TWELVEMILE CANYON WATER QUALITY STUDY

5 MARCH 2009

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TWELVEMILE WATER QUALITY STUDY

1.0 Introduction

Water Quality of Twelvemile Creek is presently degraded due to the extremely high concentration of suspended sediment. This project focused on collecting data that will aid in creating, defining, and evaluating the most feasible alternatives which focus on reducing the suspended sediment concentration in Twelvemile Creek waters. It is anticipated that, following the evaluation of the formulated alternatives, one or more alternatives will be selected, designed and constructed.

1.1 Local Area

Twelvemile Canyon is located in southern Sanpete County, Utah, directly east of the town of Mayfield (See Figure 1). Twelvemile Creek is a collection of waters originating in Twelvemile Canyon. Water from Twelvemile Creek is used for irrigation and secondary water uses in the communities of Mayfield, Gunnison, Centerfield, Axtell, and neighboring areas. Twelvemile Creek is a tributary to the San Pitch River, which then confluences with the Sevier River, the primary source of water for Yuba Reservoir. Yuba Reservoir is the primary storage facility for the populated areas of Millard County including Delta.

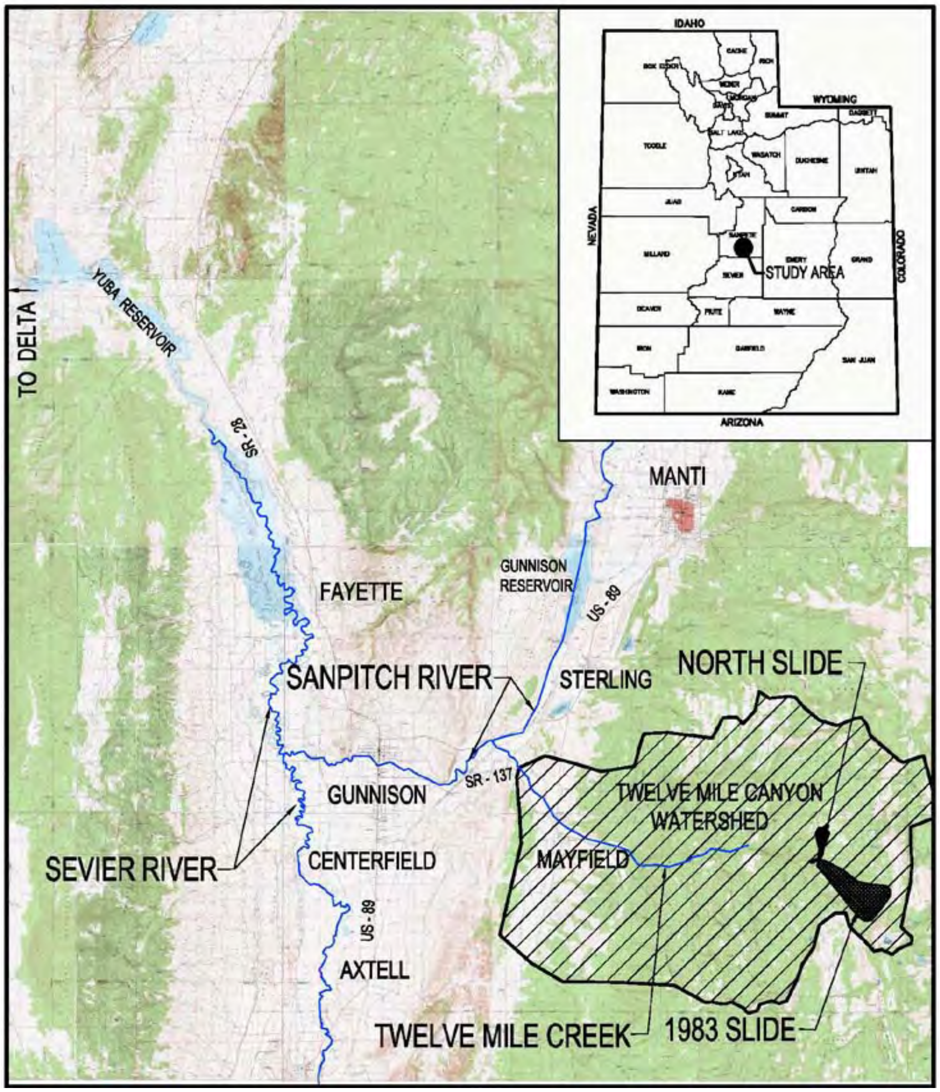

Figure 1. Study Location

1.2 Background

As the communities of Mayfield and Gunnison were settled in the mid 1800's, settlers began to divert water from Twelvemile Creek for agricultural use. Many miles of irrigation canals and ditches were constructed along foothills to water the fertile ground in the valleys below. Portions of these canals and ditches are still in use today. From the time that water was first diverted for agricultural use until 1983 the water quality of Twelvemile Creek was adequate (for secondary water use) with very little suspended sediment. This is evidenced by sediment data collected from 1975 to 1980 (Kelly, 1983) and also by the relatively small amount of sediment that had to be cleaned from the ditches and canals prior to 1983, according to locals. In addition to the use of water for irrigation, prior to 1983, Twelvemile Creek supported habitat essential for a cold water fishery. This is according to locals in the area that witnessed the changes in the Creek from pre-1983 to post-1983.

The highest precipitation totals recorded for the Twelvemile Canyon area occurred in the water years covering 1982 to 1984. This precipitation saturated the canyon soils and caused several major landslides to occur. The largest of these landslides occurred in South Fork.. (see Appendix A – Exhibits A2 and A3).

The precipitation, in addition to triggering the landslides, also caused major flooding and excessive erosion along Twelvemile Creek. This flooding destroyed bridges, roads, irrigation structures, and city and town utilities. In addition to damaging infrastructure the natural stream environment was also drastically affected by scouring the creek's channel of riparian vegetation that supported the previous fishery. The flood waters also carried massive amount of sediment that rapidly filled the water user's sediment removal devices and greatly inhibited the use of the water for irrigation use. In 1986, Danny Boore wrote a thesis on "The Impact of Twelve-Mile Canyon Mudslides on the Downstream Water Users in Sanpete County, Utah" (Boore, 1986.) This report includes information related to the 1983 slides within Twelvemile Canyon and the losses incurred by the local irrigation companies

The years following 1983 resulted in the activated slides stabilizing with very minimal slide activity within the canyon (likely due to less precipitation), but in 1998 an area in the Cooley Creek drainage, which is within the general South Fork drainage, became active (see Appendix A – Figures A3 and A4). This slide dammed off Cooley Creek's historic path to South Fork Creek and cut a new drainage path to the west. The landslide material moved down through the newly cut channel and filled in the South Fork Channel which added sediment atop the sediment deposited from the 1983 landslide (see Appendix A – Figure A4).

From 1998 to the present the Cooley Creek slide area has continued to show activity on a regular basis despite mitigation measures. In 1999, a year after the Cooley Creek Slide first moved, the Forest Service reseeded the area and by 2003 the grasses were well established atop the slide material. In 2004 the Cooley Creek Slide moved again and eliminated all but a few acres of the seeded areas. Most recently, in 2006, the Cooley Creek Slide moved again and added more material to the bottom of the canyon, extending the mud and debris flow approximately one mile downstream. Comparison of recent mapping of the area with the USGS quarter quad maps indicate there is roughly 60 to 80 feet of debris in the bottom of the canyon immediately west of the knoll at the bottom of the Cooley Creek drainage. This debris will be eroded away over time as the stream channel meanders back and forth in the channel and high flows cut deeper into the slide deposits. Based on the average width, depth, and length of the debris flow there is approximately 3,000,000 cubic yards (1,860 acre-ft) of debris in the South Fork stream channel alone.

1.3 Problem Statement

The State of Utah has designated Twelvemile Creek for Class 2B, Class 3A, and Class 4 beneficial uses. Class 2B is listed as being protected for secondary contact recreation such as boating, wading, or similar uses. Class 3A is listed as being protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain. Class 4 is listed as being protected for agricultural uses including irrigation of crops and stock watering. The purpose of these designations is to protect against controllable pollution impacting the beneficial uses for each class. The Class 3A and 4 beneficial uses are continuing to be suppressed due to the high concentration of suspended sediment in the creek.

Sediment is an extremely serious issue within the watershed. The high concentrations found in Twelvemile Creek negatively impacts cold water species and habitat. The sediment reduces water efficiency, fills ponds, plugs pipes and sprinklers, coats crops, ruins equipment, and costs thousands of dollars per year to dredge ponds and maintain piping systems. Annual costs and losses are estimated to be between $500,000 to $800,000 when combining figures from the Gunnison and Mayfield Irrigation Companies. Total damages have been conservatively estimated at over $10 million since the flood years of 1983-1984. These impacts are not just affecting farmers but the local communities and individual residents who also hold shares in the irrigation company and use irrigation water.

1.4 Impacted Entities

The Gunnison and Mayfield Irrigation Companies have been responsible for delivery of irrigation water to farmers, ranchers, and other stock holders in the central Utah region for several decades. Runoff and snow melt that comes from Twelvemile Creek and its tributaries is the sole source of water for the Mayfield Irrigation Company and one of the primary sources of water for the Gunnison Irrigation Company (The Gunnison Irrigation Company also has a right to some of the water from watershed north of Twelvemile Canyon). . The areas served by the Companies include Mayfield, Gunnison, Centerfield, Axtell, and surrounding unincorporated areas. These companies currently irrigate approximately 16,000 acres.

The impacts of the sediment laden water are not just felt by the local areas but all citizens within the lower San Pitch River and the Sevier River Watershed. This is because the Twelvemile Canyon Watershed is critical to the San Pitch River, Sevier River, and all entities downstream of Yuba Reservoir.

In addition to direct impacts (discussed in Section 1.3 above) there are also economic impacts that are directly felt by the water users and indirectly felt regionally and statewide.

2.0 Purpose and Need

The goal of this project is to reduce the concentration of suspended sediment in Twelvemile Creek so that the water can be beneficially used as intended. In order to accomplish this goal the project has been divided into three phases. This report is Phase I of the three phase plan, which includes:

- **Phase I**: Mapping and Data Gathering (includes this report). Geotechnical, hydrogeological, economic, aerial mapping, topographical, water quality and other existing data will be obtained.

Other phases are as follows:

- **Phase II**: Data Evaluation and Alternatives Analysis (not included in this report). After the existing data is gathered, it will be evaluated and alternatives intended to address the problem will be generated.

- **Phase III**: Final Design and Construction (not included in this report). The preferred alternative(s) will be implemented. Additional monies will be sought for this phase.

3.0 Project Partners and Funding

Many agencies and people have been critical in moving this project forward. A table showing the project partners along with their associated role can be found in Table 1.

The Utah Division of Water Quality recognized the water quality concerns of Twelvemile Creek and its users and granted $150,000 to completely fund Phase I. An estimated $300,000 is needed to fund Phase II. The 2008 Utah State Legislature appropriated $150,000 to partially fund Phase II while the Community Impact Board appropriated the remaining $150,000 required to complete Phase II. Funding for Phase III (Design and Construction) is yet to be determined but will include requests to USFS, Utah Department of Agriculture and Food, NRCS, CIB, Sanpete Water Conservancy District, Utah Division of Water Quality, and others.

Table 1. Project Partners.

PROJECT PARTNERS and TEAM MEMBERS		
ORGANIZATION	**CONTACT**	**ROLE SUMMARY**
Gunnison Irrigation Company	Allen Dyreng	Company President, Approvals
	Danny Boore	Management, Water sampling
	Ray Christensen	Approvals
	Russell Yardley	Approvals, Water sampling
Mayfield Irrigation Company	Bill Kay Christiansen	Company President, Approvals
	Bruce Fuller	Approvals
	Doug Willden	Management, Water sampling
Mayfield Town	John Christensen	Support
Gunnison City	Scott Hermansen	Support
Centerfield City	Darwin Jensen	Support
Utah Division Of Water Quality	Walt Baker	DWQ Approvals, Coordination
	Scott Daly	Technical reviews, Coordination with agencies
	Carl Adams	Technical reviews
Utah Division of Water Rights	Chuck Williamson	Technical reviews, Stream Alteration permits
Utah Division of Water Resources	Dan Aubrey	Technical reviews
	Ed Fall	Technical reviews
	Joel Williams	Technical reviews
	Eric Bagley	Technical reviews
Utah Water Quality Board	Jay Olsen	Public Relations, Funding
USDA Forest Service	Pam Brown	Environmental, Construction Approvals
	Marlene Depietro	Environmental, Construction Approvals
	Rod Player	Environmental Review
	Katherine Foster	Environmental Review
	Leland Matheson	Environmental Review
	Justin Humble	Technical Review and Assistance
	Karlton Moss	Technical Review
Utah Division of Natural Resources	Mike Styler	Funding, Technical Reviews, Approvals
Utah Department of Agriculture and Food	Leonard Blackham	Funding, Coordination between agencies
USDA Natural Resources Conservation Service	Brian Miller	Technical reviews and services
	Sylvia Gillen	Technical reviews and services
San Pitch Watershed Stewardship Group	Tom Shore	Local Watershed Coordination
Sanpete Water Conservancy District	David Cox	Sponsor Funding Requests, Coordination
	Ed Sunderland	Sponsor Funding Requests, Coordination
Sanpete Conservation District (soil)	Scott Sunderland	Local Support, Reviews
U.S. Senator Bob Bennet	Donna Sackett	Support
U.S. Senator Orrin Hatch	Ron Dean	Support
Utah House of Representatives	Kay McIff	Legislative Support, Funding
Utah State Senate	Darin Peterson	Legislative Support, Funding
	Ralph Okerlund	Legislative Support, Funding
Sanpete County	Claudia Jarrett	Commission Chair, Public Relations, WCD rep
Jones & DeMille Engineering	Tim Jones	Principal in Charge, Management
	Brian Barton	Project Management, Technical, Geotech
	Garrick Willden	Project Engineer, Technical, Water Quality
Kleinfelder	Greg Schlenker	Geology, Geotechnical
	John Diamond	Hydrogeology, Groundwater Resources
John Keith	John Keith	Macro-, Micro-Economics analysis

4.0 Data Collection Efforts and Results

Unfortunately, very little data exists for the Twelve Mile Canyon area, prior to this study. The following is a brief synopsis of these data collection efforts and the results obtained.

4.1 Twelvemile Geology

Kleinfelder, a nationwide geotechnical engineering firm researched and reported on the geology of Twelvemile Canyon with emphasis on the slide related activities. The following are excerpts from their report:

4.1.1 *Affected Environment*

The Mayfield Water Company diverts water for their system at the mouth of Twelvemile Canyon, and the Gunnison Water Company diverts water approximately 4.5 miles downstream of the Mayfield diversion. The Twelvemile Creek drainage area is located on the western side of the Wasatch Plateau near the town of Mayfield. In the vicinity of the Twelvemile drainage, the Wasatch Plateau has surface elevations ranging from 5,400 feet to over 10,000 feet (Witkind et al., 2007), with slopes ranging from level to over 90 percent. Above the Mayfield diversion, the drainage encompasses 37,908 acres. This area is divided into four tributary sub-drainages; Clear Creek, Birch Creek, Headwaters, and South Fork. A tabulation of these subdrainages areas is included in Table 1 (see Geotechnical Report in Appendix B), and the locations of the sub-drainage areas are shown on Figure 1 (see Geotechnical Report in Appendix B).

4.1.2 *Methods of Study*

The engineering geology of the Twelvemile Canyon vicinity was interpreted through an integrated compilation of data, observations, and analyses, including a review of literature and mapping from previous studies conducted in the area (Robinson, G.B., 1971; Harty, 1993; Witkind, et al., 1987), a photogeologic analyses of 2006 imagery, GIS analyses of elevation and terrain data, and a field reconnaissance of the site. The engineering geology conditions interpreted from our reviews and analyses were verified during the field reconnaissance. Subsurface explorations were not within the scope of this study.

4.1.3 Geologic Conditions

Geologic Setting

Twelvemile Canyon is located on the Wasatch Plateau, which is considered to be the transition zone between the Colorado Plateau Province and the Basin and Range Physiographic Provinces (Hunt, 1967, Stokes 1987). In the vicinity of Twelvemile Canyon, the plateau is an uplifted monoclinal structure which plunges steeply westward beneath Arapein Valley on its western margin near the town of Mayfield. Near the crest of the plateau, the geological structure is near-horizontal.

Geologic formations exposed in Twelvemile Canyon include the Upper Cretaceous Blackhawk Formation, the Castle Gate Sandstone, and the Price River Formation. Overlying the Upper Cretaceous formations are the Tertiary North Horn Formation and the Flagstaff Limestone. Twelvemile Creek and its tributaries have incised drainages into the plateau exposing these formations and also oversteepening slopes resulting in slope failures in many areas of the Twelvemile drainage.

Twelvemile Drainage Engineering Geology

The engineering geology of the drainage is shown on Figure 3 (see Geotechnical Report in Appendix B). The pre-Quaternary (pre 1.6 million years age) surfacial geology consists of sandstone (SS) of the Blackhawk Formation, and the Castle Gate Sandstone that are overlain by conglomerate and sandstone (CG/SS) of the Price River Formation. The North Horn Formation (MS/CS/SS) consists of alternating beds of mudstone, claystone, and sandstone, and the Flagstaff Limestone (LS) overlies the North Horn Formation.

The Quaternary deposits include landslide deposits that cover much of the Twelvemile drainage area. The landslide deposits are classified as either earthflow deposits (S(f)cb) that display primarily flow type of movement, or as complex deposits (S(c)c-b) that display a combination of movement modes (Varnes, 1978). A small area of glacial till (G(t)c-b) has been deposited by Pleistocene glaciation near the crest of the plateau on the southwest side of the drainage. Alluvial stream deposits (A(s)m-b) occupy the stream channel along Twelvemile Creek.

Seismicity and Faulting

North to south trending normal faults shown on Figure 3 (see Geotechnical Report in Appendix B) appear to have displaced the pre-Quaternary rocks in the drainage, but do not appear to have displaced Quaternary deposits. The nearest active faulting is traces associated with the Snow Lake graben, and are shown on Figure 3 as located only 1,300 feet west of the Twelvemile drainage (Black et al., 2003; USGS, and UGS, 2008).

The drainage is located within the Intermountain Seismic Belt, a seismically active region that extends from Arizona to Montana (Arabasz and Smith, 1981). Active faults in the region are potential sources for seismic loading hazards for the alignment. Active earthquake faults are considered faults that have moved during the past 15,000 years.

On the basis of both probabilistic (Frankel, et al., 1997, 2002) and deterministic (Halling, et al., 2002) ground shaking hazard analyses, the Snow Lake graben faults appear to be the greatest contributor to the seismic hazard in the drainage area. The Snow Lake graben faults should be considered active and capable of generating earthquakes as large as magnitude 6.78 (Halling, et al., 2002). Surface faulting commonly occurs in conjunction with events of magnitude 6 or larger.

Based on probabilistic estimates (Frankel, et al., 1997, 2002), the expected peak horizontal ground acceleration on rock from a large earthquake with a 10 percent probability of exceedance in 50 years is as high as 0.15*g,* and for a 2 percent probability of exceedance in 50 years is as high as 0.33*g* for the drainage area. Ground accelerations greater than these are possible but will have a lower probability of occurrence. Deterministic estimates by Halling et al. (2002) indicate the deterministic maximum peak bedrock horizontal acceleration for the drainage area would be between 0.50 and over 0.60*g.*

Landsliding and Sediment Loading Mechanisms

Approximately 11,170 acres of the Twelvemile Creek drainage is covered with landslide deposits (S(f)c-b and S(c)c-b). This comprises roughly 30-percent of the entire drainage. The area covered by landslide deposits, broken down by sub-drainage, is shown on Table 3 (see Geotechnical Report in Appendix B).

The historic landslides, landslides that have moved since 1983, are shown on Figure 4 (see Geotechnical Report in Appendix B). These landslides include the Cooley Creek landslide (72 acres), the South Fork landslide (430 acres), and the currently active portion of the South Fork landslide (32 acres), and comprise a total of 534 acres. The historic landslide area comprises only 1.5-percent of the Twelvemile drainage; however, the historic landslide areas appear to be the primary source for the excessive sediment in the Twelvemile drainage that is damaging the irrigation systems. The Cooley Creek landslide and the currently active portion of the South Fork landslide are interpreted to be active based on the observed lack of re-vegetation and the deformation of soils on the surface. These two slide areas probably undergo movement during the Spring of each year. Based on observed revegetation, the South Fork landslide appears to be presently inactive.

The active landslides should be expected to undergo future movement particularly when moist climate conditions prevail as experienced during the years of 1983 and 1998 (Fleming and Schuster, 1985; Ashland, 2003). Although mapped landslides in the

Twelvemile drainage may not be experiencing movement, these areas should be recognized as having soil and rock strengths that were weakened during the past activity, and may become susceptible to renewed activity in response to changes in climatic conditions and/or slope modifications. Also, near-by seismic ground motion from a future earthquake may trigger movement on both active and inactive landslides. In the Twelvemile drainage, both the active and the inactive landslide deposits appear to be associated with soils developed over the North Horn Formation (MS/CS/SS). The North Horn Formation is relatively weak and has been observed to be susceptible to failure (Duncan et al., 1986; Ashland, 1997).

During our June 25, 2008, reconnaissance, we observed significant sediment in Twelvemile Creek near the Mayfield diversion as documented on Figure 2-A. At the historical landslide areas we observed that mapped courses of South Fork, Twelvemile Creek, Cooley Creek, and tributaries to these two streams had changed significantly since the movement occurred based on pre-1983 USGS mapping. We observed that streams that cross the historical landslide areas were undergoing incisive erosion and down-cutting their channel beds resulting in oversteepened cut banks that were locally failing into the streams as shown on Figures 2-C and 2-E. (see Geotechnical Report in Appendix B). These smaller local failures along the streams appear to be the primary mode of sediment loading into the streams. Based on our mapping, we estimate that approximately 9.8 miles of streams cross the historical landslide areas. As future movement continues on the active landslides, including the Cooley Creek landslide and the currently active portion of the South Fork landslide, we would anticipate the sediment loading into the streams to continue.

See Appendix B for full Geotechnical Report prepared by Kleinfelder

4.2 Flow Rates

Water flow is very important in determining the amount of suspended sediment being transported in the creek. Water flow combined with the concentration of suspended sediment is required to determine the loading or amount of sediment passing a point over a set period of time.

4.2.1 Historic Data

Flow data is available from 1960 to the present. The USGS recorded flow data from 1960 to 1980 at a location just upstream from the mouth of the Canyon. From 1980 to the present, the Gunnison Irrigation Company recorded flow at the Mayfield Diversion at the mouth of the Canyon. The major discrepancy in comparing the USGS data and data from the Gunnison Irrigation Company is that the USGS data recorded flow as a daily meancalculated from a number of streamflow measurements, while the data from the Mayfield Diversion was recorded manually by an operator reading a staff gage once a day. Diurnal variation in the flow of the creek occurs due to increased amounts snowmelt during the day and decreased snowmelt at night. Therefore, Twelvemile Creek's peak flows are usually reached anywhere from 10pm to midnight (this would obviously change during wet weather conditions such as rain and snow events). With the peak flows often occurring at such late hour it is unlikely that the data recorded by an operator would take into account the peak flow. An exhibit showing the flows recorded from 1960 to 1980 by the United States Geological Survey (USGS), flow during 1984 (Boore, 1986), and flows recorded for this study are shown in Appendix C.

