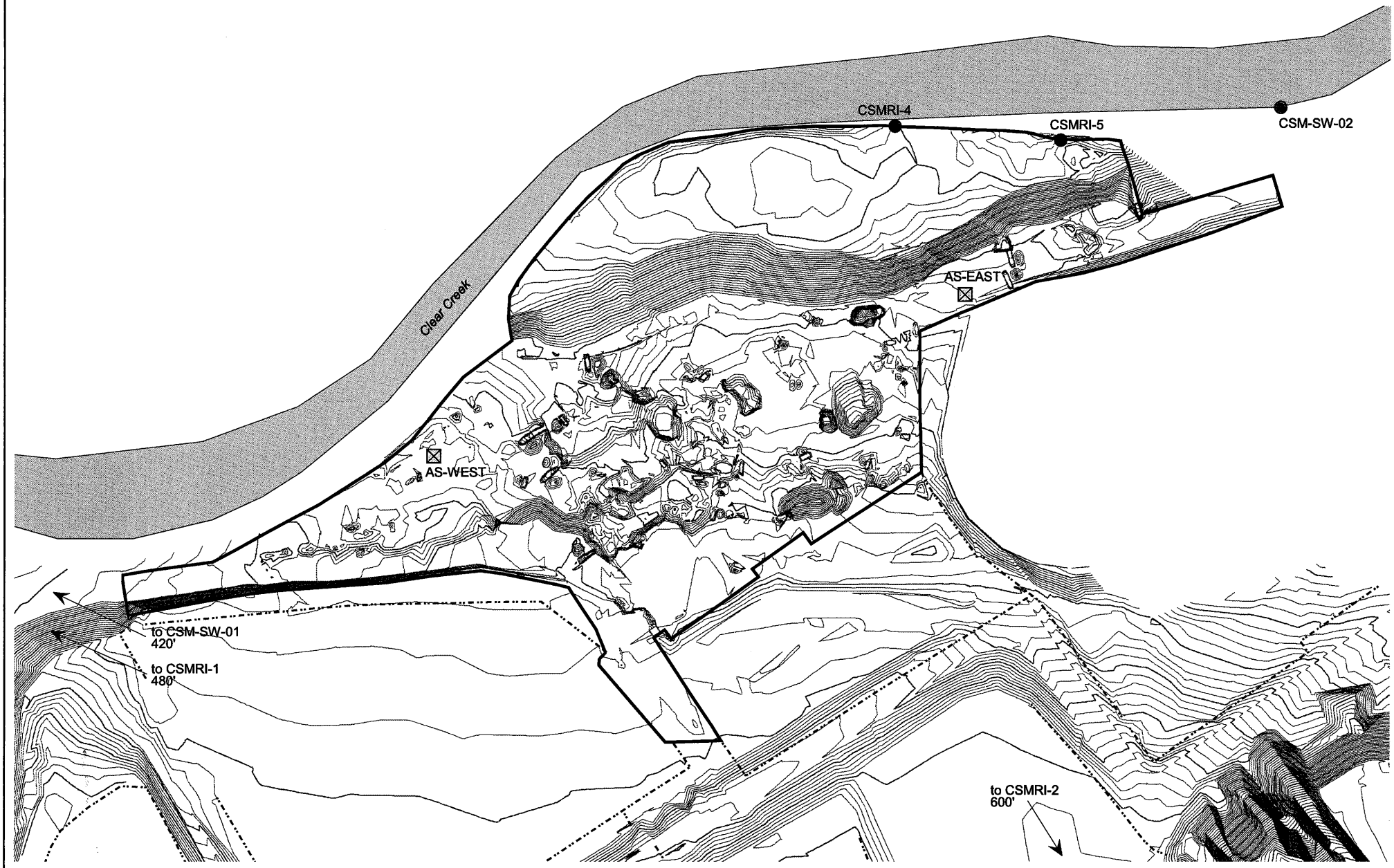

Figure 4

Site Monitoring Sample Locations

Explanation

- Wells
- Air Sample Locations
- Surface Water Sample Locations
- 1 Foot Contours
- 5 Foot Index Contour
- Property Boundary
- Fences
- Clear Creek

N

Scale: 1" = 150'