In order to determine which drainage areas were contributing most to the sediment loading within the creek a sampling plan was developed (see Appendix D – for Sampling Plan). This sampling plan required the flow of all major streams which confluence Twelvemile Creek to be measured. In addition, flows were also measured prior to and following existing suspended sediment mitigation strategies to determine their operating efficiency. Details and results of this sampling plan will be discussed in Section 4.3 Water Quality.

4.3 Water Quality

There is little recorded historical water quality data for Twelvemile Creek. From 1975 to 1980, Dennis Kelly with the US Forest Service collected suspended sediment samples from Twelvemile Creek on a nearly monthly basis (Kelly, 1983). From March of 1984 to September of 1984, Danny Boore collected 21 suspended sediment samples from Twelvemile Creek (Boore, 1986).

As previously mentioned, in order to determine which drainage areas were contributing the most to the sediment loading within the creek a sampling plan was developed. This sampling plan required the suspended sediment concentration, turbidity, and stream flow of all major streams which contribute to Twelvemile Creek be measured on at least a bi-weekly basis from April to July and a monthly basis for August and September. A map of the sampling sites (See Figure 2) and their associated drainages can be seen in Appendix D– Figure F1. Due to the diurnal variation of flow at the Mayfield Diversion on each sampling day this site was measured three times. Further details of the sampling plan can be found in Appendix D.

In addition to the suspended sediment and turbidity sampling, a sweep of water quality samples were sent to Chemtech Ford Laboratories to determine if any other constituents exceeded State Water Quality Standards for Twelvemile Creek's designated uses. The results indicated that all the constituents tested for were within the allowable limits of the State Standards. The test results can be found in Appendix D.

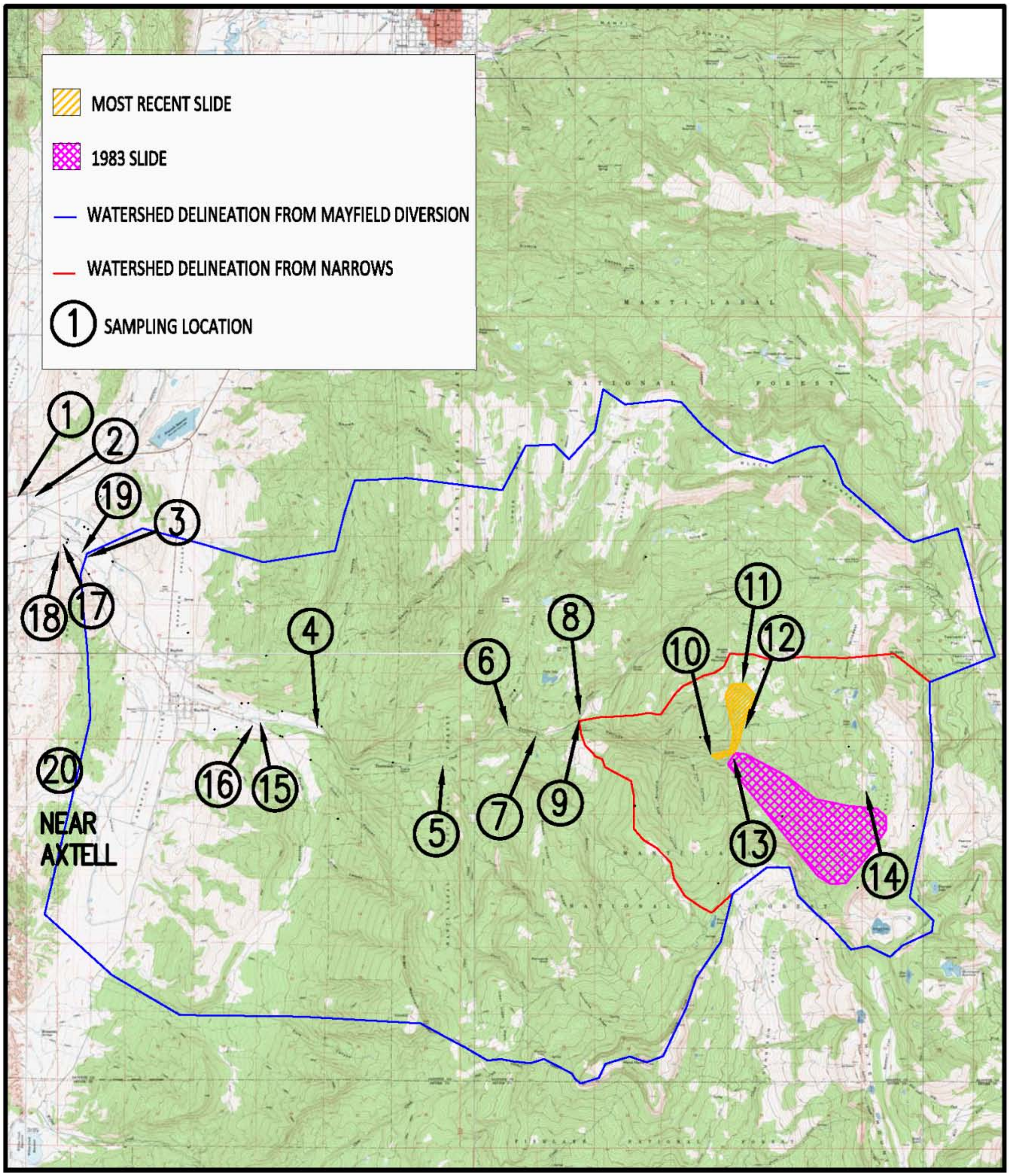

Figure 2. Sampling Sites

4.4 Summary of Sampling Results

Tables of all the sampling testing data collected are in Appendix D. Table 2 is a summary of the average monthly stream flows for each sampling site.

Table 2. Average Monthly Stream Flow

Site	Description	April	May	June	July	August	September
1	San Pitch below 12 Mile	NOT MEASURED					
2	San Pitch above 12 Mile	NOT MEASURED					
3	Gunnison - 12 Mile	6	54	82	32	4	3
4	Mayfield Diversion	37	133	135	80	60	60
5	Clear Creek	1	19	16	10	5	12
6	Birch Creek	1	13	14	10	7	9
7	Beaver Creek	2	17	32	7	2	2
8	12 Mile - Old Forks	9	34	21	8	7	5
9	South Fork	18	53	60	32	11	10
10	Bottom - New Slide	No Access	No Access	2	1	0	0
11	Top - New Slide	No Access	No Access	1	0	0	0
12	Coolie Creek	No Access	No Access	2	1	0	0
13	Bottom - Old Slide	No Access	No Access	51	28	10	7
14	Top - Old Slide	No Access	No Access	4	2	1	1
15	Mayfield Pond Influent	17	59	65	39	27	27
16	Mayfield Pond	17	59	65	39	27	27
17	Settling Pond Influent	53	91	114	126	110	55
18	Settling Pond Effluent	53	91	114	126	110	55
19	Gunnison - 12 Mile & 9 Mile	53	91	114	126	110	55
20	Axtell	8					

Figure 3 shows the (2008) average monthly flow measured for all the major drainages in Twelvemile Canyon. Water from these drainages all flow into Twelvemile Creek. The Mayfield Diversion is located along Twelvemile Creek downstream of the confluence of these drainages (see Appendix D– Figure F1). Figure 3 below shows that South Fork supplies roughly 40% of the flow that is observed at the Mayfield Diversion.

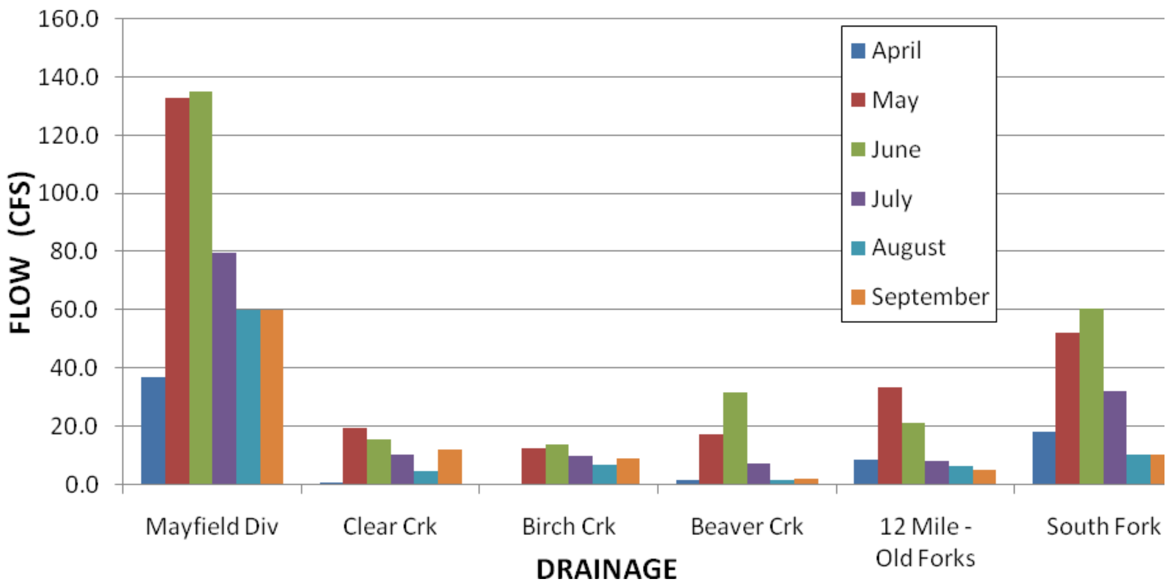

Figure 3. Average Monthly Stream Flow for Twelvemile Creek Drainages Upstream of the Mayfield Diversion. (2008)

Figure 4 shows the (2008) calculated average monthly sediment volume in cubic yards that pass each sampling site per day (see Table 3 for tabulated data). In May alone, an estimated 1382 cubic yards of suspended sediment passed through the Mayfield Diversion, and over the entire sampling period (April to September) an estimated 65,000 cubic yards of suspended passed through the Mayfield Diversion. To put it in perspective this would be equivalent to 6,500 dump truck loads of material.

Figures 3 and 4 combined show that, although South Fork contributes just under half the flow of water to Twelvemile Creek, this drainage contributes over four times as much sediment when compared to the other drainages.

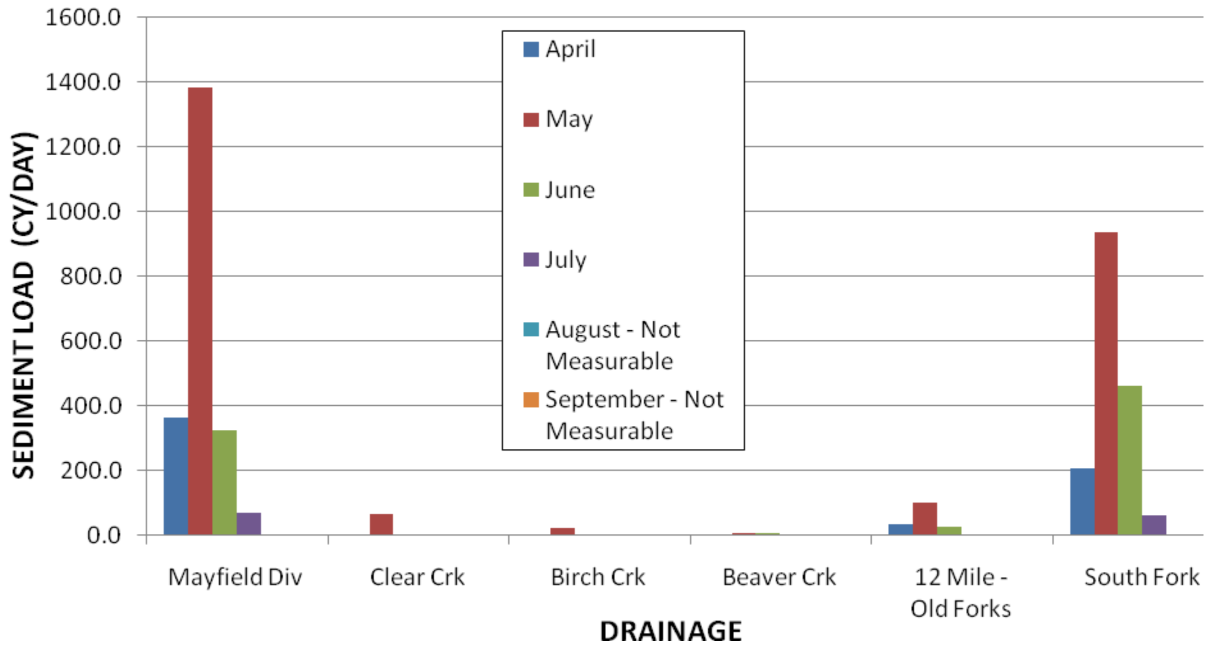

Figure 4. Average Monthly Sediment Load for Twelvemile Creek Drainages Upstream of the Mayfield Diversion. (2008)

Table 3 . Average Monthly Sediment Load

Site	Description	April	May	June	July	August	September
4	Mayfield Div	365	1383	324	70	0	0
5	Clear Creek	0	65	0	4	0	0
6	Birch Creek	0	24	2	0	0	0
7	Beaver Creek	0	8	8	0	0	0
8	12 Mile -Old Forks	34	102	26	3	0	0
9	South Fork	207	939	463	62	0	0

Figure 4 also shows an unusually high sediment load passing the Mayfield Diversion in May which cannot be accounted for by adding the contributions of the drainages, and an unusually low amount of sediment in June which also cannot be accounted for by adding up the contributions of the drainages. This may be due to existing sediment in the creek channel mobilized by the high spring flows and then the storage of sediment in the creek channel as flows decrease in June.

Throughout the sampling period a number of samples collected during April and May from the South Fork drainage and the downstream Mayfield Diversion contained what appeared to be two different types of suspended sediment. The sediment sampling procedure for determining the volume of suspended sediment required the sample to be poured into an Imhoff Cone. After one hour the volume of settled sediment was determined using the graduated marks on the cone. For some of the samples from South Fork and the Mayfield Diversion, after one hour the sediment separated into two different types of materials. These materials were noted and allowed to settle for at least 24 hours.

Figure 5 shows one of these samples in an Imhoff Cone. Notice the distinct line between the two sediments. The darker sediment appeared to be composed of sand, silt, and clay while the lighter solution appeared to be dispersed clay. Even after allowing the solution to sit for about one month, the dispersed clay only decreased slightly in volume. From observing this sample it can be concluded that conventional efforts such as settling basins would be effective in removing the darker sediment but would have little effect on the dispersed clay which would therefore be passed on through the system. For this reason, the sediment volume used in this report is the volume of the darker sediment.

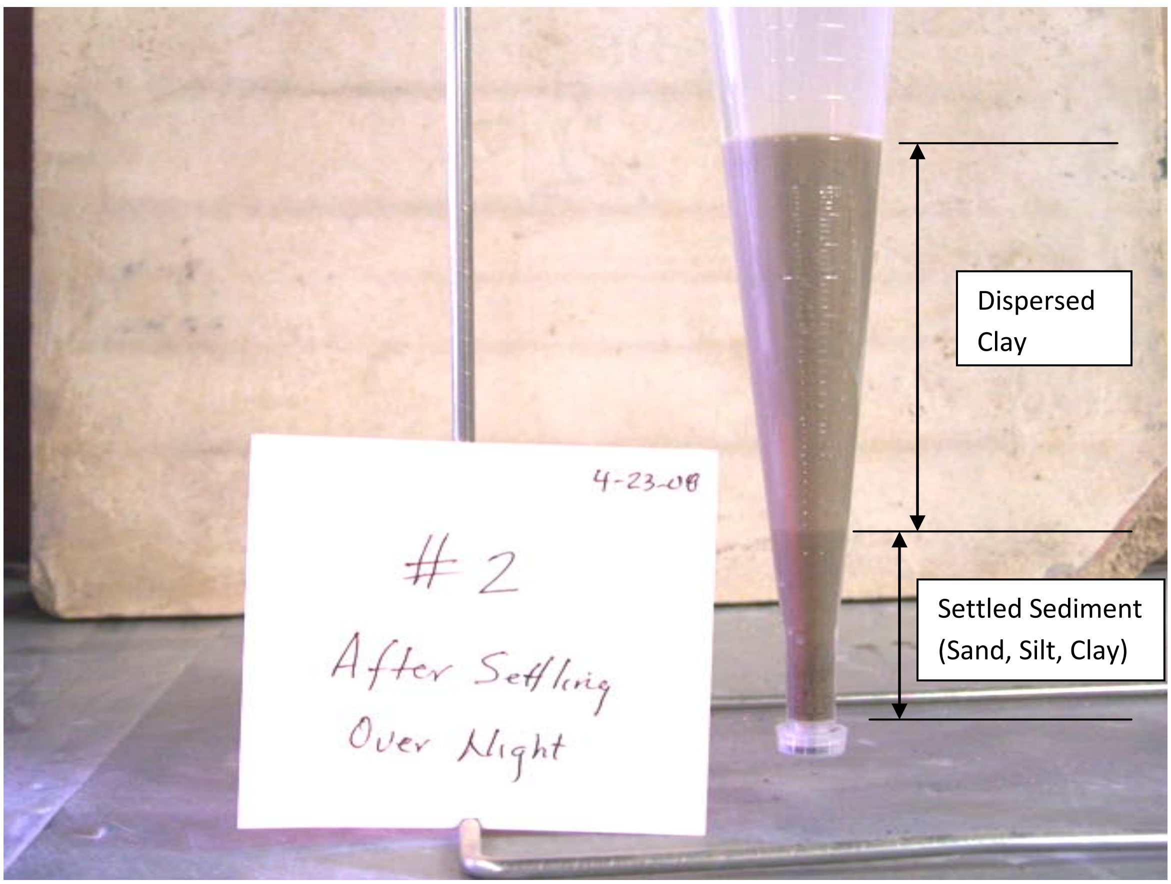

Figure 5. A suspended sediment sample from South Fork that had settled for 24 hours.

Throughout the sampling period gradations were run for selected samples. These gradations were processed to determine the particle size distribution for the suspended sediment. These gradations can be found in Appendix D.

Figure 6 shows the average monthly turbidity at each sampling site (See Table 4 for tabulated results). At the present time a required standard for turbidity does not have a set regulated value for surface waters, but limits the increase in turbidity, which, cannot be greater than 10 nephelometric turbidity units (NTU). Applying this regulation to Twelvemile Creek indicates that the South Fork drainage is in severe violation for all the months measured except April.

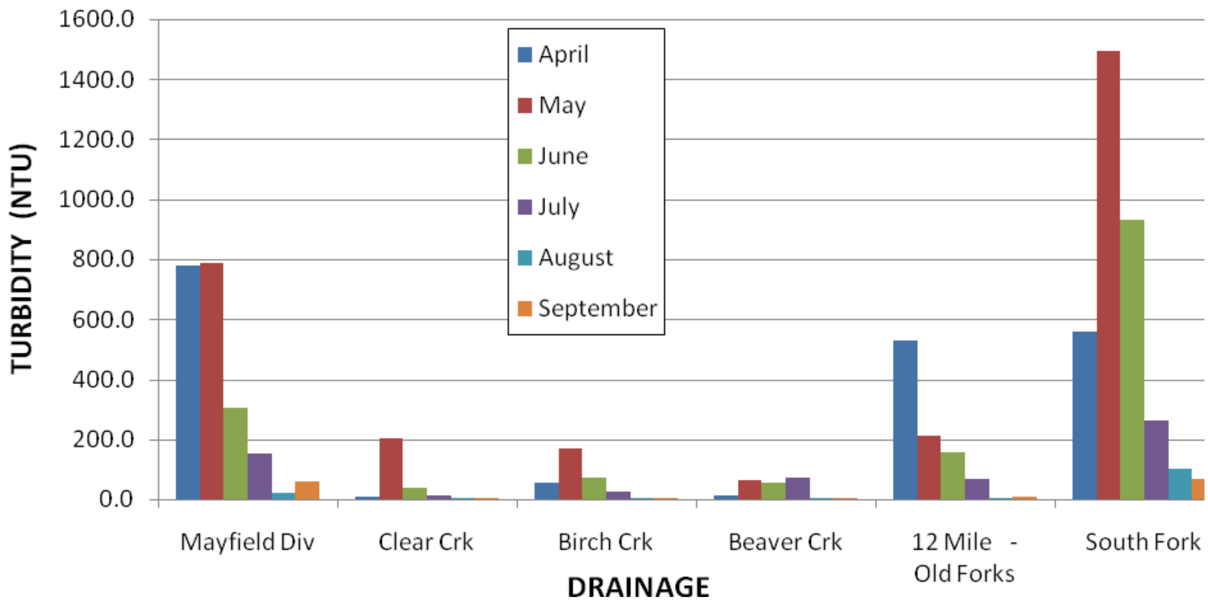

Figure 6. Average Monthly Turbidity for Twelvemile Creek Drainages Upstream of the Mayfield Diversion. (2008)

Table 3. Average Monthly Turbidity

Site	Description	April	May	June	July	August	September
4	Mayfield Div	780	788	303	154	20	57
5	Clear Creek	8	204	38	14	4	4
6	Birch Creek	56	170	73	24	4	4
7	Beaver Creek	12	62	56	72	4	5
8	12 Mile -Old Forks	531	211	158	66	4	7
9	South Fork	558	1495	931	263	100	67

Samples were also collected within the South Fork drainage along the major streams before entering the slide areas and near the bottom of the slide areas, but the data were limited due to difficulty accessing the sites. The limited data from June through September indicated that the streams prior to entering the slide areas contained an insignificant (less than 0.1mL/L) amount of suspended sediment. Based on this data, it is estimated that most of the suspended sediment from South Fork is contributed by the slide areas. Additional sampling data will be needed to better quantify the amount of suspended sediment contributed by the various slide activities within the drainage.

4.4.1 Comparison with Historic Data

Efforts were made to compare the current sampling data to the historic data mentioned in Section 1.2 of this report. The historic data recorded the amount of suspended sediment in terms of milligrams per liter near the Mayfield Diversion. Due to the large number of sediment samples collected for this report it was not feasible to dry every sample taken, therefore selected samples were dried and weighted. These samples resulted in an average density of 1.5 g/mL. This density was used to determine an estimated concentration in mg/L for each sample. Figure 7 shows the comparison of the current data from the Mayfield Diversion and historic data just upstream from the Mayfield Diversion. This figure shows a drastic increase in suspended sediment concentration during the months of April and May in 2008 as compared to samples collected from 1975 to 1980.

Although there are no recorded suspended sediment data from 1985 to 2008, according to the Mayfield and Gunnison Irrigation Companies during the years the Cooley Creek Slide has moved (1998, 2004, and 2006) the amount of suspended sediment was significantly higher than what has been recorded for 2008. Therefore, 2008 possibly can be considered a baseline in terms of relating slide activity and suspended sediment within Twelvemile Canyon.

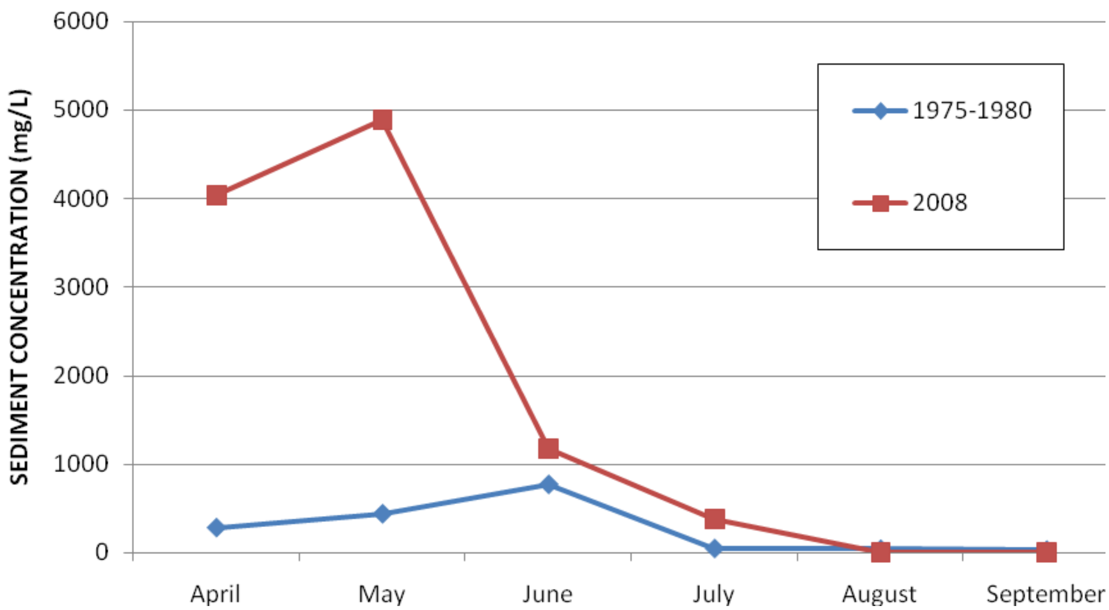

Figure 7. Average Monthly Sediment Concentration for Twelvemile Creek Measured Near the Mouth of Twelvemile Canyon.

4.4.2 Efficiency of Suspended Sediment Removal Devices in Place

In addition to the sampling efforts within Twelvemile Canyon, samples were also taken at the diversions along Twelvemile Creek and throughout the irrigation systems to determine the effectiveness of the sediment removal devices the irrigation companies have in place.

Mayfield

The Mayfield Irrigation Company diverts all of its water from the Mayfield Diversion located near the mouth of Twelvemile Canyon. From the diversion the water flows through a canal to a desilting structure. From the desilting structure the water flows through a canal to a detention pond which is used to supply the water for the pressurized irrigation system.

Sampling sites were located at the Mayfield Diversion, the irrigation pond influent, and the water surface of the irrigation pond near the effluent. Data from these sampling sites showed an estimated 82% of the suspended sediment recorded at the Mayfield Diversion being settled out prior to entering the irrigation pond. Over the course of the sampling period this percentage decrease from April to July likely due to the reduction in storage area caused by sediment settling out which in turn would decrease the hydraulic retention time of the canal system. Samples taken from the water surface of the pond showed no sediment, but sediment does flow through the outlet which is evident by the amount of sediment observed in sprinkler lines throughout the systems. In the future, a sampling location within the system near the outlet of the irrigation pond is recommended to determine the amount of sediment entering the pressurized irrigation system.

Gunnison

The Gunnison Irrigation Company has three main sources of water; Twelvemile Creek, Ninemile Reservoir, and Gunnison Reservoir. Water that is diverted from Twelvemile Creek can be mixed with water from Ninemile Reservoir to supply water to the Highland Canal System. The Highland Canal System is composed of canals and a settling pond. Five sampling sites were located: 1) downstream of the Gunnison Diversion to collect water diverted from Twelvemile Creek; 2) downstream of the confluence of water from Ninemile Reservoir and the diverted water from Twelvemile Creek; 3) at the influence of the settling pond; 4) at the effluent of the settling pond; and 5) near the end of the Highland Canal near Axtell. From these samples, the efficiency of sediment removal was determined along the canal and in the settling basin.

Data from the sediment sampling showed only a 3% decrease in sediment volume along the canal from the confluence of Twelvemile and Ninemile water to the settling pond influent. The settling pond removed an estimated 70% of the suspended sediment over the study period. This percentage decrease from April to July likely due to the reduction in storage area due to sediment settling out which would in turn decrease the hydraulic retention time of the settling pond. The data from the sampling site near the end of the system showed a decrease of 85% of the suspended sediment when compared with the sediment volume at the confluence of Twelvemile and Ninemile waters. This indicates that on average an estimated 12% of the suspended sediment is deposited in the canal system between the effluent of the settling pond to just west of Axtell.

4.4.3 Recommended Future Sampling Efforts

Future sampling efforts should include continued sampling of the sites specified in this study with additional sampling sites within the South Fork Drainage. Data from the existing sites will be useful in establishing data trends and for comparing differences on a yearly basis. The additional sites within the South Fork drainage would be valuable in determining specific areas or stream reaches where a significant amount of sediment is becoming suspended, and would also be useful in sizing pipes and other remediation techniques.

4.5 Existing Suspended Sediment Removal Techniques

The Gunnison and Mayfield Irrigation Companies are currently using detention devices to settle out some of the suspended sediment in the Twelvemile Creek water. The detention devices include a desilting structure, gates within the creek to back the water up, deepened canals, and detention ponds.

The desilting structure is a steep concrete V channel that is shallow on the upstream end and slopes down to a gate on the downstream end (See Figure 8). This structure allows the water velocity to slow down and allows the sediment to settled out. Once the desilting structure has a considerable amount of sediment, the downstream gate is opened and the water detained in the structure sluices the sediment out and back into Twelvemile. Creek. Once clean the gate is shut and the water again fills the structure and sediment begins to be settled out. The problem with this type of structure is if the influent water carries a lot of sediment the structure has to be flushed frequently (Mayfield has had to flush it 3 to 4 times a day) and every time the structure is flushed the water that is used to flush the settled sediment out is lost, in addition due to the flat slope of the canal the water that has passed the desilting structure and is in the canal also flow back and out the sluice gate. Also due to the small size of clay particles a considerable amount is not settled out in the desilting structure and continues on into the system.

Figure 8. Mayfield Desilting Structure.

The gates at the Gunnison Diversion within Twelvemile Creek are used to back the water up and allow the sediment to settleout (See Figure 9). These gates allow the water to slow down enough so a portion of the suspended sediment can settled out. The water then diverted out the creek channel and into a canal. When the sediment in the creek channel upstream of the gates accumulates to a point where the sediment needs to be removed the gates are opened and the water flowing in the creek washes the sediment out of the creek channel. The problem with this technique is that due to the steep grade and small width of the natural stream channel only a small amount of water can be detained. Therefore much of the sediment passes on into the canal.

Figure 9. Upstream of the Gunnison Diversion Along Twelvemile Creek.

Detention ponds have been constructed by both irrigation companies (See Figures 10 and Figure 11). These structures hold a large volume of water that allows the suspended sediment to settle out of the water. These structures work well but they are expensive to maintain because the sediment has to physically be removed from them. The Mayfield Irrigation Company's detention pond was not intended to primarily remove sediment, but was designed to buffer the water used and the amount of flow available (which is variable due to the diurnal variation of Twelvemile Creek). As the detention time in the Mayfield Irrigation's Company detention pond decreases it becomes more difficult to manage the water available for use. In addition the Mayfield Irrigation Company does not own any additional land to build another detention pond on and all of the land adjacent to their canal is hydraulically unusable and/or publicly owned. The Gunnison Irrigation Company uses a number of ponds some are for the sole purpose of settling out sediment some are more for flow regulation. The difficulty the Gunnison Irrigation has is in order to construct a detention pond large enough to settle out the suspended sediment requires costly design, review, and clearances and after they are constructed they have to be cleaned on a regular basis.

Both irrigation companies have attempted to constructed devices that would collect sediment and sluice the settled material back into Twelvemile Creek, but the Companies indicate that state and federal agencies have discouraged these devices due to the high concentration of sediment in the water returning to the creek.

Figure 10. Gunnison Detention Pond (water is diverted from the canal to the pond shown in the background and then flows back into the canal).

Figure 11. Mayfield Detention Pond (open channel influent on the right and outlet to pressurized pipe system on the upper left).

4.6 Mapping

Aerial photographs and mapping of the South Fork drainage area and the areas near the Mayfield and Gunnison Twelvemile Creek diversions is included in this project. An aerial photograph of the South Fork Drainage Area in Twelvemile Canyon is shown in Appendix A- Exhibits A3 and A4. . A USGS topographical map showing the areas covered is in Appendix A.- Figure 1C.

4.7 Hydrogeological Study

A hydrogeological study was conducted by Kleinfelder West, Inc. to determine the probability of using groundwater to replace the sediment laden Twelvemile Creek water (The full report can be found in Appendix E). The Gunnison and Mayfield Irrigation Companies indicated that the required combined groundwater flow is around 160 cfs (120 cfs for Gunnison and, 40 cfs for Mayfield). Hydrogeologists working for Keinfelder West, Inc. concluded:

> "There are five locations within the proposed study area . . . that have potential for groundwater production. Each of the potential well locations target groundwater in the unconsolidated valley fill deposits as well as groundwater in the Green River Formation. It is important to note that there are technical issues that need to be considered before proceeding with the well drilling at any of the proposed locations. In addition, available hydrogeologic information suggests that aquifers in the area have groundwater production potential, however, it is unlikely that these aquifers would be capable of supplying the desired 160 cfs to wells within the study area."

Although this initial wells siting study concluded that wells near Mayfield are unlikely to produce the total required amount of water for both companies, a well siting study may be conducted in the future to determine the potential of groundwater production in the deeper valley fills within the Gunnison Valley area, and future test wells may be drilled near Mayfield to determine if groundwater may feasibly be used to replace some or all of the water required by Mayfield Irrigation Company.

4.8 Economic Data Collection and Evaluation

John Keith, an emeritus professor (Utah State University) in economics, evaluated the socioeconomic impacts of the suspended sediment to the local agricultural community and the community in general. John Keith's full report follows.

ECONOMIC ANALYSIS OF THE EFFECTS OF SUSPENDED SEDIMENT IN THE TWELVE-MILE CREEK WATERSHED

John E. Keith
Department of Applied Economics
Utah State University

Introduction

In order to assess the economics of programs to manage or contain the sedimentation due to soil characteristics and land instability in the Twelve-Mile Creek watershed, the effects of that sedimentation on users of the water from that drainage must be determined. The following report provides a reconnaissance-level economic analysis and economic impact analysis of those effects.

Data

The data provided relates to several possible costs associated with sedimentation in the watershed. Water from Twelve-Mile Creek, which carries the bulk of the sediment to users served by the Mayfield Irrigation Company and the Gunnison Irrigation Company, and users downstream to Yuba Reservoir, is used for irrigation of both agricultural crops and household yards and gardens. The sediment reportedly reduces the quality and probably the quantity of agricultural crops, and results in increased maintenance requirements for sprinkler systems. Moreover, the irrigation companies that get water from this drainage must minimize the effects of that sediment on their distribution systems. In an attempt to minimize the effect of sedimentation, these companies have created settling ponds, but these ponds must be cleaned often or their usefulness is lost.

The effect of sedimentation on crop yield is not known at present, although most farmers in the area indicate that the yield reduction due to sediment is significant. However, the quality of dairy hay produced in the region is clearly affected by the sediment load. Data on the Relative Feed Value (RFV) for the first two hay cuts was provided by Yardley Dairy and by Jason Parker (2004-2007) of the Dairyland Laboratories, Inc., for the Mayfield irrigators (who use fully sedimented water from Twelve-Mile Creek), and two different groups of irrigators from the Gunnison Irrigation District, one that used mixed water (from relatively unsedimented sources and from Twelve-Mile Creek) and one that used no Twelve-Mile Creek water. There were two observation fields for each group, as can be seen in the attached Excel file. There were observations for each of the three water using groups for the first and second cuttings of hay. The data were provided for four years: 2004 to 2007, although there were some fields for which data on RFV values were missing. The raw data may be found on the attached Excel File.

These data were then subjected to a statistical analysis to determine (1) the average value of RFV for each group, (2) the standard deviation of the RFV for each group, and (3) whether or not these means were statistically significantly different among the three groups. The means and standard deviations for each group are listed in Table 1. Results from the analysis of differences among the means are listed in Table 2.

Table 1. Means and Standard Deviations of RFVs among Groups

Hay Cutting	**Average for all observations with no sediment**	**Standard deviation for all observations no sediment**
First	178.61	10.12
Second	182.82	12.16
	Average for all observations with 12-Mile water (full sediment)	**Standard deviation for all observations with 12-Mile water (full sediment)**
First	158.98	13.23
Second	142.76	20
	Average for all observations with mixed water	**Standard deviation for all observations with mixed water**
First	170.15	15.53
Second	164.1	15.01

To determine if the sediment load has an effect on RFV values, a test for significant difference between the averages of the RFV values for the three groups must be made. This test is performed by calculating a "t" value (distributed as the usual student's "t") comparing the differences between the averages divided by square root of the sum of variances of each group (the standard deviation squared) divided by the respective number of observations. These are the calculations in the first column of Table 2. Those calculated "t" values are compared to "t" values calculated by weighting the "t" value for each group with a given degree of "significance" (usually .05, 0.10 or .15 percent) and the number of observations less 1 (taken from a standard student's "t" table) by its variance divided by the number of observations. These formulae can be found in any standard statistics text. Once the calculated and "standard" "t" values are obtained, if the calculated "t" value is greater than the "standard" "t" value (for a given number of observations and significance level), the difference in the means is deemed "significant" at the level associated with the "standard" "t" value. The numbers in red in Table 2 indicate the significance level at which the means between the groups is "different."

Table 2. Statistical Analysis of the Differences of Means

Hay cutting	Calculated "t" values by group and cutting	Standard "t" values at different probabilities		
	No sediment compared to full sediment	significantly different at the .05 level	significantly different at the .10 level	significantly different at the .15 level
First	3.249693941	1.91272886	1.424233783	1.200626646
Second	4.19159459	2.015	1.476	1.156
	Mixed water compared to full sediment			
First	1.488336638	1.91760103	1.42948784	1.127692704
Second	2.146047774	1.98905079	1.463025394	1.148071074
	No sediment compared to mixed water			
First	1.208400225	1.924	1.44	1.134
Second	2.482385777	1.96006281	1.454266608	1.142718483

As can be seen in Table 2, the calculated “t” values for the difference in the averages is highly significant in the no sediment compared to the full sediment case (calculated “t” value greater than the “t” values at probability of 5%), and for the second cuttings in the other two groups. For the mixed water compared to the full sediment case in the first cut, the difference in the means is significant at the 10% level, which is normally considered as “significant” in statistical analysis. For the no sediment – mixed water case for the first cut, the means are significantly different at the 15% level, which is somewhat less than normally accepted as “significantly different.” In general, the larger the number of observations, the more sensitive these tests are (that is, the more likely it is that significant differences will be found). In this case, there are few numbers of observations (six to eight in each category), so that it is expected that as more data become available on the differences in RFVs among the three groups, the more likely it is that the test for significant differences in the means will show significance. Therefore, the differences in the means were used to calculate the lost value to hay crops.

In addition to the RFV values, the Mayfield and Gunnison Irrigation Companies provided information about the expenditures they made to clean canals and settling ponds over the past 5 years, as well as information from their water users about added costs of sprinkler repair and replacement (Boore). Average annual expenditures calculated from these data can be found in Table 3. The Mayfield

Irrigation company estimated their costs by comparing a “normal” cost of maintenance with their average annual costs over the past 5 years. The Gunnison Irrigation Company reported their average expenditures by category. Note that the annual average costs of maintenance for Mayfield increased sharply after 2005. This was due to the advent of a significant debris slide (the North Slide) in early 2006. These data are available from the two irrigation companies.

Table 3. Costs of Maintenance

System maintenance							
Mayfield Irrigation Company							
		Sprinkler repair					
			Normal	$5,000			
			Mayfield	$20,000			
			Added cost	$15,000			
		Maintenance		pre 06		post 06	
			Annual avg	$11,995		$16,250	
	Total maintenance cost for Mayfield			pre 06		post 06	
				$26,995		$31,250	
Gunnison Irrigation Company							
		Annual average maintenance costs					
			sediment removal			$16,952	
			Sprinkler damage (incl labor costs)			$37,254	
			Cleaning holding ponds			$40,500	
			Pond construction			$10,157	
	Total maintenance cost for Gunnison					$104,863	
				pre 06		post 06	
Total cost				$131,858		$136,114	

Finally, in order to assess the impacts of sedimentation on household expenditures, a survey was designed and distributed to households in Manti, Mayfield and Gunnison. The former city is unaffected by the Twelve-Mile Creek sedimentation and their data were collected to determine a base-line of “normal” expenditures. There were only seven responses from residents of Gunnison and most reported little or no costs due to excessive sedimentation. Moreover, the statistical reliability of those responses (measured by the standard deviation) was poor. Table 4 reports the average expenditures by category for the residents of Mayfield for 2006 and 2008. The average annual total household cost due to sedimentation is $233.71 ($467.42/2) . There are reportedly 140 occupied homes in Mayfield, according to the Mayfield, Utah page of the www.city-data.com website. Thus, the total annual expenditure is $32,719. This estimate is likely quite low, since it does not include the cost of time for household members to clean and repair their sprinkling equipment. In the survey, the amount of time required was qualitative identified and appeared to be relatively substantial.

Table 4. Average household costs due to sedimentation in Mayfield, Utah

Filters or Sediment		Piping and Delivery System from Main				Sprinkler or Other		Other
Purchase	Maintenance	Valve Cleaning	Valve Replacement	Pipe Cleaning	Pipe Replacement	Cleaning	Replacement	Cost
$ 120.86	$ 40.62	$ 10.00	$ 36.29	$ -	$ 26.80	$ 24.58	$ 125.57	$ 82.70

Economic Value Analysis

Table 5 presents the calculations necessary to determine the average annual economic cost of suspended sediment to hay producers. The first two columns indicate the average RFV value for the two groups of producers indicated. As indicated above, these averages are statistically significant from each other at a minimum of the .15 percent level. The difference between the two is the reduction in RFV values due to sedimentation (the fifth column). Jason Parker reported that in 2007, the loss of one RFV point resulted in the deduction of $0.50 per ton of hay purchased by the dairy. The difference is then converted to loss in revenue per to the farmer ton of hay by multiplying the difference in RFV values by $0.50 (the sixth column). The first cut of hay averages about 2.5 tons of hay per acre; the second cut averages about 1.5 tons of hay per acre. The total loss per acre is found by multiplying the economic loss per ton times the appropriate number of tons (column 7). Then the total loss per acre is multiplied by the total number of acres (1,800 served by the Mayfield Irrigation Company, and 12,000 acres served by the Gunnison Irrigation District). The total economic loss per cut is found in column 8. In 2008, the reductioin in price increased to $1.00 per RFV point per ton. Columns 9, 10, and 11 indicate the same calculations as in columns 7, 8 and 9, but using the 2008 price reduction.

In order to accomplish a benefit-cost analysis, the present values of the streams of benefits and costs to a project over its life must be determined. The benefits to controlling sedimentation in Twelve-Mile Creek are the elimination of losses and added costs. To determine the present value of the cost to agricultural producers, the average annual losses to RFV values (Table 5) plus the added costs of maintenance (Table 3 above) are taken as the average annual losses over the proposed 20-year life of the project (for example, the 2008 loss in RFV value, $787,409 plus the post 2006 maintenance cost of $136,114 for a total annual average cost of $923,523). It was assumed that the project would eliminate the excess sedimentation such than no loss in hay RFV value or added costs of maintenance to the irrigation districts or households would occur. A 5 percent discount rate was chosen as appropriate, although arguments for higher and lower rates could be made. The current return to long term US Treasury bills (normally an indicator risk-free time preferences) is approximately 3.5 percent, but these rates are at long- term lows due to the sluggish economy. A 5 percent rate is more typically a long term

Table 5. Losses due to reduced RFV values in Mayfield and Gunnison irrigation areas

		RFV	RFV	RFV						
		average	**average**	**difference**	**2007 price**	**2.5t/ac first cut**		**2008 price**	**2.5t/ac first cut**	
					50c/RFV	**1.5t/ac secnd cut**		**1.00/RFV**	**1.5t/ac secnd cut**	
Mayfield		**no sediment**	**full sediment**				**1,800 acres**			**1,800 acres**
	First cut	178.6143	158.98	19.6342857	9.817142857	24.54286	44177.14	19.63428571	49.08571	88354.2857
	secnd cut	182.8183	142.761667	40.0566667	20.02833333	30.0425	54076.5	40.05666667	60.085	108153
	Costs to Mayfield only from lost RFVs						**98253.64**			**196507.286**
				RFV						
				difference						
Gunnison	no mud	**no sediment**	**mixed water**				**12,000 acres**			**12,000 acres**
	First cut	178.6143	170.148571	8.46571429	4.232857143	10.58214	126985.7	8.465714286	21.16429	253971.429
	secnd cut	182.8183	164.1	18.7183333	9.359166667	14.03875	168465	18.71833333	28.0775	336930
	Costs to Gunnison only from lost RFVs						**295450.7**			**590901.429**
Total							***393704.4***			***787408.71***

Table 6. Present value of all losses to irrigated agriculture at 5% discount rate for 20 years

Mayfield and Gunnison Irrigation Companies						
		07 RFV prices			**08 RFV prices**	
		Maintenance Costs pre 06	**Maintenance cost post 06**		**Maibntenance cost pre 06**	**Maintenancer cost post 06**
		$6,549,669	$6,602,695		$11,456,095	$11,509,122
Mayfield Irrigation Company Only						
		$2,867,700	$2,920,726		$4,092,157	$4,145,184

average. The present value of these costs and losses is shown in Table 6. Using the same present value technique and discount rate, the present value of losses to Mayfield households is $407,753. Thus, the total losses to the water users in the area, as estimated using available data, is between $7 and $12 million for both irrigation companies, and between $3.3 and $4.5 million for Mayfield Irrigation Company alone. Using the 3.5 percent discount rate would increase these values to $8 to $13.5 million and $3.6 to $5.2 million, respectively.

Economic Impact Analysis

The economic impact analysis was accomplished using IMPLAN© modeling for Sanpete County. Several assumptions were made relative to this modeling. First, only the "export" value of any change should be used in an IMPLAN regional model. This is because local expenditures by local residents may or may not take place in the local community as a result of a given change. Thus, only the change in exported values can be considered. The hay produced by the growers in the Mayfield and Gunnison Irrigation Districts is exported, sold to local dairies, and used for feed for livestock in about equal proportions. However, there is no formal way to link reduced quantities of milk produced and exported by local dairies to the loss in RFV. Thus, it is assumed that that value is lost to potential exports of hay, rather than to local sales of hay to dairies or to livestock feeders. It is likely, however, that local dairies would indeed have to purchase higher quality hay from outside the local area, so this "import substitution" is the basis for the analysis. Local household expenditures on sprinkling systems were not included in the analysis, because they are, in fact, not directly linked to exports. Those expenditures cannot be assumed to be import substitutions, but rather the expenditures would probably have been made locally for other goods and services.