0 50 100 150 200 Feet

CSMRI
Data Evaluation Report

Stoller

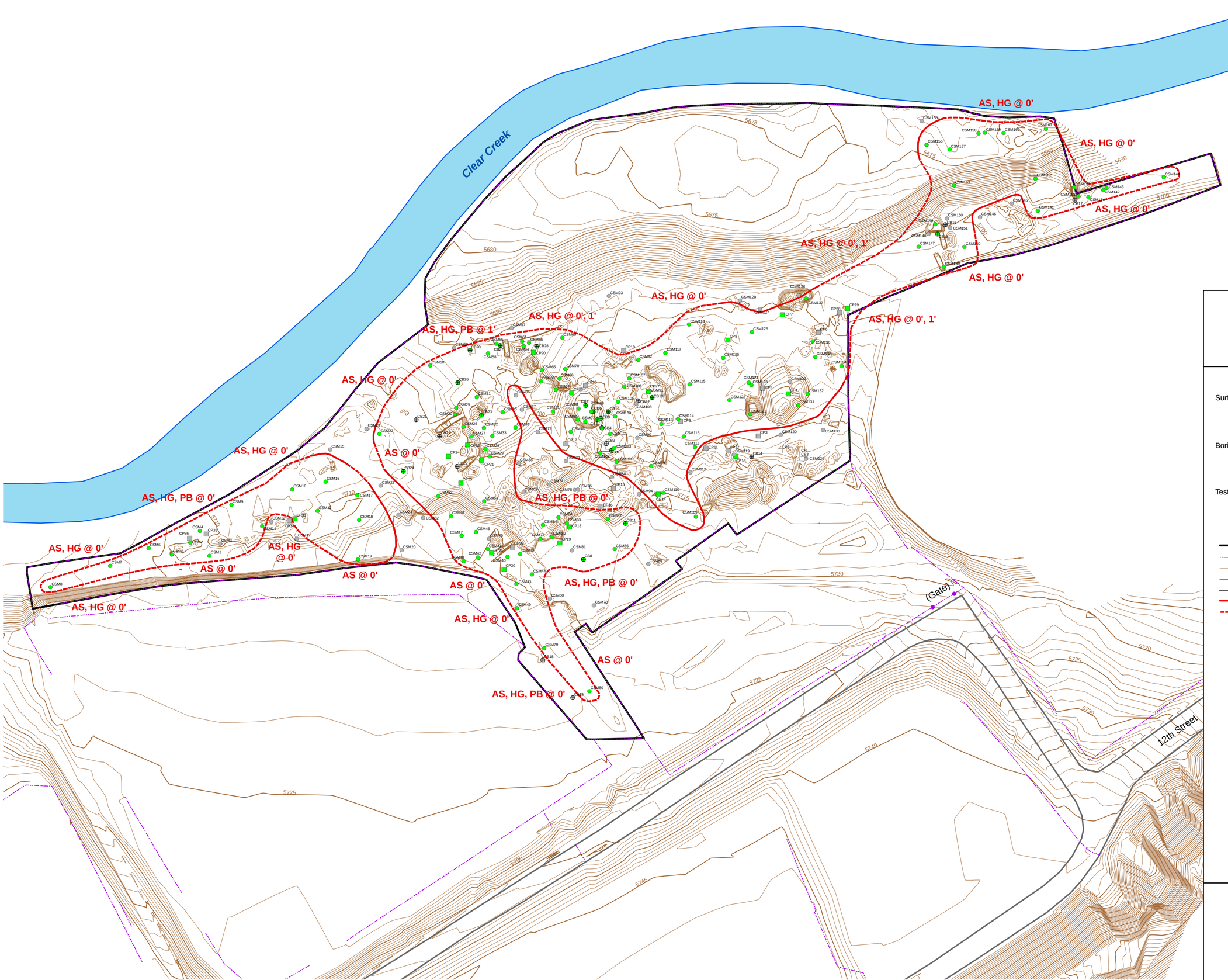

Figure 5

Metals Extent
Surface and Subsurface Soil

Explanation

Surface Samples
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Borings
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Test Pits
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Known Extent
- Inferred Extent

N
W E
S

Scale: 1" = 75'