Thus, the annual loss of from $393,704and $787,409 of direct payments to irrigators (representing 2007 and 2008 RFV prices) was used as the (negative) change in final demand for the hay. That value was adjusted to take account of "local purchase coefficients" which IMPLAN generates by county to account for the fact that only a part of total expenditures on hay production would be made in Sanpete County (about 2-3% would be non-local according to the IMPLAN model data). The local (county) output (total sales) multiplier is about 1.3; that is, for every $1.00 of reduced direct payments, about $1.30 in total payments will be lost, or an additional $0.30 will be lost to the whole economy as a result of the $1.00 loss. The local annual impact of lost hay value would be a loss of between 4 and 8 total jobs, $122,000 to $245,000 in household income, and $244,000 to $487,500 in value added (household income plus returns to capital investments). To examine the effect on the State of Utah, the same output multiplier is about 1.35. Thus, the major portion of the secondary impacts of the loss of hay value occurs in Sanpete County.

Summary and Conclusions

There is a substantial loss in economic value due to the heavy sedimentation in Twelve-Mile Creek. The loss in net present value of hay quality ranges from aboug $400,000 to almost $800,000 per year. Added to that loss are the increased maintenance costs, which total approximately about

$140,000 per year. The net present value to irrigators ranges from about $7 million to $12 million. Another $400,000 in present value is lost to households in Mayfield as a result of increased maintenance on their sprinkling systems. These present values are probably underestimates of the losses, since household time for sprinkler maintenance was not included, nor was any loss in productivity (other than RFV value) to irrigators. Thus, for a benefit-cost analysis, these values should be compared to a project cost to determine if there are sufficient benefits to warrant action. It should also be noted, however, that it was implicitly assumed that whatever project would be proposed would eliminate the heavy sediment load. Should these projects only reduce that sediment load, additional analysis of benefits would be required.

Recommendations

This reconnaissance study focused only on the losses of RFV values to hay producers and on the maintenance costs of both irrigation companies and households as a result of the heavy sedimentation of Twelve-Mile Creek. Data on reductions in crop production and/or quality for all crops grown in the two irrigation districts were not available, nor were data on the effects of sediment loading on downstream water users. Moreover, much of the sediment is deposited in Yuba Reservoir, resulting in a loss of reservoir capacity, which was not taken into account also due to lack of data. Other losses, such as recreational fisheries, should also be considered in a detailed analysis. Thus, the losses described above should be considered as a significant underestimation of total losses due to sedimentation.

Citations

Parker, Jason. 2004-2007. Reports to the Yardley Dairy on the Relative Feed Values of Hay in the Mayfield and Gunnison Irrigation Districts.

Boore, Danny, 2008. Personal Communications.

5.0 Phase I Conclusions

As previously mentioned this report is a compilation of the data gathered for Phase I of the three phase plan. Phase I required the gathering of the following data types: Geotechnical, hydrogeological, economic, aerial mapping, topographical, and water quality. Based on the compilation and review of the data gathered the following conclusions, which are not comprehensive but encapsulate the major findings, have been drawn.

1. Suspended sediment loads in Twelvemile Creek from 1983 to the present exceed previous suspended sediment loads recorded from 1975 to 1980 (only records available) and likely are the highest since the irrigation systems were created in the mid 1800's.

2. In 2008 very little slide activity occurred in Twelvemile Canyon, therefore most of the suspended sediment within Twelvemile Creek is likely attributed to the erosion of stream banks by meandering stream channels through old slide deposits. Also in 2008 even with very little slide activity suspended sediment concentrations were over four times greater that sediment concentrations recorded in 1975 to 1980.
3. Sediment samples from the South Fork drainage showed the presents of dispersed clays, which cannot be feasibly settled out in conventional settling basins.
4. The hydrogeologic study showed that totally replacing Twelvemile Creek water with groundwater was not feasible due to the quantity of groundwater that would be required and the lack of groundwater potential in the area.
5. Economic losses to the Mayfield and Gunnison Irrigation Companies are estimated to be between $400,000 and $800,000 annually. Additional losses to individual residents are being calculated based on submitted survey results.
6. Based on the annual losses the present value over a 20-year life of the proposed siltation prevention project ranges from about $7 to $12 million.

6.0 Phase I Recommendations

We recommend proceeding into Phase II with the objective of generating and evaluating the feasibility of mitigation alternatives. In addition the following items should be continued from Phase 1:

1. With only a small amount of historic suspended sediment data, sampling efforts should continue in Phase II. These efforts should include continued sampling at the designated sites for comparison and to determine any trending in the data. Also more frequent and earlier (May, June) sampling at the locations within the South Fork Drainage will aid in determining which areas within this watershed are contributing the most to the amount of suspended sediment observed in Twelvemile Creek. And lastly, a sampling site within the Mayfield pressurized irrigation system downstream of the pond will allow the amount of sediment entering the pressurized irrigation system to be determined.
2. Although the hydrogeologic study showed that totally replacing Twelvemile Creek water with groundwater was not feasible in the future, a well siting study within the Gunnison Valley may indicate potential for groundwater replacement, and future test wells in the Mayfield area may be useful in determining the feasibility of replacing a portion of Twelvemile Creek water with groundwater.
3. Additional geotechnical information will be required in order to formulate mitigation effort alternatives. This additional geotechnical information will include drill sites

located on the slide areas in the South Fork drainage. Soil samples from these drill sites will indicate the depth and physical condition of the slipping plane of the associated slide. Permitting for this activity is currently under way.

4. Based on what is known, at this point, the following is a list of conceivable mitigation alternatives.
   a. Channelizing work (realign & armor)
   b. Piping selected areas (hydroelectric plant possibilities)
   c. Revegitation (seeding)
   d. Collect spring/seep water near sources and divert from slides
   e. Stream diversion
   f. Subsurface water collection (French Drain)
   g. Retention devices – for settling out the suspended sediments
   h. Chemical treatment for more rapid settlement

7.0 References

Boore, Danny L. "The Impact of Twelve-Mile Canyon Mudslides on Downstream Water Users in Sanpete County, Utah." Utah State University, Thesis, 1986.

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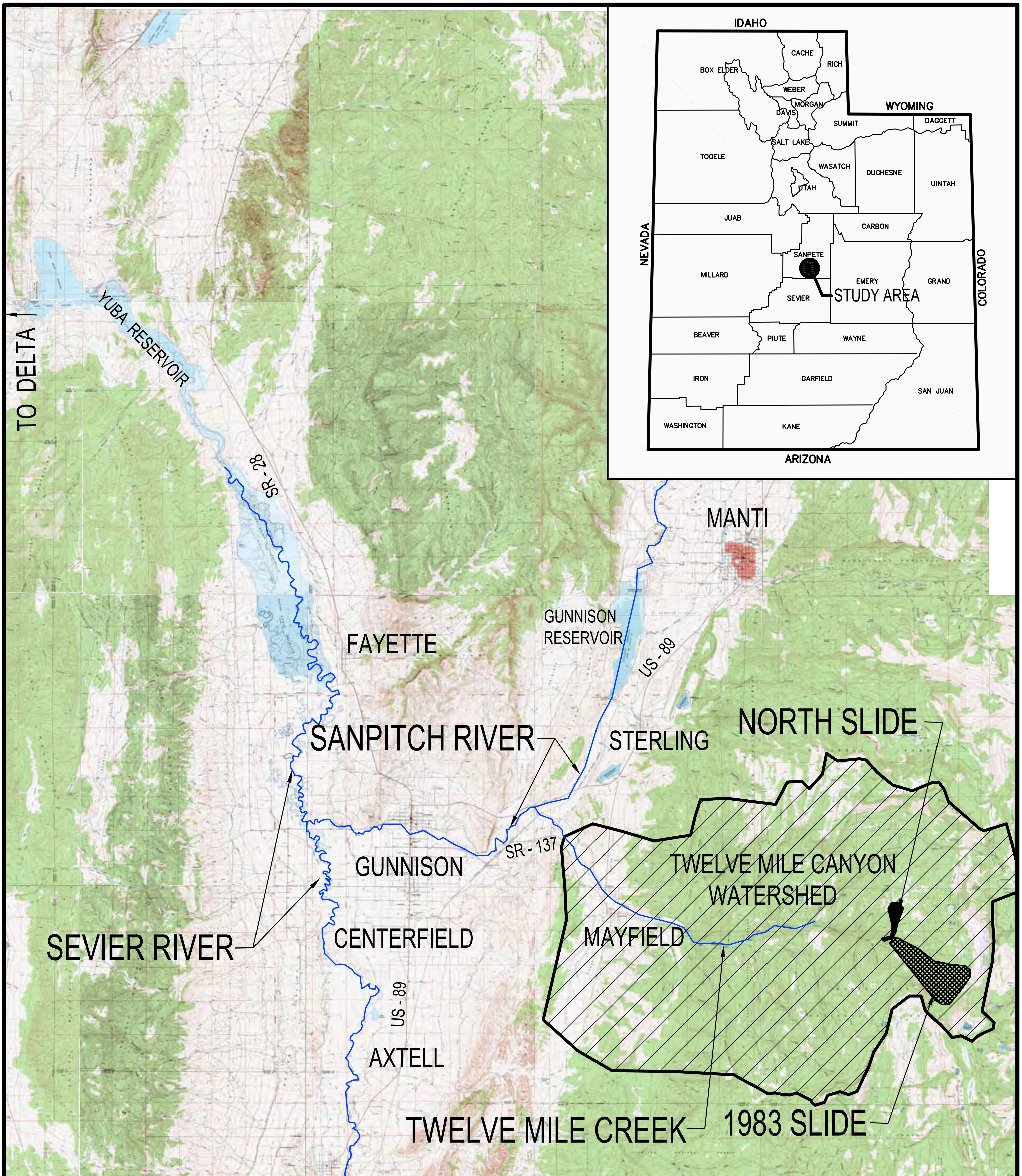
(See geotechnical report in Appendix B for references stated in Section 4.1)

APPENDIX A

MAPS & IMAGERY



Jones & DeMille Engineering 1535 South 100 West - Richfield, Utah 84701 Phone (435) 896-8266 Fax (435) 896-8268 www.jonesanddemille.com	N	SANPETE COUNTY — FIGURE: 1 TWELVE MILE CANYON WATER QUALITY STUDY AREA
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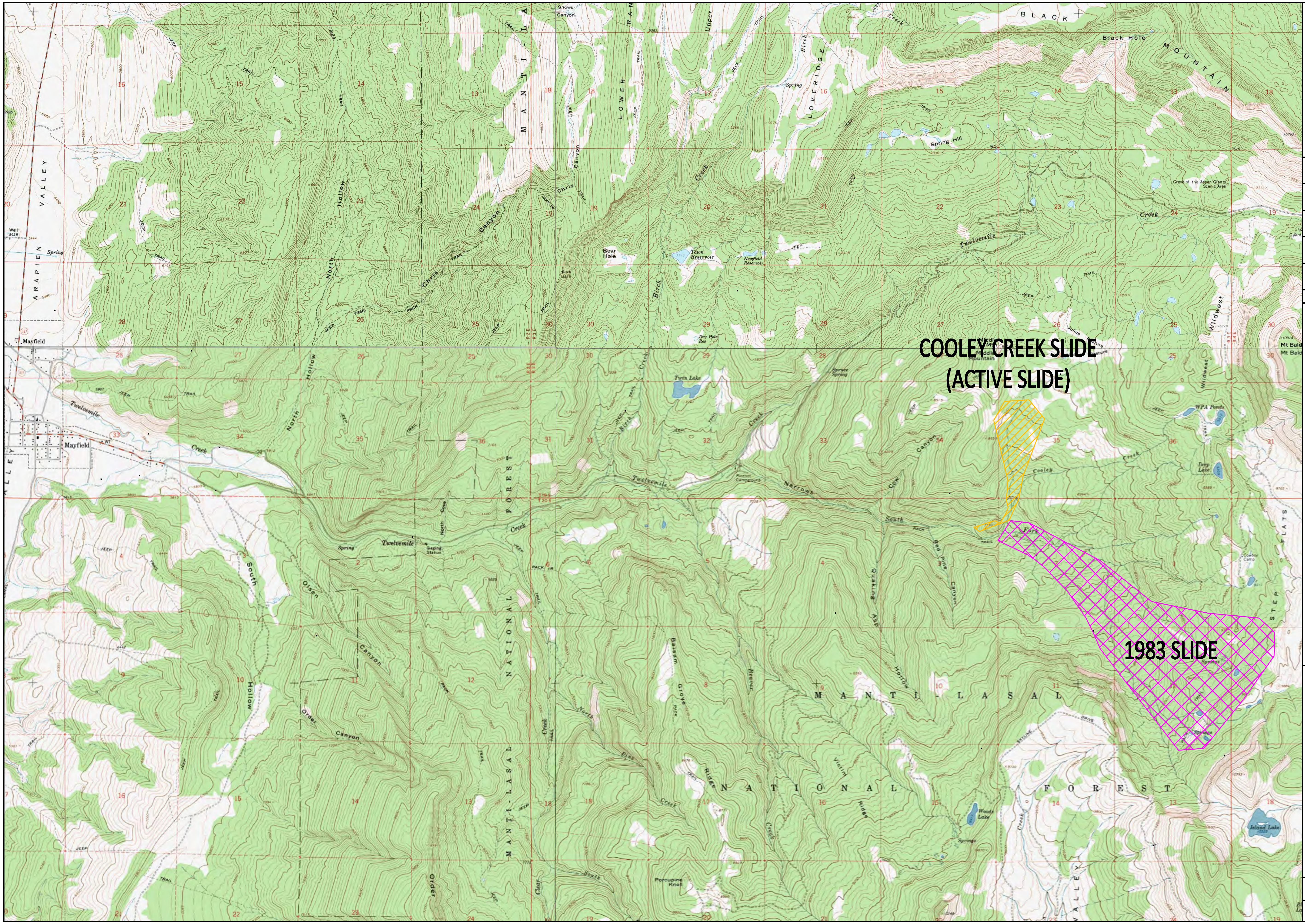

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SANPETE COUNTY
TWELVEMILE CANYON
SLIDE AREAS

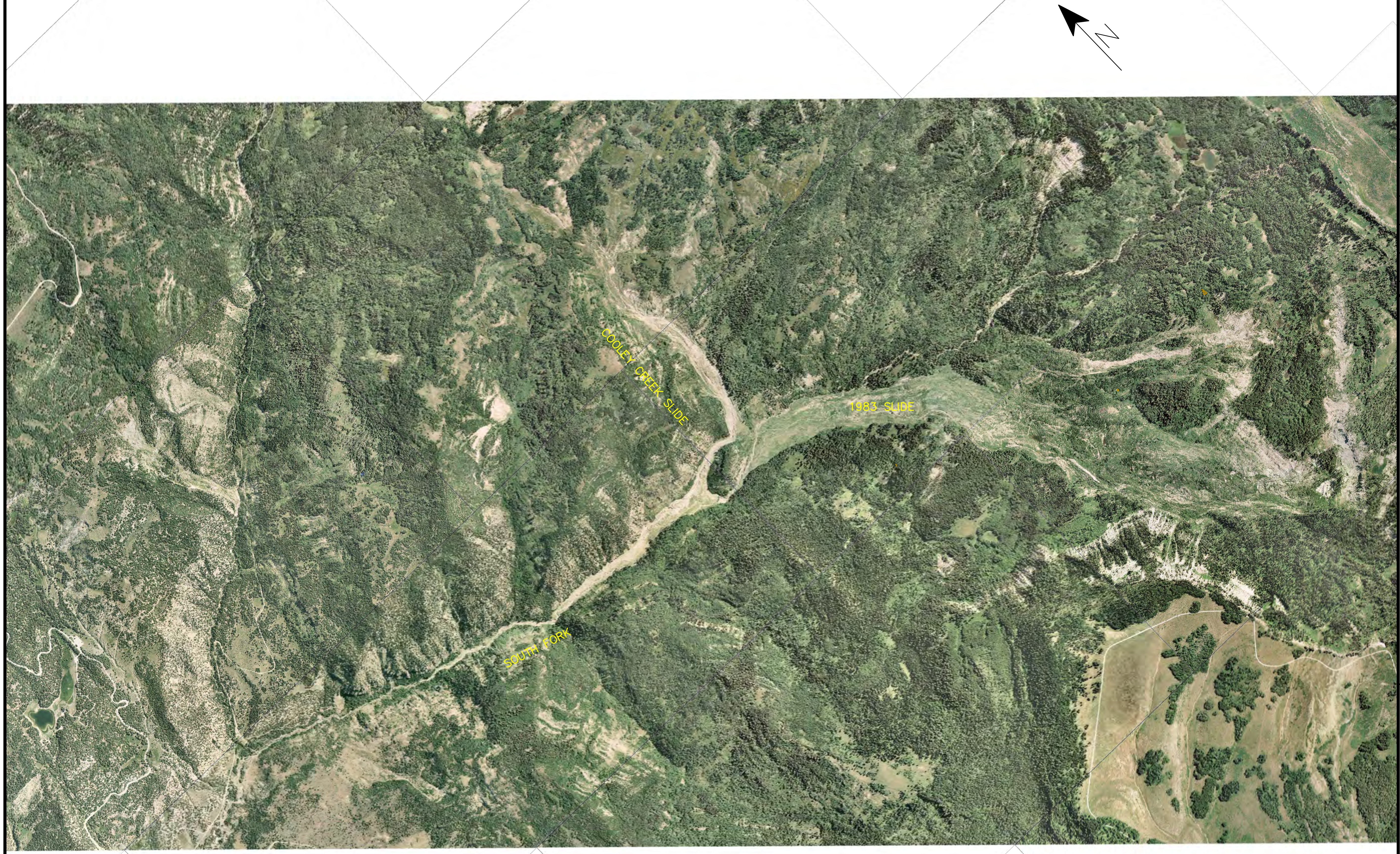
PROJECT NUMBER: 0711-190

SCALE: 1"=4000'

ORIGINAL SUBMISSION FOR AUTHORIZATION
REVISIONS

DWG CREATED: CR_DATE
LAST UPDATE: 11/25/2008

SANPETE COUNTY
SHEET NO. A2



SANPETE COUNTY

TWELVEMIL:E CANYON

SOUTHFORK DRAINAGE

PROJECT NUMBER: 0711-190

Jones & DeMille Engineering, Inc.
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APPROVAL RECOM.: DATE PROJECT DESIGN ENGINEER

APPROVED: DATE

DESIGN: . CHECK: .

DRAWN: . CHECK: .

QUANT: . CHECK: .

REVIEW

DATE: .

BY: .

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
	ORIGINAL SUBMISSION FOR AUTHORIZATION					

REVISIONS

SCALE: 1"=2000'

DWG NAME: SD-SITE_HIGH

SHT SET: ####

DWG CREATED: 11/25/2008

PEN TBL: [illegible]

LAST UPDATE: 11/26/2008

SANPETE COUNTY

SHEET NO. A3

SHEET NO. A4	SANPETE COUNTY	SANPETE COUNTY TWELVEMIL:E CANYON SOUTHFORK DRAINAGE PROJECT NUMBER: 0711-190	Jones & DeMille Engineering, Inc. 1535 South 100 West - Richfield, Utah 84701 Phone (435) 896-8266 Fax (435) 896-8268 www.jonesanddemille.com	ORIGINAL SUBMISSION FOR AUTHORIZATION REVISIONS

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APPROVED: ____ DATE	DRAWN: . .	CHECK: . .	DATE: .
	QUANT: . .	CHECK: . .	BY: .