Feet
0 50 100 200

CSMRI
Data Evaluation Report

Stoller

J:\projects\CSMRI2\mfs_nhlocs.mxd

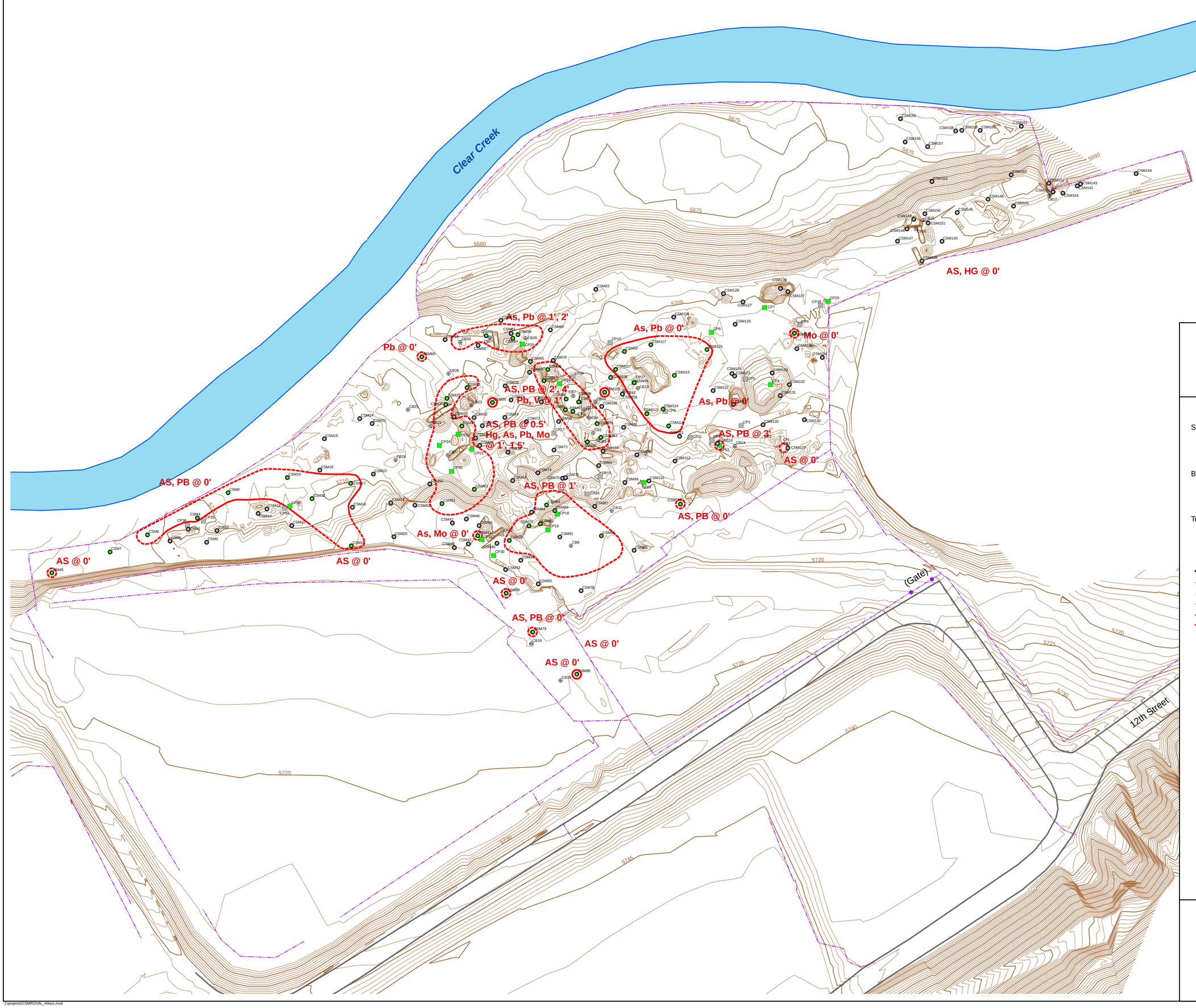

Figure 6

Metals Extent With Revised Action Levels
Surface and Subsurface Soil

Explanation

Surface Samples
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Borings
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Test Pits
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Known Extent
- Inferred Extent

N W E S

Scale: 1" = 75'

Feet
0 50 100 200

CSMRI
Data Evaluation Report

Stoller

J:\projects\CSMRI2\mfs_mHocs.mxd

Figure 7

Alpha Extent
Surface and Subsurface Soil

Clear Creek

U, TH @ 1'
U @ 7'
TH @ 16'

TH @ 16'

TH @ 0'

U, TH @ 2'

TH @ 0', 3'

TH @ 4'

TH @ 0'

TH @ 0', 11'

TH @ 0.5', 1.5'
U @ 0.5'

U @ 1'

TH @ 1'

TH @ 0.5'

TH @ 0', 1', 3'

TH @ 0'

U, TH @ 1'

TH @ 0

U, TH @ 1'

(Gate)

12th Street

Explanation

Surface Samples
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Borings
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Test Pits
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Known Extent
- Inferred Extent