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS

SCALE: 1"=2000'	DWG NAME: 3D-SITE_HIGH SHT SET: ####	DWG CREATED: 11/25/2008 PEN TBL: _1stndrd-b2000.ctb	LAST UPDATE: 11/26/2008

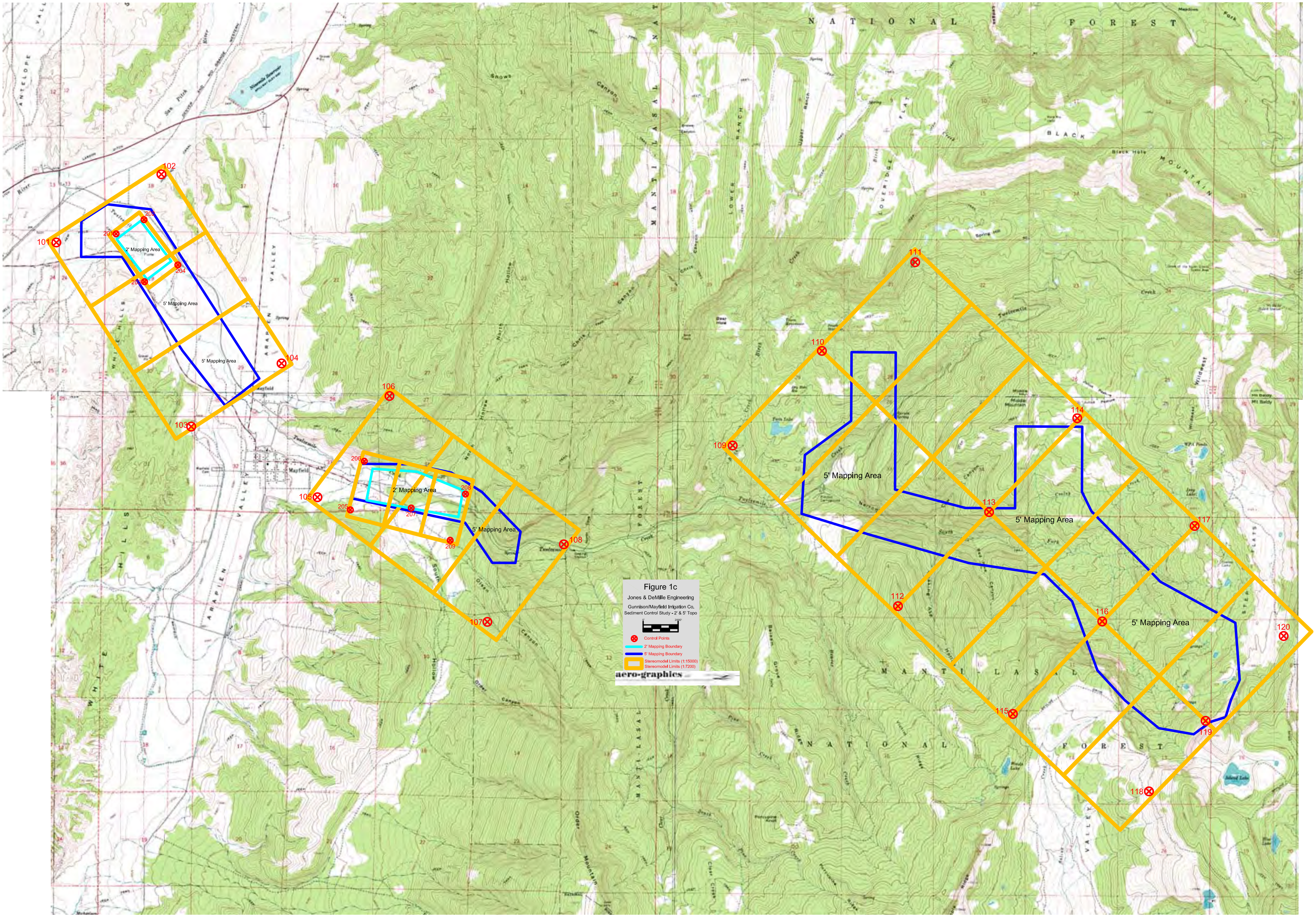
Figure 1c
Jones & DeMille Engineering
Gunnison/Mayfield Irrigation Co.
Sediment Control Study - 2' & 5' Topo
0'
2000'
Control Points
2' Mapping Boundary
5' Mapping Boundary
Stereomodel Limits (1:15000)
Stereomodel Limits (1:7200)
aero-graphics
2' Mapping Area
5' Mapping Area
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N A T I O N A L
F O R E S T
M A N T I - L A S A L
BLACK MOUNTAIN
Mayfield
Twelvemile
ARAPIEN VALLEY
WHITE HILLS

APPENDIX B

GEOTECHNICAL REPORT

GEOLOGICAL EVALUATION AND SUPPORT FOR GEOTECHNICAL PLANNING AND ECONOMIC COST-BENEFIT ANALYSES FOR CONTROL OF SEDIMENT IN IRRIGATION WATER FROM TWELVEMILE CREEK SANPETE COUNTY, UTAH

February 3, 2009

A report prepared for:

Jones & DeMille Engineering
1535 South 100 West
Richfield, UT 84701

GEOLOGICAL EVALUATION AND SUPPORT FOR GEOTECHNICAL PLANNING AND ECONOMIC COST-BENEFIT ANALYSES FOR CONTROL OF SEDIMENT IN IRRIGATION WATER FROM TWELVEMILE CREEK SANPETE COUNTY, UTAH

File No.: 92092

Prepared By:

LICENSED PROFESSIONAL GEOLOGIST
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STATE OF UTAH

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Project Geologist

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Principal Geotechnical Engineer

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February 3, 2009

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FIGURES

1. INTRODUCTION

1.1 PURPOSE AND SCOPE-OF-WORK

The Twelvemile Creek area is located on the western side of the Wasatch Plateau, with surface elevations ranging from 5,400 feet to over 10,000 feet, encompassing an approximately 38,000-acre drainage area. Manti-La Sal National Forest Lands cover much of the Twelvemile Creek drainage area. Beginning in the high runoff years of 1982 through 1984, landslides and earthflows were either activated or reactivated in the Twelvemile Canyon drainage, initially in the drainage of the South Fork of Twelvemile Creek. Additional landslide and earthflow movement initiated in 1998 in the adjacent Cooley Creek drainage, resulting in a coalescence of landslide deposits at the confluence of South Fork of Twelvemile Creek and Cooley Creek. The historical movement of the two landslide areas has resulted in large increases in sediment loads which are transported down stream by Twelvemile Creek where they become diverted into the Mayfield and Gunnison Irrigation Companies systems. These high sediments have caused extensive and costly damages to the irrigation systems, as well as to the crops and lands irrigated with water from these companies (Boore, 1986).

Although extensive areas of active and inactive landsliding have been mapped in the Twelvemile Creek Drainage (Witkind, et al, 1987; Harty, 1993), these features have not been studied in detail or in relevance to sediment loads. To assist in mitigating this problem, Kleinfelder has prepared this geological evaluation to support the Geotechnical Planning and Economic Cost-Benefit Analyses for Control of Sediment in Irrigation Water from Twelvemile Creek.

The objectives and scope of this study were planned through correspondence between Mr. Timothy Jones, P.E., of Jones and DeMille Engineering Inc., and Dr. Greg Schlenker of Kleinfelder. The objectives and scope for this evaluation are as follows:

1. Develop an understanding of the affected geological environment through GIS data acquisition and literature review and to attend and participate in one partner development scoping meeting.

2. Prepare and deliver a report summarizing the geological characterization of the affected environment, GIS data files developed during our characterization analyses, and participate in one project partner meeting to discuss the results of the data evaluation and characterization.

Authorization to perform this study was provided by Mr. Jones with the signing of our Master Services Agreement dated January 7, 2008.

1.2 AFFECTED ENVIRONMENT

The Mayfield Water Company diverts water for their system at the mouth of Twelvemile Canyon, and the Gunnison Water Company diverts water approximately 4.5 miles down stream of the Mayfield diversion. The Twelvemile Creek drainage area is located on the western side of the Wasatch Plateau near the town of Mayfield, as shown on Figure 1. In the vicinity of the Twelvemile drainage, the Wasatch Plateau has surface elevations ranging from 5,400 feet to over 10,000 feet (Witkind et al., 2007), with slopes ranging from level to over 90 percent. Above the Mayfield diversion, the drainage encompasses 37,908 acres. This area is divided into four tributary sub-drainages; Clear Creek, Birch Creek, Headwaters, and South Fork. A tabulation of these sub-drainages areas is included in Table 1, and the locations of the sub-drainage areas are shown on Figure 1.

Table 1
Twelvemile Canyon Sub-Drainage Areas

Sub-Drainage Name	Area Acres
Birch Creek	6,310
Clear Creek	11,308
Headwaters	10,053
South Fork	10,237
Total Area	**37,908**

Cover in the Twelvemile study area generally consists of sagebrush, grass, and pinion juniper woodlands below elevations of 7,000 feet. Above 7,000 feet the cover generally consists of aspen fir forests with grass and sedge occupying open areas (Utah AGRC, 2001).

2. METHODS OF STUDY

2.1 INVESTIGATION

The engineering geology of the Twelvemile Canyon vicinity was interpreted through an integrated compilation of data, observations, and analyses, including a review of literature and mapping from previous studies conducted in the area (Robinson, G.B., 1971; Harty, 1993; Witkind, et al., 1987), a photogeologic analyses of 2006 imagery, GIS analyses of elevation and terrain data, and a field reconnaissance of the site. The engineering geology conditions interpreted from our reviews and analyses were verified during the field reconnaissance. Subsurface explorations were not within the scope of this study.

2.2 SITE OBSERVATIONS

On-site observations were made at the locations of the South Fork landslide and the Cooley Creek landslide during our reconnaissance on June 25, 2008. Photographs of the slide areas at the time of our observations are included on Figure 2. Also during our reconnaissance on June 25, 2008, we met with members of the Mayfield Water Company board to discuss details and gain information relevant to this study.

2.3 GEOGRAPHIC INFORMATION DATA

Geographic information relevant to this study was obtained from the State of Utah and the Federal Government. The state sources included Automated Geographic Reference Center (AGRC), and the Utah Geological Survey (UGS). The Federal data was obtained online from the U.S. Geological Survey (USGS) National Geologic Map Database (USGS) and Quaternary Fault and Fold Database of the United States (*http://earthquake.usgs.gov/regional/qfaults/*). The Manti-La Sal National Forest also provided requested geographic information layers. The geographic information layers of relevant use to the study are tabulated in Table 2:

Table 2
Geographic Information Layers Used For Study Analysis

Layer Name	Description	Layer Type	Layer Source
q2521, q2522, q2523 q2621, q2622 and q2623	1:24,000 Scale USGS topographic maps (pre-1983 topography)	Raster	AGRC
NAIP2006_Sanp1.img q2523_sw_NAIP2006 q2523_nw_NAIP2006 q2623_sw_NAIP2006	1-Meter resolution color USDA National Agricultural Imagery Program Arial Imagery (2006 overflight)	Raster	AGRC
Merged_DEM_ASC	1:24,000 5-Meter Digital Elevation Model merged for study area coverage (2006 topography)	Raster	AGRC Kleinfelder
Shaded	Merged_DEM_ASC converted to a shaded relief rendering of study area	Raster	AGRC Modified by Kleinfelder
q100_9866_us_c.sid	1:100,000 geologic mapping raster file of the Manti 30' X 60 Quadrangle, Utah, by Witkind et al, 1987	Raster	USGS
SGID_U100_ForestServiceBoundary	1:100,000 scale shape file of Forest Service Lands Boundaries.	Vector	AGRC
SGID_U100_Landslides_Areas	1:100,000 scale shape file of Landslide areas as Mapped by Harty (1993)	Vector	AGRC
geounits	1:100,000 geologic mapping shape file of the Manti 30' X 60 Quadrangle, Utah, by Witkind et al, 1987	Vector	UGS
GLQ_Witkind_12mile_Clip	Geologic mapping by Witkind et al, (1987) modified by Kleinfelder to provide greater detail to	Vector	UGS Modified by Kleinfelder

Layer Name	Description	Layer Type	Layer Source
	Twelvemile drainage area.		
twelvmile_plus_motorized_trails 2	Shape file map of motorized trails in the vicinity of the Twelvemile drainage	Vector	Manti-La Sal National Forest
SGID_U024_Watersheds_Area	1:24,000 Scale shape file mapping of Sanpete County watersheds	Vector	AGRC
12_Mile_Drainage	SGID_U024_Watersheds _ Area modified to include only Twelvemile drainage area	Vector	AGRC Modified by Kleinfelder
Watersheds_Area	SGID_U024_Watersheds _ Area modified to include sub-drainage detail for Twelvemile drainage area	Vector	AGRC Modified by Kleinfelder
Faults	1:100,000 geologic mapping of structural faults shape file of the Manti 30' X 60 Quadrangle, Utah, by Witkind et al, 1987	Vector	UGS
qFaults	1:100,000 mapping of Quaternary age faults compiled for the United States (USGS and UGS, 2008)	Vector	USGS
SGID_U024_Streams	1:24,000 Scale shape file mapping of Sanpete County streams	Vector	AGRC
12_Mile_Streams_Post_failure	1:24,000 Scale shape file mapping of Sanpete County with modifications to the Twelvemile drainage area	Vector	AGRC Modified by Kleinfelder

3 GEOLOGIC CONDITIONS

3.1 GEOLOGIC SETTING

Twelvemile Canyon is located on the Wasatch Plateau, which is considered to be the transition zone between the Colorado Plateau Province and the Basin and Range Physiographic Provinces (Hunt, 1967, Stokes 1987). In the vicinity of Twelvemile Canyon, the plateau is an uplifted monoclinal structure which plunges steeply westward beneath Arapein Valley on its western margin near the town of Mayfield. Near the crest of the plateau, the geological structure is near-horizontal.

Geologic formations exposed in Twelvemile Canyon include the Upper Cretaceous Blackhawk Formation, the Castle Gate Sandstone, and the Price River Formation. Overlying the Upper Cretaceous formations are the Tertiary North Horn Formation and the Flagstaff Limestone. Twelvemile Creek and its tributaries have incised drainages into the plateau exposing these formations and also oversteepening slopes resulting in slope failures in many areas of the Twelvemile drainage.

3.2 TWELVEMILE DRAINAGE ENGINEERING GEOLOGY

The engineering geology of the drainage is shown on Figure 3. The pre-Quaternary (pre 1.6 million years age) surfacial geology consists of sandstone (SS) of the Blackhawk Formation, and the Castle Gate Sandstone that are overlain by conglomerate and sandstone (CG/SS) of the Price River Formation. The North Horn Formation (MS/CS/SS) consists of alternating beds of mudstone, claystone, and sandstone, and the Flagstaff Limestone (LS) overlies the North Horn Formation.

The Quaternary deposits include landslide deposits that cover much of the Twelvemile drainage area. The landslide deposits are classified as either earthflow deposits (S(f)c-b) that display primarily flow type of movement, or as complex deposits (S(c)c-b) that display a combination of movement modes (Varnes, 1978). A small area of glacial till (G(t)c-b) has been deposited by Pleistocene glaciation near the crest of the plateau on the southwest side of the drainage. Alluvial stream deposits (A(s)m-b) occupy the stream channel along Twelvemile Creek.

3.3 SEISMICITY AND FAULTING

North to south trending normal faults shown on Figure 3 appear to have displaced the pre-Quaternary rocks in the drainage, but do not appear to have displaced Quaternary deposits. The nearest active faulting is traces associated with the Snow Lake graben, and are shown on Figure 3 as located only 1,300 feet west of the Twelvemile drainage (Black et al., 2003; USGS, and UGS, 2008).

The drainage is located within the Intermountain Seismic Belt, a seismically active region that extends from Arizona to Montana (Arabasz and Smith, 1981). Active faults in the region are potential sources for seismic loading hazards for the alignment. Active earthquake faults are considered faults that have moved during the past 15,000 years.

On the basis of both probabilistic (Frankel, et al., 1997, 2002) and deterministic (Halling, et al., 2002) ground shaking hazard analyses, the Snow Lake graben faults appear to be the greatest contributor to the seismic hazard in the drainage area. The Snow Lake graben faults should be considered active and capable of generating earthquakes as large as magnitude 6.78 (Halling, et al., 2002). Surface faulting commonly occurs in conjunction with events of magnitude 6 or larger.

Based on probabilistic estimates (Frankel, et al., 1997, 2002), the expected peak horizontal ground acceleration on rock from a large earthquake with a 10 percent probability of exceedance in 50 years is as high as 0.15*g*, and for a 2 percent probability of exceedance in 50 years is as high as 0.33*g* for the drainage area. Ground accelerations greater than these are possible but will have a lower probability of occurrence. Deterministic estimates by Halling et al. (2002) indicate the deterministic maximum peak bedrock horizontal acceleration for the drainage area would be between 0.50 and over 0.60*g*.

3.4 LANDSLIDING AND SEDIMENT LOADING MECHANISMS

Approximately 11,170 acres of the Twelvemile Creek drainage is covered with landslide deposits (S(f)c-b and S(c)c-b). This comprises roughly 30-percent of the entire drainage. The area covered by landslide deposits, broken down by sub-drainage, is shown on Table 3.

Table 3
Twelvemile Canyon Landslide Area by Sub-Drainage

Sub-Drainage Name	Area Acres	Landslide Area Acres	Percent Area
Birch Creek	6,310	614	9.7
Clear Creek	11,308	1,753	15.5
Headwaters	10,053	5,005	49.8
South Fork	10,237	3,798	37.1
Total Area	**37,909**	**11,170**	**29.5**

The historic landslides, landslides that have moved since 1983, are shown on Figure 4. These landslides include the Cooley Creek landslide (72 acres), the South Fork landslide (430 acres), and the currently active portion of the South Fork landslide (32 acres), and comprise a total of 534 acres. The historic landslide area comprises only 1.5-percent of the Twelvemile drainage; however, the historic landslide areas appear to be the primary source for the excessive sediment in the Twelvemile drainage that is damaging the irrigation systems. The Cooley Creek landslide and the currently active portion of the South Fork landslide are interpreted to be active based on the observed lack of re-vegetation and the deformation of soils on the surface. These two slide areas probably undergo movement during the Spring of each year. Based on observed re-vegetation, the South Fork landslide appears to be presently inactive.

The active landslides should be expected to undergo future movement particularly when moist climate conditions prevail as experienced during the years of 1983 and 1998 (Fleming and Schuster, 1985; Ashland, 2003). Although mapped landslides in the Twelvemile drainage may not be experiencing movement, these areas should be recognized as having soil and rock strengths that were weakened during the past activity, and may become susceptible to renewed activity in response to changes in climatic conditions and/or slope modifications. Also, near-by seismic ground motion from a future earthquake may trigger movement on both active and inactive landslides. In the Twelvemile drainage, both the active and the inactive landslide deposits appear to be associated with soils developed over the North Horn Formation (MS/CS/SS). The North Horn Formation is relatively weak and has been observed to be susceptible to failure (Duncan et al., 1986; Ashland, 1997).

During our June 25, 2008, reconnaissance, we observed significant sediment in Twelvemile Creek near the Mayfield diversion as documented on Figure 2-A. At the historical landslide areas we observed that mapped courses of South Fork, Twelvemile Creek, Cooley Creek, and tributaries to these two streams had changed significantly since the movement occurred based on pre-1983 USGS mapping. We observed that streams that cross the historical landslide areas were undergoing incisive erosion and down-cutting their channel beds resulting in oversteepened cut banks that were locally failing into the streams as shown on Figures 2-C and 2-E. These smaller local failures along the streams appear to be the primary mode of sediment loading into the streams. Based on our mapping, we estimate that approximately 9.8 miles of streams cross the historical landslide areas. As future movement continues on the active landslides, including the Cooley Creek landslide and the currently active portion of the South Fork landslide, we would anticipate the sediment loading into the streams to continue.

4. CONCLUSIONS

4.1 CONCLUSIONS

The historical landslide movement that is resulting in the excessive sediment from the Twelvemile drainage is both large in area and complex in terms of mode of movement. Thus, mitigation strategies to control future movement would in turn require large and complex structural, re-grading, and/or dewatering efforts that would need to be based upon detailed engineering studies. Additionally, the historical landslide areas are surrounded by steep slopes and access is presently limited to all terrain vehicle trails. It is our opinion that multiple mitigation strategies will be required to mitigate the excessive sediment loads in this area.

5. CLOSURE

5.1 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

Kleinfelder offers various levels of investigative and engineering services to suit the varying needs of different clients. Although risk can never be eliminated, more detailed and extensive studies yield more information, which may help understand and manage the level of risk. Since detailed study and analysis involves greater expense, our clients participate in determining levels of service, which provide information for their purposes at acceptable levels of risk. The client and key members of the design team should discuss the issues covered in this report with Kleinfelder, so that the issues are understood and applied in a manner consistent with the owner's budget, tolerance of risk and expectations for future performance and maintenance.

The work performed was based on project information provided by Jones & DeMille. If Jones & DeMille does not retain Kleinfelder to review any plans and specifications, including any revisions or modifications to the plans and specifications, Kleinfelder assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Jones & DeMille must obtain written approval from Kleinfelder's engineer that such changes do not affect our recommendations. Failure to do so will vitiate Kleinfelder's recommendations.

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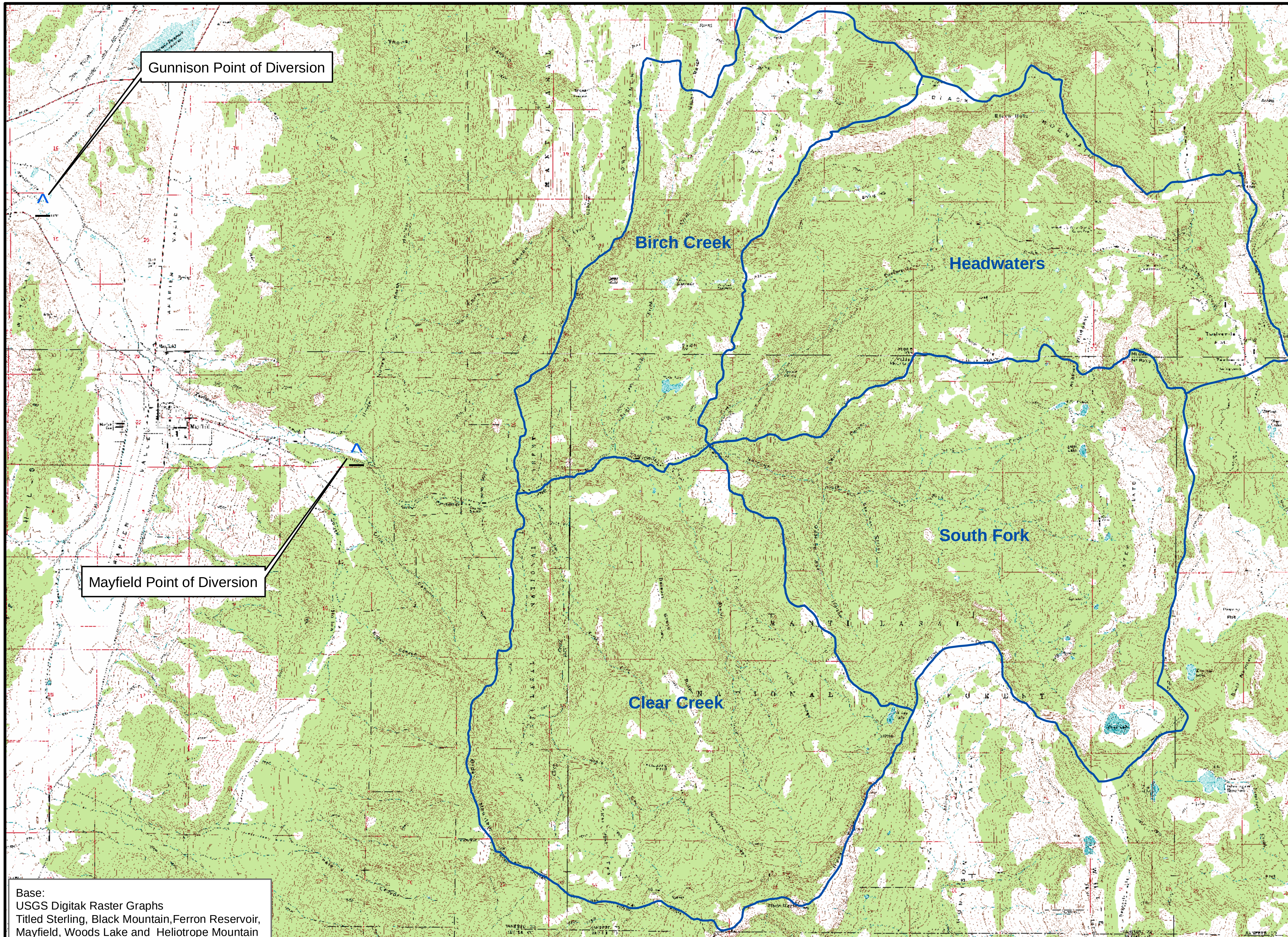
FIGURES



Base:
USGS Digitak Raster Graphs
Titled Sterling, Black Mountain,Ferron Reservoir,
Mayfield, Woods Lake and Heliotrope Mountain

Table 1

Twelvemile Canyon Sub-Drainage Areas

Sub-Drainage Name	Area Acres
Birch Creek	6310
Clear Creek	11308
Headwaters	10053
South Fork	10237
Total Area	37908

Sub-Drainage Boundaries

N

0 3,200 6,400 12,800 19,200 25,600 Feet

1:72,000

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Twelvemile Canyon Drainage Area

Geological Evaluation and Support for Geotechnical Planning and Economic Cost-Benefit Analyses for Control of Sediment in Irrigation Water
Twelvemile Creek Sanpete County, Utah

FIGURE 1

Cartography By: GCS | Date: 11/05/08 | Project Number: 92092 | File Name: SLC9A013

Figure 2-A Twelvemile Creek near the Mayfield Diversion

Figure 2-C Cooley Creek erosion of landslide deposits

Figure 2-E South Fork Twelvemile Creek erosion of landslide deposits

Figure 2-B Cooley Creek (1998) Landslide

Figure 2-D South Fork (1983) Landslide

Figure 2-E South Fork (1983) Landslide currently active portion

N

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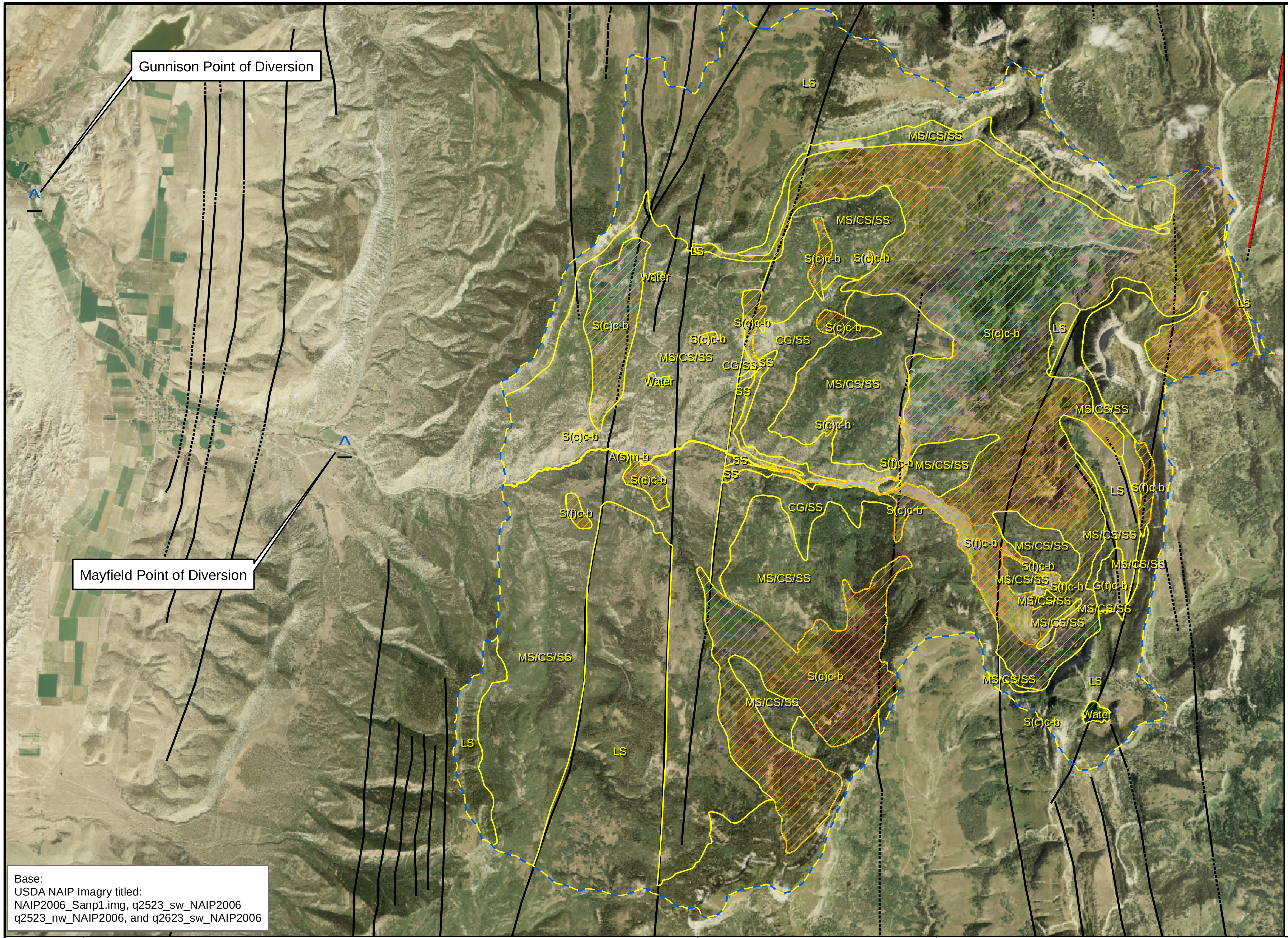
Twelvemile Canyon Site Observations

Geological Evaluation and Support for Geotechnical Planning and Economic Cost-Benefit Analyses for Control of Sediment in Irrigation Water
Twelvemile Creek Sanpete County, Utah

FIGURE 2

Cartography By: GCS | Date: 02/03/2009 | Project Number: 92092 | File Name: SLC9A014.mxd



Explanation

A(s)m-b - Alluvial stream deposits silt to boulder size particles

G(t)c-b - Glacial till deposits clay to boulder size particles

S(c)c-b - Landslide complex deposits clay to boulder size particles

S(f)c-b - Landslide earthflow deposits clay to boulder size particles

LS - Limestone bedrock

MS/CS/SS - Mudstone, claystone and sandstone bedrock formation

CG/SS - Conglomerate and sandstone bedrock formation

SS - Sandstone bedrock formation

Water

Landslide Areas

Faults

Approximate Loaction

Inferred Location

Trace

Actice Holocene Trace

Drainage Boundary

N

0 3,000 6,000 12,000 18,000 24,000 Feet

1:72,000

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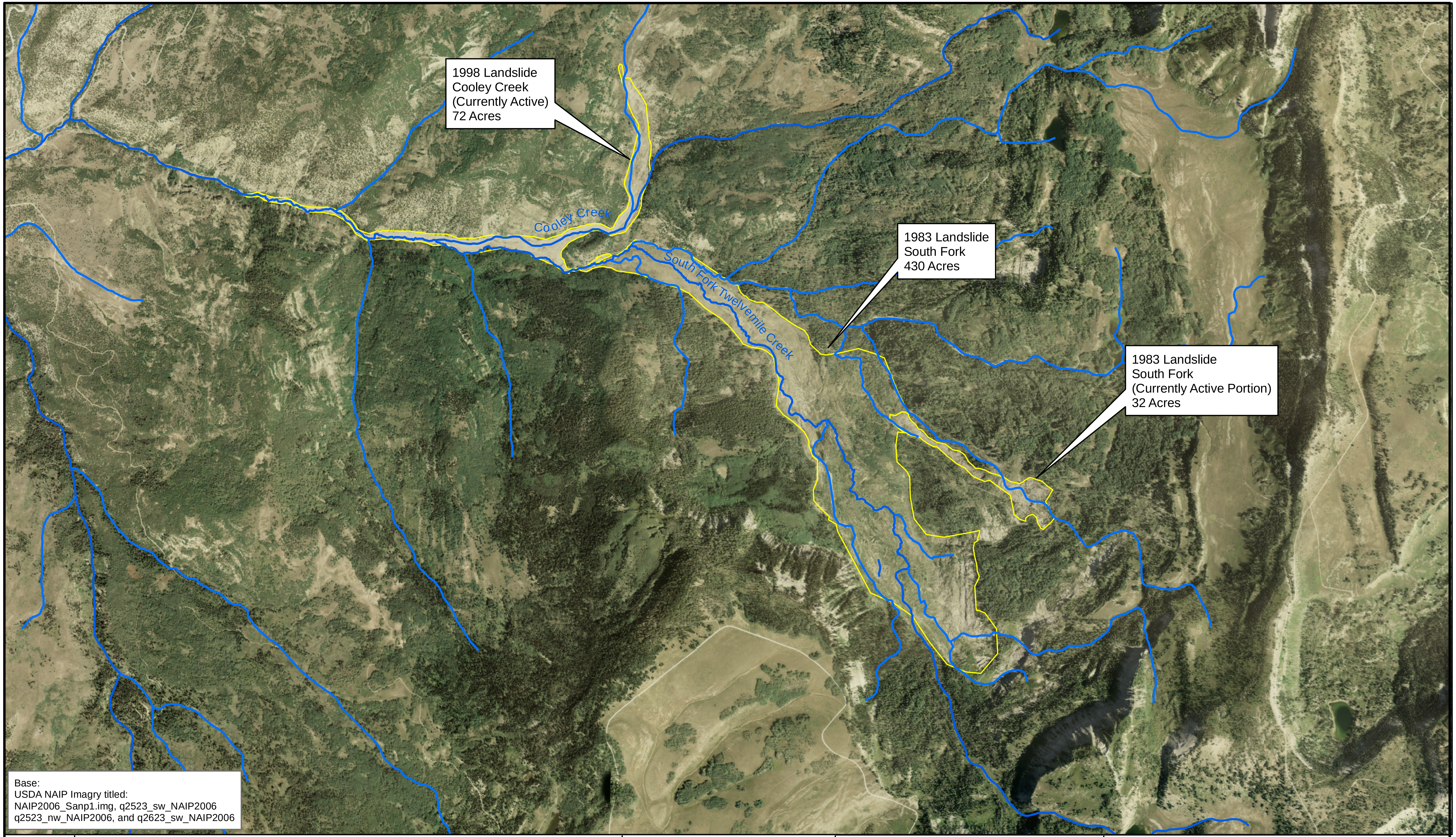
Twelvemile Canyon Engineering Geology

Geological Evaluation and Support for Geotechnical Planning and Economic Cost-Benefit Analyses for Control of Sediment in Irrigation Water
Twelvemile Creek Sanpete County, Utah

FIGURE 3

Cartography By: GCS | Date: 11/05/08 | Project Number: 92092 | File Name: SLC9A015



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Historical Landslide Movement Areas

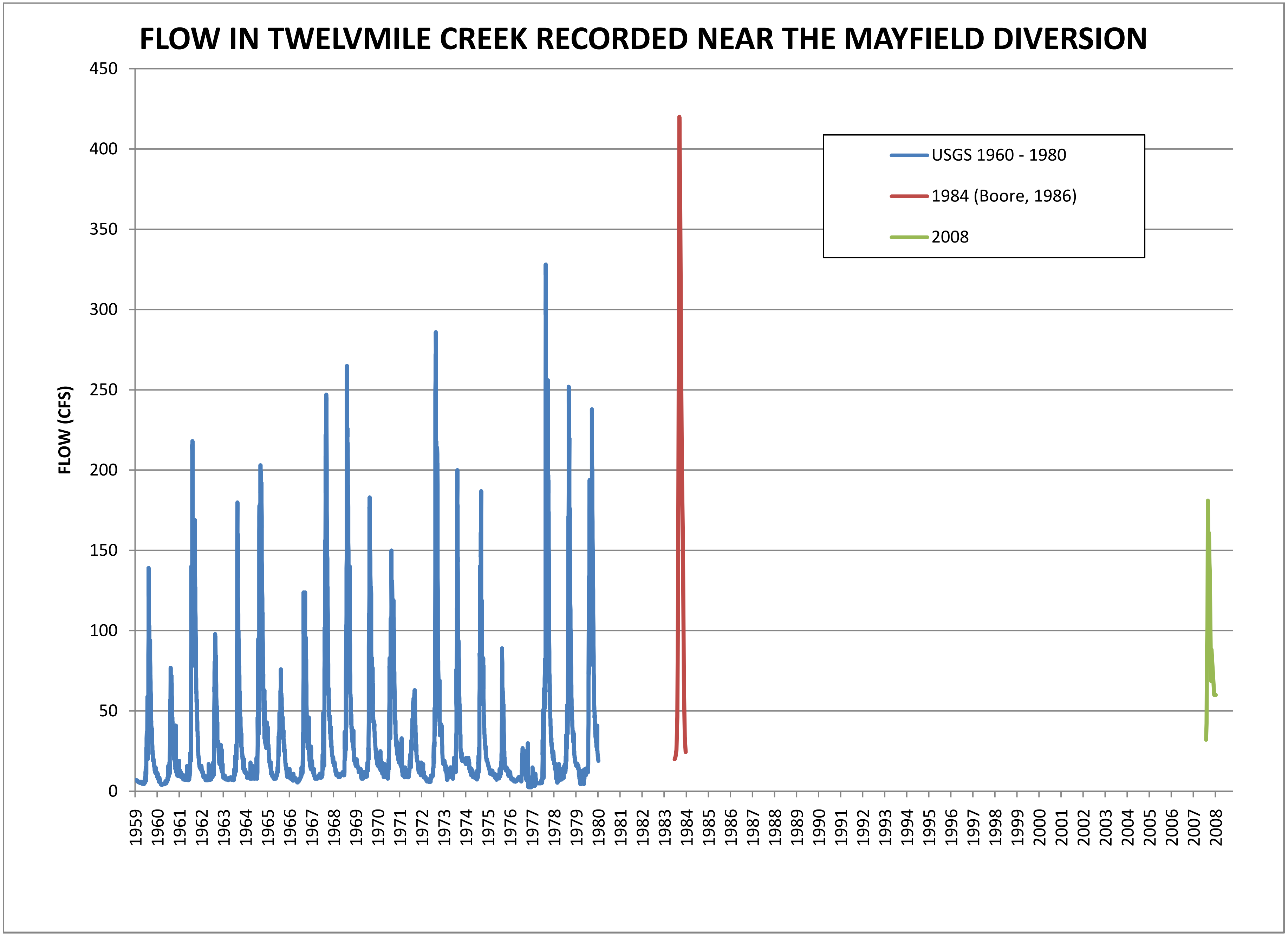
Geological Evaluation and Support for Geotechnical Planning and Economic Cost-Benefit Analyses for Control of Sediment in Irrigation Water
Twelvemile Creek Sanpete County, Utah

FIGURE 4

Cartography By: GCS | Date: 11/05/08 | Project Number: 92092 | File Name: SLC9A016

APPENDIX C

TWELVE MILE CREEK FLOW DATA



FLOW IN TWELVMILE CREEK RECORDED NEAR THE MAYFIELD DIVERSION
FLOW (CFS)
0
50
100
150
200
250
300
350
400
450
USGS 1960 - 1980
1984 (Boore, 1986)
2008
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
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1978
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2002
2003
2004
2005
2006
2007
2008

APPENDIX D

WATER QUALITY SAMPLING

Water Quality Sampling Plan

Twelve Mile Canyon Water Quality Study - 2008

OBJECTIVES

For this project the purpose of collecting water samples is to quantify constituents, namely suspended sediment, which is being transported in Twelve Mile Creek. The quantification of water borne constituents supports this project in five ways: (1) Quantifying the loading and determining the particle size distribution of the suspended sediment allows mitigation strategies, such as settling basins, to be better designed; (2) Collecting samples at all the major influent streams indicates which watershed areas are contributing most to the total suspended sediment, which allows mitigation strategies aimed at stabilizing the sediment within the watershed to be more focused; (3) Quantifying constituents that exceed state regulatory standards for the beneficial use of Twelve Mile Creek gives justification for federal and state funding in addition to permits for work to be completed on state and federal lands; (4) Comparing samples before and after the mitigation strategies are in place indicates how well the mitigation strategies are performing; (5) Comparing results to historical data gives greater understanding of how the watershed has changed over time.

CONSTITUENTS OF INTEREST

The major constituent of interest in Twelve Mile Creek is suspended sediment. The suspended sediment is classified by determining the concentration, loading and particle size of the suspended sediment. The concentration is determined by collecting a sample, using standardized methods, and analyzing the sample using standard laboratory methods to determine the volume and/or mass of the undissolved solids. This mass or volume of undissolved solids is divided by the total volume of the collected sample to determine the concentration (e.g. mg/L or mL/L). The loading of suspended sediment is the mass or volume of suspended sediment that passes a point over a set period of time (e.g. mg/sec or mL/sec). The loading is determined by multiplying the concentration of suspended sediment by the flow. The particle size distribution of the sediment is determined by drying a sample and running the dry material though gradually varied sieve sizes.

Although suspended sediment is the foremost constituent of concern, a sweep of other chemical constituents is measured to get a better view of the overall water quality of Twelve Mile Creek.

SAMPLING PLAN

In order to accomplish the objectives outlined above, water samples were collected at 20 sampling sites (See Figure 1 attached) on a weekly or monthly basis. The sampling site locations selected represent the water flowing from the major drainages within Twelve Mile Canyon and indicate the change in sediment loading along each reach, particularly in the slide areas. Table 1 describes the frequency of sample collection for each sampling site. At each sampling site a 1 liter sample is collected and the stream flow is recorded when a weir or flume is in place or estimated by measuring the width and average depth of the stream channel and then estimating the velocity using floatable matter. Flow estimated by multiplying the measured area by the estimated velocity resulted in theoretical flow rates higher than the measurement at the downstream weir. This result is expected because the velocity measured using a floatable material is higher than the velocity at the stream channel boundaries. A reducing factor of 0.8 is multiplied by the flow for each stream where the flow is estimated. This factor is determined by dividing the measurement made at the flow measuring device by the total flow from all streams above the flow measurement device.

Sampling Site 1 is the most downstream sampling site and is located downstream of the San Pitch River and Twelve Mile Creek confluence. The flow is not measured at this site.

Sampling Site 2 is located along the San Pitch River just upstream of the confluence with Twelve Mile Creek. The flow is not measured at this site.

Sampling Site3 is located just downstream of the Gunnison Irrigation Company's diversion within Twelve Mile Creek. At this location the flow is determined using an existing flume.

Sampling Site 4 is located just upstream of the Mayfield Irrigation Company's diversion structure within Twelvemile Creek. This is the most frequently sampled site because it represents the entire Twelve Mile Watershed and the water flow can easily be measured. During high flow conditions samples and flow measurements were made three times (morning, noon, night) on the sampling day.

Sampling Site 5 is located along Clear Creek. The flow is estimated at this site.

Sampling Site 6 is located along Birch Creek. The flow at this site is calculated based on the depth of water flowing through a culvert.

Sampling Site 7 is located along Beaver Creek. The flow is estimated at this site.

Sampling Site 8 is located along Twelve Mile Creek upstream of the confluence with the creek coming from the Narrows (South Fork). The flow is estimated at this site.

Sampling Site 9 is located along South Fork upstream of the confluence with Twelve Mile Creek. Samples from this site were collected weekly because it represents the watershed with the majority of the slide activity. The flow will be estimated at this site.

Sampling Site 10 is located along Cooley Creek at the base of the New Slide. The flow is estimated at this site.

Sampling Sites 11 and 12 are located along streams near Julius Flats and Cooley Creek, respectively, before it enters the new slide. The amount of sediment material being added to the downstream water from the Colley Creek Slide is able to be calculated by subtracting the loading at sampling sites 11 and 12 from sampling site 10. The flow is estimated at these sites.

Sampling Site 13 is located along South Fork just upstream of any debris caused by the Cooley Creek Slide. The flow is estimated at this site.

Sampling Site 14 is located just south of Shingle Mill Reservoir, upstream of any slide activity. The flow is estimated at this site.

Sampling Sites 15 and 16 take samples from the influent stream going into the Mayfield Irrigation Company's Reservoir and near the outlet from the Mayfield Irrigation Company's Reservoir, respectively. Data from these sampling sites in conjunction with data from Sampling Site 4 indicates how much sediment is being deposited in the reservoir, upstream canal, and desilting structure. The flow is measured at the Mayfield Diversion.

Sampling Site 17 and 18 are located on Gunnison Irrigation Company's Highline Canal just upstream and downstream of the settling basin located near State Route 137. The purpose of this sampling site is to determine how much sediment is being removed due to the settling basin and upstream canal. The flow is measured using the flume located along the Highline Canal.

Sampling Site 19 is located along the Highline Canal just downstream of the confluence of the water coming from Nine Mile. This sampling site is necessary to define the amount of sediment initially in the irrigation water prior to entering the over excavated canal and settling pond associated with Sampling Sites 17 and 18. The flow is measured using the flume located along the Highline Canal.

Sampling Site 20 is located close to the end of the Highland (in Axtell). Data from this sampling site indicates the amount of sediment being deposited along the length of the Highland Canal.

SAMPLE COLLECTION & FLOW MEASUREMENT

The Gunnison and Mayfield Irrigation Companies collected the majority of the suspended sediment samples and recorded the measured or estimated stream flow. The sediment samples are collected using a DH-81 suspended sediment sampler for flow depths of greater than 1 foot. This sampling device allows a depth integrated sample to be collected, assuming that heavier or more massive sediment particles are located closer to the stream bed than lighter or smaller sediment particles. Flow depths of less than 1 foot are assumed to be well mixed due to agitation of the stream by the rocky stream bed.

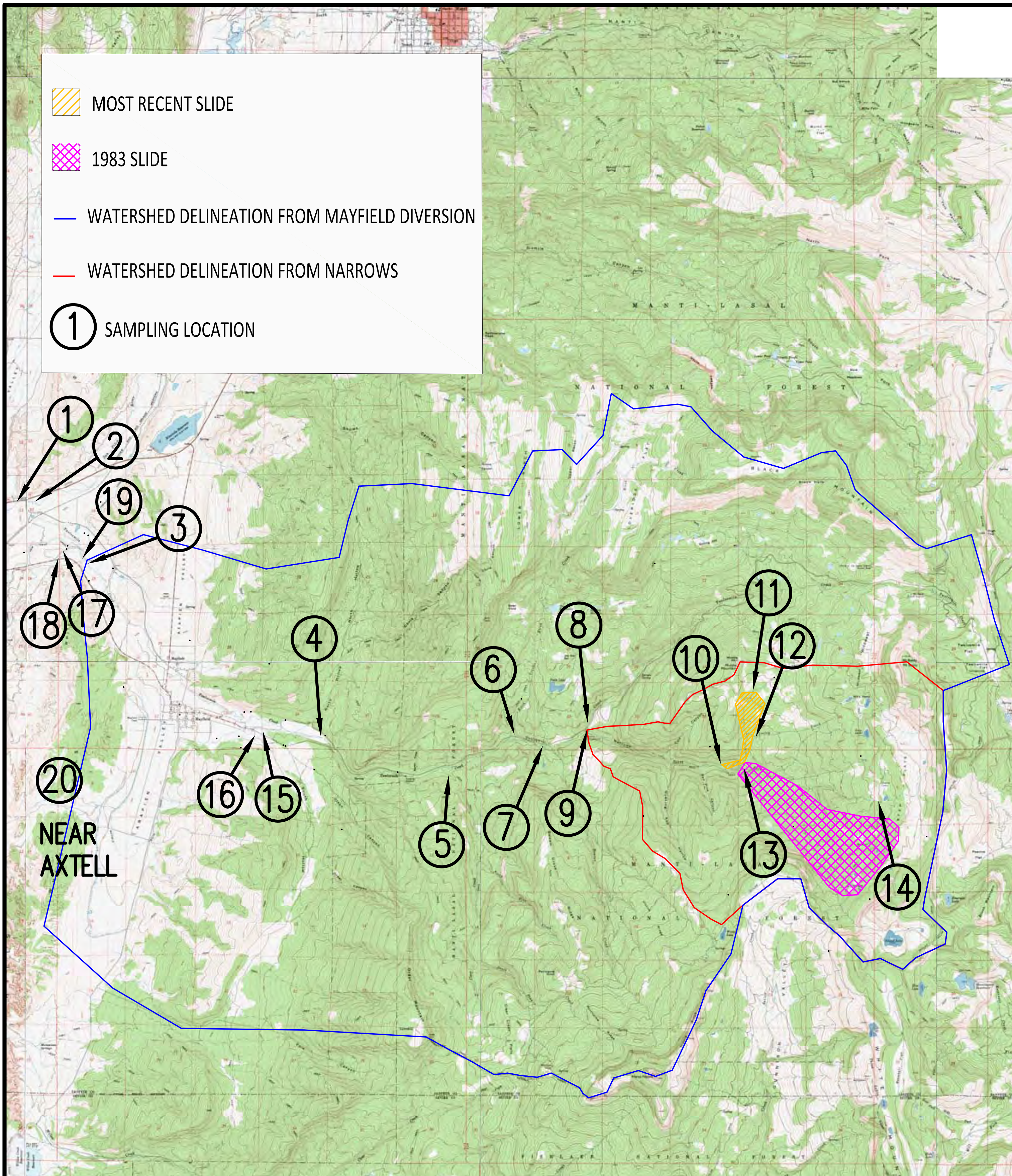
The stream flow is recorded when a weir or flume is in place or estimated by measuring the width and average depth of the stream channel and then estimating the velocity using floatable matter. Flow estimated by multiplying the measured area by the estimated velocity resulted in theoretical flow rates higher than the measurement at the downstream weir. This result is expected because the velocity measured using a floatable material is higher than the velocity at the stream channel boundaries. A reducing factor of 0.8 is multiplied by the flow for each stream where the flow is estimated. This factor is determined by dividing the measurement made at the flow measuring device by the total flow from all streams above the flow measurement device.