N
W E
S

Scale: 1" = 75'

Feet
0 50 100 200

CSMRI
Data Evaluation Report

Stoller

J:\projects\CSMRI2\vfs_nhalpha.mxd

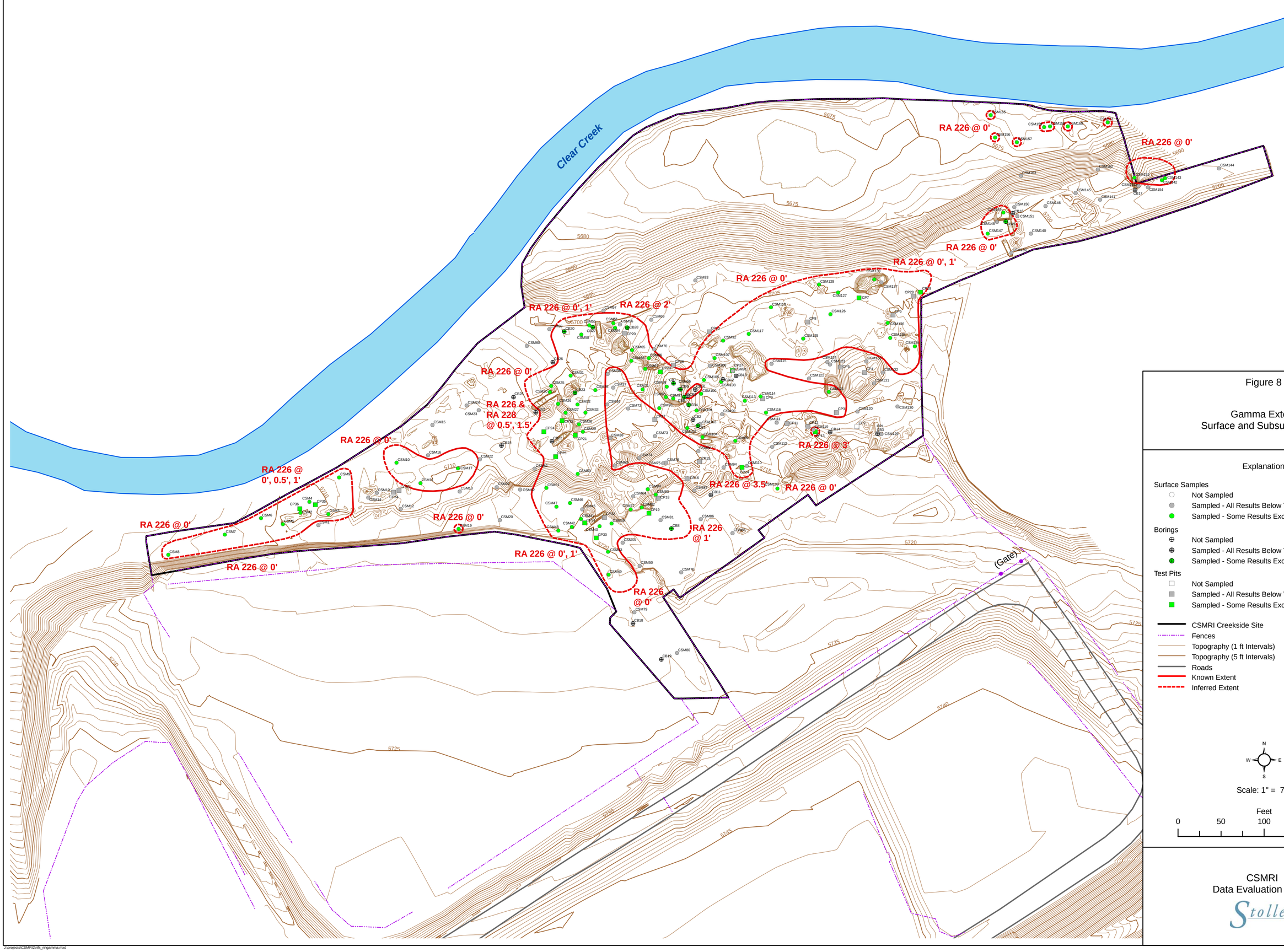

Figure 8

Gamma Extent
Surface and Subsurface Soil

Explanation

Surface Samples
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Borings
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Test Pits
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Known Extent
- Inferred Extent

N
W E
S

Scale: 1" = 75'

Feet
0 50 100 200

CSMRI
Data Evaluation Report

Stoller

J:\projects\CSMRI2\sfs_nhgamma.mxd