SAMPLE ANALYSIS

Jones and DeMille Engineering ran gradations on the suspended sediment and determined the amount of solids by dry weight (drying the sample) and the amount of settleable solids by volume (using an Imhoff cone). A qualified lab is used to determine the concentrations of other chemical constituents.

QUALITY ASSURANCE

A duplicate sample is taken at one sampling location each week. The location of the duplicate sample varies over the course of the sampling period.



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SCALE: 1" = 10,000'

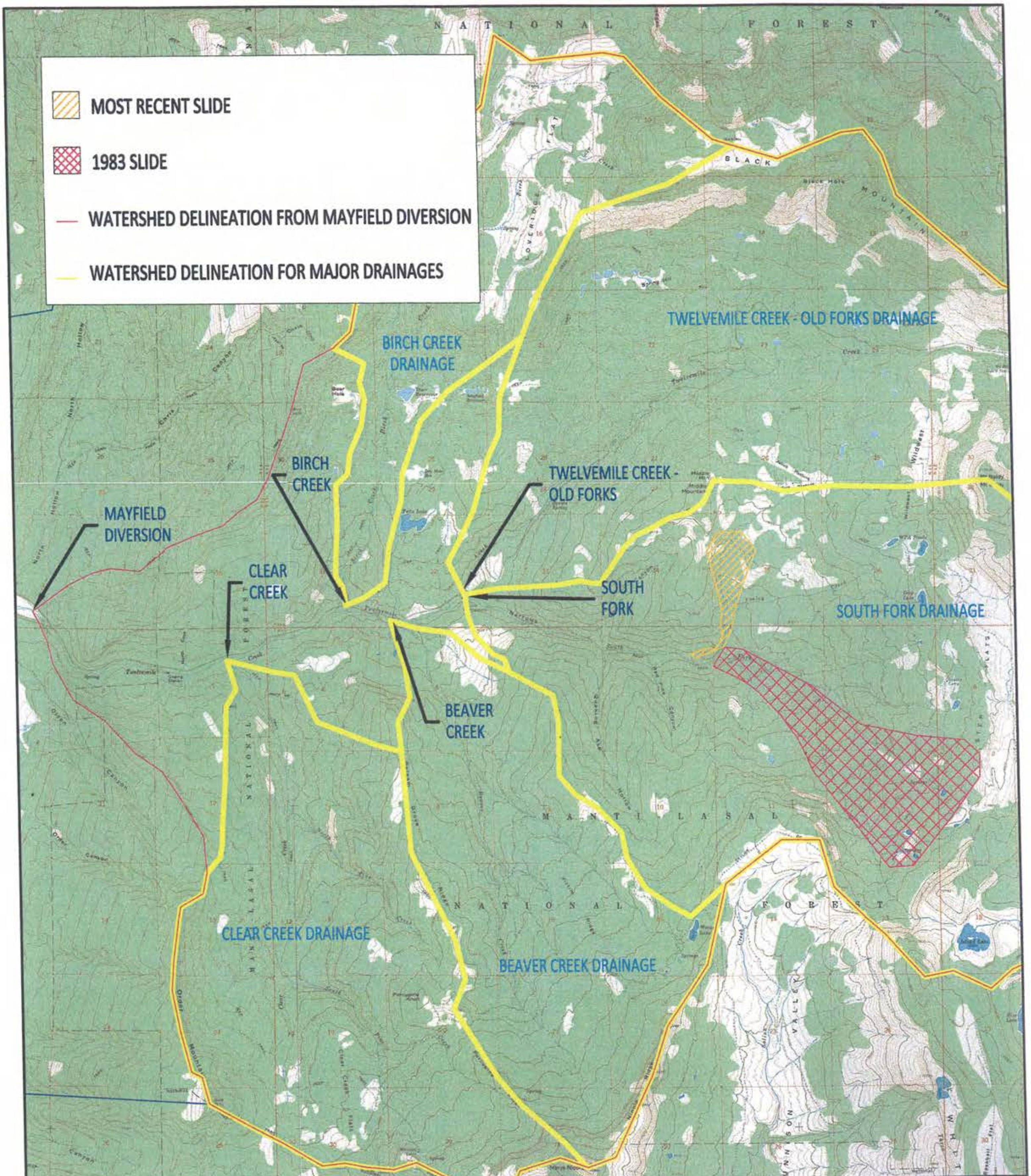
SANPETE COUNTY

FIGURE: 1

TWELVE MILE CANYON

WATER QUALITY SAMPLING LOCATIONS

DRAWN:
PEN TBL: _1stndrd-ir2800.ctb
PROJECT:
SHEET: 1
CHECK:
FILE: SLIDE
LAST UPDATE: 4/10/2008



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SCALE: 1" = 10,000'

SANPETE COUNTY			FIGURE: F1
TWELVE MILE CANYON			
WATER QUALITY SAMPLING LOCATIONS			
DRAWN:	PEN TBL: _1stndrd-ir2800.ctb	PROJECT:	SHEET: F1
CHECK:	FILE: SAMPLING	LAST UPDATE: 4/10/2008	

WATER SAMPLING													SEDIMENT TESTING				
Sampling Site	Bottle No.	Date	Time	Weather	WIDTH (FT)	DEPTH (FT)	TIME (SEC)	LENGTH (FT)	GAGE (FT)	Theoretical FLOW (CFS)	Adjusted FLOW (CFS)	Sampled by	Date	Time	Turbidity (NTU)	Wet Volume (mL/L)	Tested by
4 M	1	4/6/08	9:20 AM	Clear, Cool						--		GW	4/8/08	--	521.6	0.35	KN
9	2	4/6/08	9:20 AM	Clear, Cool						--		GW	4/8/08	--	510.1	0.80	KN
8	3	4/6/08	9:20 AM	Clear, Cool						--		GW	4/8/08	--	225.8	0.30	KN
7	4	4/6/08	9:20 AM	Clear, Cool						--		GW	4/8/08	--	3.76	0.00	KN
6	5	4/6/08	9:20 AM	Clear, Cool						--		GW	4/8/08	--	15.76	0.00	KN
1	13	4/18/08	4:50 PM	Sunny, Warm								TY	4/22/08	8:25 AM	701.8	1.00	PN
2	14	4/18/08	5:10 PM	Sunny, Warm								TY	4/21/08	3:30 PM	4.12	0.00	PN
3	9	4/18/08	4:10 PM	Sunny, Warm					0.25	5.2	5.2	TY	4/21/08	3:35 PM	705.2	0.80	PN
4 M	64	4/19/08	7:30 AM	Sunny, Cool					0.42	36.4	36.4	GW	4/25/08	9:01 AM	899.4	2.9	PN
4 A	1	4/18/08	2:30 PM	Sunny, Warm					0.35	28.0	28.0	TY	4/21/08	1:30 PM	797.2	1.20	PN
4 N																	
5	6	4/18/08	3:30 PM	Sunny, Warm	3.5	0.33	6	6		1.2	0.9	TY	4/21/08	3:25 PM	8.28	0.00	PN
6	5	4/18/08	3:17 PM	Sunny, Warm						0.6	0.5	TY	4/21/08	2:48 PM	97.08	0.00	PN
7	4	4/18/08	3:10 PM	Sunny, Warm	3	0.58	5	6		2.1	1.7	TY	4/21/08	2:45 PM	19.33	0.00	PN
8	3	4/18/08	3:00 PM	Sunny, Warm	8	0.58	7	16		10.7	8.5	TY	4/21/08	1:35 PM	835.3	1.00	PN
9	2	4/18/08	2:50 PM	Sunny, Warm	4.5	1.5	5	20		27.0	21.6	TY	4/22/08	10:45 AM	152	4.00	PN
10																	
11																	
12																	
13																	
14																	
15	7	4/18/08	3:40 PM	Sunny, Warm						12.6	12.6	TY	4/21/08	3:20 PM	150.1	0.00	PN
16	8	4/18/08	3:50 PM	Sunny, Warm						12.6	12.6	TY	4/21/08	3:27 PM	51.55	0.00	PN
17	10	4/18/08	4:30 PM	Sunny, Warm						53.0	53.0	TY	4/21/08	3:40 PM	214.7	0.40	PN
18	12	4/18/08	4:30 PM	Sunny, Warm						53.0	53.0	TY	4/22/08	7:15 AM	118.5	0.00	PN
19	11	4/18/08	4:16 PM	Sunny, Warm					1.08	53.0	53.0	TY	4/22/08	7:10 AM	275.5	0.40	PN
20	67	4/18/08	9:50 AM	Sunny, Warm					0.78	8.1	8.1	GW	4/22/08	8:30 AM	293.3	0.40	PN
9	40	4/26/08	6:34 AM	Frost Cool, Clear	4	1.5	2.5	8		19.2	15.4	TY	4/30/08	11:55 AM	1013	1.10	KN
4 M	36	4/26/08	6:54 AM	Frost Cool, Clear					0.42	36.4	36.4	TY	4/29/08	1:45 PM	755.2	0.90	KN
4 A	32	4/26/08	12:30 PM	45° Clear West Wind					0.42	36.4	36.4	RY	4/29/08	7:20 AM	292.7	0.30	KN
4 N	37	4/26/08	8:07 PM	warm sunny					0.52	54.0	54.0	TY	4/29/08	3:00 PM	1862.4	8.00	KN
3	17	4/26/08	7:13 AM	Cool Clear					0.30	7.0	7.0	TY	4/29/08	7:10 AM	1369.2	3.00	KN
20	64	4/26/08	1:30 PM	Cool Sunny					0.80	8.5	8.5	GW	4/29/08	1:55 PM	346.4	0.40	KN
9	13	4/26/08	6:30 PM	Cool Sunny								GW	4/30/08	11:45 AM	163.2	5.00	KN
1	4	5/3/08	12:10 PM	Warm Sunny								TY	5/6/08	12:10 PM	632.6	0.90	KN
2	$5M^2$	5/3/08	12:30 PM	Warm Sunny								TY	5/6/08	9:05 AM	3.31	0.00	KN
3	9	5/3/08	11:22 AM	Cloudy Warm					0.38	10.0	10.0	TY	5/6/08	12:15 PM	806.6	0.85	KN
4 M	18	5/3/08	8:42 AM	Sunny Warm					0.48	46.6	46.6	TY	5/6/08	12:24 PM	569.3	0.60	KN
4 A	31	5/3/08	1:20 PM	Sunny Warm					0.50	50.0	50.0	TY	5/6/08	1:43 PM	494.4	0.50	KN
4 N	20	5/3/08	8:35 PM	Sunny Warm					0.61	72.2	72.2	TY	5/6/08	12:27 PM	690.9	5.00	KN
5	67	5/3/08	10:30 AM	Sunny Warm	5	0.83	10.75	16		6.2	4.9	TY	5/7/08	9:45 AM	7.24	0.00	KN
6	2	5/3/08	10:15 AM	Sunny Warm						4.6	3.6	TY	5/6/08	12:10 PM	21.63	0.00	KN
7	49	5/3/08	10:02 AM	Sunny Warm	4	0.75	3.43	8		7.0	5.6	TY	5/7/06	9:40 AM	12.85	0.00	KN
8	50	5/3/08	9:34 AM	Sunny Warm	7	1	5.04	16		22.2	17.8	TY	5/7/08	9:34 AM	115.4	0.20	KN

WATER SAMPLING													SEDIMENT TESTING				
Sampling Site	Bottle No.	Date	Time	Weather	WIDTH (FT)	DEPTH (FT)	TIME (SEC)	LENGTH (FT)	GAGE (FT)	Theoretical FLOW (CFS)	Adjusted FLOW (CFS)	Sampled by	Date	Time	Turbidity (NTU)	Wet Volume (mL/L)	Tested by
9	51	5/3/08	9:19 AM	Sunny Warm	6	1.25	4.78	20		31.4	25.1	TY	5/8/08	8:25 AM	830.2	1.2	KN
10																	
11																	
12																	
13																	
14																	
15	12	5/3/08	10:55 AM	Cloudy Warm						22.5	22.5	TY	5/6/08	12:18 PM	521.8	0.00	KN
16	11	5/3/08	11:00 AM	Cloudy Warm						22.5	22.5	TY	5/6/08	12:30 PM	43.94	0.00	KN
17	30	5/3/08	12:53 PM	Warm Sunny					1.52	92.0	92.0	TY	5/6/08	1:40 PM	156	0.30	KN
18	33	5/3/08	12:53 PM	Sunny Warm					1.52	92.0	92.0	TY	5/7/08	9:25 AM	130.2	0.20	KN
19	34	5/3/08	11:14 AM	Cloudy Warm					1.52	92.0	92.0	TY	5/7/08	9:28 AM	213.5	0.20	KN
20																	
4 M	16	5/3/08	8:52 AM	Sunny Warm					0.48	46.6	46.6	TY	5/6/08	12:01 PM	518.3	0.60	KN
4 A	SM1	5/3/08	1:20 PM	Sunny Warm					0.50	50.0	50.0	TY	5/6/08	9:00 AM	496.4	0.40	KN
4 N	32	5/5/08	9:33 PM	Night Cool					0.98	150.6	150.6	GW	5/6/08	1:45 PM	181.2	6.50	KN
9	61	5/5/08	9:53 PM	Night Cool						100.0	80.0	GW	5/8/08	8:31 AM	107.8	7.00	KN
4A	60	5/6/08	7:00 AM	Dawn Cool					0.82	118.6	118.6	GW	5/8/08	8:28 AM	2144	2.00	KN
3	1	5/10/08	9:20 AM	Sunny Warm					0.90	40.0	40.0	TY	5/12/08	11:07 AM	1673.4	5.00	KN
4M	8	5/10/08	8:30 AM	Sunny Warm					0.69	89.8	89.8	TY	5/12/08	1:36 PM	552.6	0.60	KN
4A	19	5/10/08	1:30 PM	Sunny Warm					0.68	87.6	87.6	TY	5/12/08	1:38 PM	550.6	0.60	KN
4N	10	5/10/08	8:23 AM	Sunny Warm					0.87	130.1	130.1	TY	5/12/08	1:37 PM	1919	3.50	KN
9	6	5/10/08	8:55 AM	Sunny Warm	7	1.42	4.44	20		44.8	35.8	TY	5/12/08	11:10 AM	1071	1.20	KN
4M	63	5/10/08	8:30 AM	Sunny Warm					0.69	89.8	89.8	TY	5/12/08	1:39 PM	592.1	0.60	KN
4A	5	5/10/08	1:30 PM	Sunny Warm					0.68	87.6	87.6	TY	5/12/08	11:09 AM	496.6	0.70	KN
4N	7	5/10/08	8:23 AM	Sunny Warm					0.87	130.1	130.1	TY	5/12/08	1:35 PM	2094	3.00	KN
1	2	5/17/08	9:10 AM	Sunny Warm								TY	5/22/08	7:40 AM	963.9	1.70	KN
2	67	5/17/08	9:17 AM	Sunny Warm								TY	5/23/08	7:34 AM	5.25	0.00	KN
3	20	5/17/08	8:39 AM	Sunny Warm					1.48	88.0	88.0	TY	5/22/08	7:43 AM	1044	2.40	KN
4M	31	5/17/08	8:13 AM	Sunny Warm					0.95	145.5	145.5	TY	5/22/08	2:02 PM	867.1	2.00	KN
4A	34	5/17/08	12:51 PM	Sunny Warm					1.10	180.0	180.0	TY	5/22/08	2:04 PM	788.1	0.90	KN
4N	16	5/17/08	9:53 AM	Warm Clear Sky					1.24	217.6	217.6	TY	5/22/08	7:41 AM	554.1	16.00	KN
5	59	5/17/08	10:15 PM	Sunny Warm						35.0	28.0	TY	5/23/08	7:33 AM	577.3	1.75	KN
6	27	5/17/08	7:48 AM	Sunny Warm		0.92				23.3	18.6	TY	5/22/08	2:00 PM	404.3	0.80	KN
7	21	5/17/08	7:42 AM	Sunny Warm	1	1	1.98	12		6.1	4.8	TY	5/22/08	7:44 AM	131	0.40	KN
8	47	5/17/08	7:30 AM	Sunny Warm	8	1.83	3.6	16		65.1	52.1	TY	5/23/08	7:31 AM	408.1	1.40	KN
9	52	5/17/08	7:16 AM	Sunny Warm	8	2	3.24	20		98.8	79.0	TY	5/23/08	7:32 AM	2616	4.70	KN
10																	
11																	
12																	
13																	
14																	

WATER SAMPLING / SEDIMENT TESTING

Sampling Site	Bottle No.	Date	Time	Weather	WIDTH (FT)	DEPTH (FT)	TIME (SEC)	LENGTH (FT)	GAGE (FT)	Theoretical FLOW (CFS)	Adjusted FLOW (CFS)	Sampled by	Date	Time	Turbidity (NTU)	Wet Volume (mL/L)	Tested by
15	37	5/17/08	8:27 AM	Sunny Warm						65.5	65.5	TY	5/22/08	2:05 PM	850.9	0.85	KN
16	23	5/17/08	8:27 AM	Sunny Warm						65.5	65.5	TY	5/22/08	7:45 AM	48.08	0.00	KN
17	18	5/17/08	9:00 AM	Sunny Warm						89.0	89.0	TY	5/22/08	7:42 AM	1230.6	1.70	KN
18	30	5/17/08	9:00 AM	Sunny Warm						89.0	89.0	TY	5/22/08	2:01 PM	735.4	0.50	KN
19	32	5/17/08	8:44 AM	Sunny Warm					1.49	89.0	89.0	TY	5/22/08	2:03 PM	1081	2.50	KN
20																	
9	40	5/17/08	7:16 AM	Sunny Warm	8	2	3.24	20		98.8	79.0	TY	5/23/08	7:30 AM	1861.2	8.00	KN
3	9	5/24/08	9:55 AM	Partly Cloudy Cool					1.37	78.0	78.0	TY	5/28/08	9:40 AM	489.4	0.70	Pam
4M	12	5/24/08	8:59 AM	Partly Cloudy Cool					0.89	134.7	134.7	TY	5/28/08	9:41 AM	520.8	0.70	Pam
4A	19	5/24/08	12:23 PM	Partly Cloudy Warm					0.91	138.7	138.7	TY	5/28/08	9:42 AM	598.5	0.50	Pam
4N	30	5/24/08	10:00 PM	Dark , Cool					1.10	180.0	180.0					0.80	
9	46	5/24/08	9:24 AM	Partly Cloudy Cool	8	1.33	3.61	20		58.9	47.2	TY	5/28/08	9:44 AM	1412.4	2.20	Pam
9	57	5/24/08	9:28 AM	Partly Cloudy	8	1.33	3.61	20		58.9	47.2	TY	5/28/08	9:45 AM	1760.8	2.40	Pam
1	63	5/31/08	1:30 AM	Sunny, Warm								TY	6/6/08	8:36 AM	404.1	0.50	KN
2	14	5/31/08	11:40 AM	Sunny, Warm								TY	6/5/08	1:54 PM	2.77	0.00	KN
3	37	5/31/08	11:00 AM	Sunny, Warm					1.31	72.0	72.0	TY	6/6/08	7:19 AM	607.3	1.10	KN
4M	16	5/31/08	8:45 AM	Sunny, Warm					0.90	137.0	137.0	TY	6/5/08	1:52 PM	490.9	0.60	KN
4A	61	5/31/08	12:00 AM	Sunny, Warm					0.90	137.0	137.0	Ty	6/6/08	8:33 AM	524.6	0.50	KN
4N	1	5/31/08	9:54 AM	Clear, Cool					1.01	156.6	156.6	TY	6/8/08	1:45 PM	2004	3.50	KN
5	52	5/31/08	10:05 AM	Sunny, Warm	7	1.08	5	21		31.9	25.5	TY	6/6/08	7:25 AM	27.98	0.00	KN
6	50	5/31/08	9:52 AM	Sunny, Warm		0.83				19.1	15.3	TY	6/6/08	7:22 AM	84.12	0.20	KN
7	21	5/31/08	9:43 AM	Sunny, Warm	7	1.67	4	18		52.5	42.0	TY	6/6/08	7:10 AM	41.17	0.10	KN
8	5	5/31/08	9:37 AM	Sunny, Warm	11	1	4	14		38.5	30.8	TY	6/5/08	1:46 PM	108	0.00	KN
9	56	5/31/08	9:30 AM	Sunny, Warm	9	1.33	4	20		60.0	48.0	Ty	6/6/08	8:30 AM	1544.6	7.50	KN
10																	
11																	
12																	
13																	
14																	
15	31	5/31/08	10:15 AM	Sunny, Warm						61.7	61.7	TY	6/6/08	7:10 AM	469.7	0.60	KN
16	67	5/31/08	10:20 AM	Sunny, Warm						61.7	61.7	TY	6/6/08	7:10 AM	93.29	0.00	KN
17	18	5/31/08	11:30 AM	Sunny, Warm					1.78	118.0	118.0	TY	6/6/08	7:10 AM	408.1	0.40	KN
18	32	5/31/08	11:12 AM	Sunny, Warm					1.78	118.0	118.0	TY	6/6/08	7:10 AM	336.1	0.20	KN
19	7	5/31/08	11:05 AM	Sunny, Warm					1.78	118.0	118.0	TY	6/6/08	7:10 AM	455.1	0.70	KN
20																	
3	10	6/7/08	9:34 AM	Cloudy, Cool					1.62	102.0	102.0	TY	6/9/08	11:00 AM	738.9	0.90	DH
4M	60	6/7/08	8:54 AM	Cloudy, Cool					1.01	156.6	156.6	TY	6/9/08	11:12 AM	542	3.10	DH
4A	20	6/7/08	1:40 PM	Cloudy, Rainy					1.03	161.8	161.8	TY	6/9/08	11:03 AM	439.7	0.60	DH
4N	34	6/7/08	10:02 AM	Partly Cloudy					1.04	164.4	164.4	TY	6/9/08	11:09 AM	486.5	0.50	DH
9	27	6/7/08	11:40 AM	Cloudy, Rainy	10	1.75	3.24	20		108.0	86.4	TY	6/9/08	11:06 AM	1946.8	3.25	DH

WATER SAMPLING													SEDIMENT TESTING				
Sampling Site	Bottle No.	Date	Time	Weather	WIDTH (FT)	DEPTH (FT)	TIME (SEC)	LENGTH (FT)	GAGE (FT)	Theoretical FLOW (CFS)	Adjusted FLOW (CFS)	Sampled by	Date	Time	Turbidity (NTU)	Wet Volume (mL/L)	Tested by
1																	
2																	
3																	
4M																	
4A																	
4N																	
5																	
6																	
7																	
8																	
9																	
10	34	6/12/08		Sunny, Clear	2.5	0.42	3	8		2.8	2.2	TY	6/17/08	10:30 AM	684.3	0.70	KN
11	10	6/12/08		Sunny, Clear	3.5	0.21	3	6		1.5	1.2	TY	6/17/08	11:30 AM	50.19	0.00	KN
12	20	6/12/08		Sunny, Clear	3.5	0.33	6	10		1.9	1.5	TY	6/17/08	12:30 PM	45.8	0.00	KN
13	60	6/12/08		Sunny, Clear	16	1	3.5	14		64.0	51.2	TY	6/17/08	1:30 PM	725	0.70	KN
14	27	6/12/08		Sunny, Clear	4	0.42	3.5	10		4.8	3.8	TY	6/17/08	2:30 PM	40.47	0.00	KN
15																	
16																	
17																	
18																	
19																	
20																	
1	21	6/14/08	2:35 PM	Sunny, Clear								TY	6/23/08	1:10 PM	196.8	0.03	Pam
2	57	6/14/08	2:35 PM	Sunny, Clear								TY	6/23/08	2:35 PM	43.65	0.10	Pam
3	31	6/14/08	2:15 PM	Sunny, Clear					1.39	79.0	79.0	TY	6/23/08	1:10 PM	273.9	0.45	Pam
4M	61	6/14/08	6:05 AM	Partly Cloudy					0.94	143.8	143.8	TY	6/23/08	3:50 PM	291.2	0.50	Pam
4A	37	6/14/08	1:25 PM	Sunny, Clear					0.91	138.7	138.7	TY	6/23/08	2:35 PM	264.6	0.80	Pam
4N	30	6/14/08		Sunny, Clear					0.94	143.8	143.8	TY	6/23/08	1:10 PM	401	0.50	Pam
5	50	6/14/08	1:50 PM	Sunny, Clear	7	1	6	16		18.7	14.9	TY	6/23/08	2:35 PM	44.84	0.00	Pam
6	67	6/14/08	1:40 PM	Sunny, Clear		0.75				15.6	12.5	TY	6/23/08	3:50 PM	59.34	0.10	Pam
7	63	6/14/08	1:35 PM	Sunny, Clear	7	1.33	3	16		49.8	39.8	TY	6/23/08	3:50 PM	49.73	0.10	Pam
8	5	6/14/08	1:30 PM	Sunny, Clear	12	1	4.5	14		37.3	29.9	TY	6/23/08	10:50 AM	198.8	0.30	KN
9	14	6/14/08	1:32 PM	Sunny, Clear	8	1.5	4	20		60.0	48.0	TY	6/23/08	10:50 AM	627.7	1.90	KN
10																	
11																	
12																	
13																	
14																	
15	32	6/14/08	2:05 PM	Sunny, Clear						62.4	62.4	TY	6/23/08	1:10 PM	221.6	0.20	Pam
16	52	6/14/08	2:06 PM	Sunny, Clear						62.4	62.4	TY	6/23/08	2:35 PM	6.51	0.00	Pam
17	1	6/14/08	2:30 PM	Sunny, Clear					1.70	110.0	110.0	TY	6/23/08	10:50 AM	198.8	0.30	KN
18	7	6/14/08	2:30 PM	Sunny, Clear					1.70	110.0	110.0	TY	6/23/08	10:50 AM	193.6	0.10	KN
19	18	6/14/08	2:19 PM	Sunny, Clear					1.70	110.0	110.0	TY	6/23/08	10:50 AM	246.9	0.40	
20																	

WATER SAMPLING														SEDIMENT TESTING				
Sampling Site	Bottle No.	Date	Time	Weather	WIDTH (FT)	DEPTH (FT)	TIME (SEC)	LENGTH (FT)	GAGE (FT)	Theoretical FLOW (CFS)	Adjusted FLOW (CFS)	Sampled by		Date	Time	Turbidity (NTU)	Wet Volume (mL/L)	Tested by
3	16	6/21/08	11:15 AM	Sunny, Clear					1.32	73.0	73.0	TY		6/23/08	10:50 AM	216.8	0.45	KN
4M	8	6/21/08	9:29 AM	Sunny, Clear					0.89	134.7	134.7	TY		6/23/08	10:50 AM	211.2	0.40	KN
4A	38	6/21/08	12:01 PM	Sunny, Clear					0.90	137.0	137.0	TY		6/23/08	2:35 PM	205.5	0.50	Pam
4N	19	6/21/08	9:35 AM	Partly Cloudy					0.87	130.1	130.1	TY		6/23/08	1:10 PM	243.2	0.30	Pam
9	46	6/21/08	11:45 AM	Sunny, Clear	9	1.5	4	20		67.5	54.0	TY		6/23/08	9:36 AM	471.4	0.60	Pam
1	3	6/28/08	6:33 AM	Sunny, Hazy								TY		7/3/08	3:30 PM	799.7	1.90	
2	56	6/28/08	6:26 AM	Sunny, Hazy								TY		7/3/08	3:24 PM	11.08	0.00	
3	60	6/28/08	9:27 AM	Sunny, Hazy						48.0	48.0	TY		7/3/08	1:54 PM	274.6	0.40	
4M	34	6/28/08	8:31 AM	Sunny, Hazy						107.4	107.4	TY		7/3/08	11:13 AM	271.9	0.40	
4A	20	6/28/08	1:00 PM	Sunny, Hazy						100.8	100.8	TY		7/3/08	12:00 PM	0.4	0.40	
4N	10	6/28/08	9:45 AM	Sunny, Hazy						103.0	103.0	TY		7/3/08	3:21 PM	283.2	0.50	
5	51	6/28/08	6:00 AM	Sunny, Hazy	6	1	5	17		20.4	16.3	TY		7/3/08	3:18 PM	31.82	0.00	
6	22	6/28/08	5:35 AM	Sunny, Hazy		0.84				19.2	15.4	TY		7/3/08	11:16 AM	86.02	0.00	
7	53	6/28/08	5:28 AM	Sunny, Hazy	7	0.92	3.4	16		30.3	24.2	TY		7/3/08	1:51 PM	62.45	0.00	
8	13	6/28/08	5:24 AM	Sunny, Hazy	10	0.5	4	13		16.3	13.0	TY		7/3/08	1:57 PM	117.9	0.30	
9	27	6/28/08	5:15 AM	Sunny, Hazy	8.5	1.33	3.4	20		66.7	53.3	TY		7/3/08	2:00 PM	678.4	1.10	
10																		
11																		
12																		
13																		
14																		
15	2	6/28/08	1:11 PM	Sunny, Hazy						45.4	45.4	TY		7/3/08	3:27 PM	303.7	0.40	
16	49	6/28/08	1:09 PM	Sunny, Hazy						45.4	45.4	TY		7/3/08	1:45 PM	90.09	0.00	
17	sm 1	6/28/08	9:10 AM	Sunny, Hazy						119.0	119.0	TY		7/3/08	1:45 PM	136.9	0.40	
18	41	6/28/08	9:10 AM	Sunny, Hazy						119.0	119.0	TY		7/3/08	11:19 AM	159.3	0.30	
19	33	6/28/08	9:18 AM	Sunny, Hazy						119.0	119.0	TY		7/3/08	1:51 PM	62.45	0.20	
3	1	7/5/08	9:09 AM	cloudy						26.0	26.0	TY		7/16/08	10:10 AM	148.7	0.30	
4M	30	7/5/08	8:25 AM	cloudy						78.80	78.8	TY		7/16/08	10:10 AM	146.8	0.40	
4A	18	7/5/08	1:22 PM	cloudy						85.4	85.4	TY		7/16/08	10:10 AM	155.9	0.50	
4N	32	7/5/08	9:40 PM	cloudy						81.0	81.0	TY		7/16/08	10:10 AM	160.2	0.20	
9	21	7/5/08	8:44 AM	cloudy	8	1.16	4	20		46.4	37.1	TY		7/16/08	10:10 AM	337	1.10	
9	52	7/5/08	8:44 AM	cloudy										7/16/08	10:10 AM	323.1	0.50	
1	46	7/12/08	6:30 AM	Hazy								TY		7/16/08	2:00 PM	68.92	0.3	Walt
2	14	7/12/08	6:35 AM	Hazy								TY		7/16/08	11:35 AM	5.64	0	Walt
3	16	7/12/08	6:59 AM	Hazy						12.0	12.0	TY		7/16/08	11:35 AM	90.34	0.1	Walt
4M	31	7/12/08	8:30 AM	Clear						70.0	70.0	TY		7/16/08	2:00 PM	213.6	0.1	Walt
4A	8	7/12/08	2:30 PM	Partly Cloudy						68.0	68.0	TY		7/16/08	10:10 AM	110.7	0.05	Walt
4N	37	7/12/08	8:42 AM	Hazy						68.0	68.0	TY		7/16/08	2:00 PM	122.7	0	Walt
5	63	7/12/08	7:30 AM	Hazy	6	0.75	5.5	16		13.1	10.5	TY		7/16/08	3:25 PM	13.85	0.1	Walt

WATER SAMPLING													SEDIMENT TESTING				
Sampling Site	Bottle No.	Date	Time	Weather	WIDTH (FT)	DEPTH (FT)	TIME (SEC)	LENGTH (FT)	GAGE (FT)	Theoretical FLOW (CFS)	Adjusted FLOW (CFS)	Sampled by	Date	Time	Turbidity (NTU)	Wet Volume (mL/L)	Tested by
6	57	7/12/08	8:15 AM	Hazy		0.67				12.5	10.0	TY	7/16/08	3:25 PM	23.64	0	Walt
7	50	7/12/08	7:44 AM	Hazy	6.5	0.42	3	10		9.1	7.3	TY	7/16/08	2:00 PM	71.87	0	Walt
8	4	7/12/08	8:05 AM	Hazy	9	0.33	4	14		10.4	8.3	TY	7/16/08	10:10 AM	66.3	0.1	Walt
9	67	7/12/08	7:57 AM	Hazy	7	0.67	4	20		23.5	18.8	TY	7/16/08	3:25 PM	277.4	0.3	Walt
10																	
11																	
12																	
13																	
14																	
15	5	7/12/08		Hazy						31.5	31.5	TY	7/16/08	10:10 AM	91.18	0	
16	Sm4	7/12/08	8:39 AM	Hazy						31.5	31.5	TY	7/16/08	10:10 AM	61.54	0	Walt
17	Sm3	7/12/08	9:15 AM	Hazy						132.0	132.0	TY	7/16/08	2:00 PM	64.95	0.1	Walt
18	7	7/12/08	9:20 AM	Hazy						132.0	132.0	TY	7/16/08	10:10 AM	66.85	0	
19	19	7/12/08	6:55 AM	Hazy						132.0	132.0	TY	7/16/08	11:35 AM	66.04	0.1	Walt
20																	
3	10	7/19/08	8:30 AM	Raining						40.0	40.0	TY	7/22/08	9:35 AM	158.9	0.20	Ked
4M	33	7/19/08	8:47 AM	Sunny, Clear						89.8	89.8	TY	7/22/08	9:35 AM	204.4	0.40	Ked
4A	20	7/19/08	1:52 PM	Sunny, Clear						87.6	87.6	TY	7/22/08	9:35 AM	112.8	0.20	Ked
4N	34	7/19/08	8:40 AM	Raining						87.6	87.6	TY	7/22/08	9:35 AM	159.5	0.50	Ked
9	54	7/19/08	9:06 AM	Sunny, Clear	7	1.17	4	20		40.8	40.8	TY	7/22/08	9:35 AM	174.5	0.00	Ked
1	22	8/30/08	5:15 AM	Rainy									9/3/08	1:43 PM	8.2		Ked
2	49	8/30/08	9:05 AM	Rainy									9/4/08	6:12 AM	2.44		
3	33	8/30/08	8:50 AM	Rainy							4.4		9/4/08	6:05 AM	10.2		
4M		8/30/08															
4A	20	8/30/08	12:15 PM	Cloudy/Hot							60.0		9/3/08	1:40 PM	19.87		Ked
4N		8/30/08															
5	65	8/30/08	7:50 AM	Cloudy	5.5	0.67	10	17		6.2	5.0		9/4/08	2:37 PM	3.84		
6	68	8/30/08	7:32 AM	Cloudy		6"					6.9		9/4/08	2:48 PM	4.12		
7	6	8/30/08	7:25 AM	Cloudy	6	0.33	7	8		2.3	1.8		9/3/08	1:11 PM	4.08		Ked
8	54	8/30/08	7:20 AM	Cloudy	5	0.83	7	14		8.3	6.7		9/4/08	7:17 AM	3.58		
9	63	8/30/08	7:15 AM	Cloudy	6	0.67	6	20		13.3	10.7		9/4/08	2:33 PM	100.2		
10	62	8/30/08	2:30 PM	Cloudy							0.1		9/4/08	8:47 AM	11.44		
11		8/30/08									0.0						
12	67	8/30/08	1:45 PM	Cloudy/Hot	2	0.17	15	8		0.2	0.1		9/4/08	2:42 PM	12.48		
13	66	8/30/08	2:15 PM	Very Cloudy	9	0.42	6	20		12.5	10.0		9/4/08	2:40 PM	71.98		
14	57	8/30/08		Rainy	2	0.33	5	8		1.1	0.9		9/4/08	8:45 AM	19.53		
15	S3	8/30/08	8:00 AM	Rainy						27.0	27.0		9/4/08	6:14 AM	50.45		
16	29	8/30/08	8:05 AM	Rainy						27.0	27.0		9/3/08	2:02 PM	45.99		
17	30	8/30/08	8:37 AM	Rainy							110.0		9/3/08	2:06 PM	23.27		
18																	
19	34	8/30/08	8:45 AM	Rainy							110.0						

WATER SAMPLING													SEDIMENT TESTING				
Sampling Site	Bottle No.	Date	Time	Weather	WIDTH (FT)	DEPTH (FT)	TIME (SEC)	LENGTH (FT)	GAGE (FT)	Theoretical FLOW (CFS)	Adjusted FLOW (CFS)	Sampled by	Date	Time	Turbidity (NTU)	Wet Volume (mL/L)	Tested by
20																	
1	21	9/26/08		Clear/Sunny								TY	9/29/08	1:52 PM	5.26		
2	24	9/26/08		Clear/Sunny								TY	9/29/08	2:01 PM	4.46		
3	3	9/26/08		Clear/Sunny							3.2	TY	9/29/08	1:36 PM	4.79		
4M	9	9/27/08		Clear/Sunny								TY	9/29/08	1:38 AM	26.83		
4A	17	9/27/08		Partly Cloudy							60.0	TY	9/29/08	1:48 PM	57.16		
4N	35	9/27/08		Clear								TY	9/29/08	2:12 PM	64.17		
5	25	9/26/08		Clear/Sunny	5.5	0.83	5	17		15.5	12.4	TY	9/29/08	2:03 PM	4.05		
6	41	9/26/08		Clear/Sunny		7				9.3	9.3	TY	9/29/08	2:20 PM	4.09		
7	59	9/26/08		Clear/Sunny	5.5	0.25	6	12		2.8	2.2	TY	9/29/08	2:30 PM	4.88		
8	11	9/26/08		Clear/Sunny	5	0.75	8	14		6.6	5.3	TY	9/29/08	1:41 PM	7.05		
9	40	9/26/08		Clear/Sunny	5	0.58	4.5	20		13.0	10.4	TY	9/29/08	2:16 PM	66.92		
10	13	9/27/08		Raining	2	0.17	4	6		0.5	0.4	TY	9/29/08	1:43 PM	18.69		
11		9/27/08									0.0	TY	9/29/08				
12	56	9/27/08		Raining							0.3	TY	9/29/08	2:27 PM	6.53		
13	52	9/27/08		Partly Cloudy	4.5	0.5	3	12		9.0	7.2	TY	9/29/08	2:25 PM	161.4		
14	27	9/27/08		Partly Cloudy	2	0.25	4.5	7		0.8	0.6	TY	9/29/08	2:08 PM	13.75		
15	26	9/26/08		Clear/Sunny							27.0	TY	9/29/08	2:06 PM	29.4		
16	50	9/26/08		Clear/Sunny							27.0	TY	9/29/08	2:22 AM	24.72		
17	36	9/26/08		Clear/Sunny							55.0	TY	9/29/08	2:44 PM	30.09		
18	61	9/26/08		Clear/Sunny							55.0	TY	9/29/08	2:35 PM	25.92		
19	60	9/26/08		Clear/Sunny							55.0	TY	9/29/08	2:32 PM	19.85		
20		9/26/08										TY	9/29/08				

SIEVE ANALYSIS
ASTM D422, C136
AASHTO T27

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435-896-8266 Fax 435-896-0282

Project Name : Twelve Mile Quality Water Study
Client : Gunnison-Mayfiled Irrig. Co.
Date : 04-29-2008
Project No. : 0711-190
Segment No. : S-059gr
Contractor :
Sample Location : Sampling Site # 9 South Fork (Narrows)
Sample Source : Twelve Mile Crrek
W.O. No. : S-059gr
Sample Description : Water Sample Bottle #2 Rec. 4-22-08
Ref. Specification :
Fineness Modulus: 0.16
Station No.: , Starting , Ending
Ref. Line :
Class :
Category No.:
Offset Limit: , Starting , Ending
Elevation :
Activity No. :

Initial Dry Weight Prior to Washing +T1, (g)	a	11.1	Weight Prior to Washing, (g)	c=a-b	11.1
Tare T1 Weight, g	b		Weight after Washing / #200 , (g)	f=d-e	2.2
Dry Weight After Washing / #200 + T2 , (g)	d	2.17	Wash Loss, (g)	g=c-f	8.9
Tare T2 Weight, g	e		Total Percent Passing #200 ,(%)	(g+Pan)/c	85.9

Sieve Size	Weight Ret., (g)	Accumulated Weight Ret., (g)	Percent Ret., (g)	Percent Passing, (%)	Specification
#80 (0.180mm)			0.0	100.0	
#100 (0.150mm)	0.17	0.2	1.5	98.5	
#200 (0.075mm)	1.39	1.6	12.5	86.0	
Pan	0.60				
Total	2.16				

Remarks : Sediment Gradation from Sample after test

Tested by Ked R. Nielsen

Ked R. Nielsen
Supervisor's Signature

Jones & DeMille Engineering

1535 South 100 West, Richfield Utah 84701
Phone: (435)896-8266 Fax: (435)896-8268

Project Name:	Twelve Mile Water Study	**Date:**	5/2/2008
Project Number:	0711-190	**Sample Date:**	4/26/2008
Client:	Gunnison & Mayfield Irrigation Co.	**Sampled By:**	
Sample Location:	Site #9	**Material Type:**	Run-Off
Pit / Plant / Source:	South Fork (Narrows)		

Moisture Determination

Wet Weight	13.08
Dry Weight	13.08
Moisture	0
After Wash Weight	1.24
% Moisture	0.0

Lab. # S-062gr
Pan # TM
AASHTO:
Unified:

Sieve Analysis

SIEVE	WEIGHT RETAINED	PERCENT RETAINED	PERCENT PASSING	TARGET / SPECS	SIEVE
1"	0	0.0	100.0		25mm
3/4"	0	0.0	100.0		19mm
1/2"	0	0.0	100.0		12.5mm
3/8"	0	0.0	100.0		9.5mm
#4	0	0.0	100.0		4.75mm
#8	0	0.0	100.0		2.36mm
#10	0	0.0	100.0		
#16	0	0.0	100.0		1.18mm
#20	0	0.0	100.0		
#30	0	0.0	100.0		600um
#40	0	0.0	100.0		
#50	0	0.0	100.0		300um
#80	0	0.0	100.0		
#100	0	0.0	100.0		150um
#200	1.22	9.3	90.7		75um
#-200	11.86	90.7	0.0		-75um
TOTAL	13.08				

TESTED BY: Ked R. Nielsen Bottle # 13 Sampled 4-26 Rec 4-28 Tested 4-30

REMARKS: Silt and clay Turbidity = 154.2 Very Dark Brown color in Cone
mL/L Readings Dark Line 5.0 Light Colored Line 96

LAB SUPERVISOR: Ked R. Nielsen

Jones & DeMille Engineering

1535 South 100 West, Richfield Utah 84701
Phone: (435)896-8266 Fax: (435)896-8268

Project Name: Twelve Mile Water Study
Project Number: 0711-190
Client: Gunnison & Mayfield Irrigation Co.
Sample Location: Site # 4 North
Pit / Plant / Source: Mayfield Diversion

Date: 5/8/2008
Sample Date: 5/3/2008
Sampled By: Garrick
Material Type: Water Sample

Moisture Determination

Wet Weight	12.66
Dry Weight	12.66
Moisture	0
After Wash Weight	3.59
% Moisture	0.0

Lab. # S-064gr
Pan # QT
AASHTO:
Unified:

Sieve Analysis

SIEVE	WEIGHT RETAINED	PERCENT RETAINED	PERCENT PASSING	TARGET / SPECS	SIEVE
1"	0	0.0	100.0		25mm
3/4"	0	0.0	100.0		19mm
1/2"	0	0.0	100.0		12.5mm
3/8"	0	0.0	100.0		9.5mm
#4	0	0.0	100.0		4.75mm
#8	0	0.0	100.0		2.36mm
#10	0	0.0	100.0		
#16	0	0.0	100.0		1.18mm
#20	0	0.0	100.0		
#30	0	0.0	100.0		600um
#40	0	0.0	100.0		
#50	0	0.0	100.0		300um
#80	0	0.0	100.0		
#100	0	0.0	100.0		150um
#200	3.28	25.9	74.1		75um
#-200	9.38	74.1	0.0		-75um
TOTAL	12.66				

TESTED BY: Ked R. Nielsen **Bottle # 32 Sampled 5-5 Rec 5-6 Tested 5-6-(**

REMARKS: **Silt and clay Turbidity = 181.2 Wet Volume = 110 mL/L**

LAB SUPERVISOR: Ked R. Nielsen

Jones & DeMille Engineering

1535 South 100 West, Richfield Utah 84701
Phone: (435)896-8266 Fax: (435)896-8268

Project Name:	Twelve Mile Water Study	**Date:**	5/8/2008
Project Number:	0711-190	**Sample Date:**	5/3/2008
Client:	Gunnison & Mayfield Irrigation Co.	**Sampled By:**	Garrick
Sample Location:	Site # 4 North	**Material Type:**	Water Sample
Pit / Plant / Source:	Mayfield Diversion		

Moisture Determination

Wet Weight	5.43
Dry Weight	5.43
Moisture	0
After Wash Weight	1.3
% Moisture	0.0

Lab. # S-063gr
Pan # R2
AASHTO:
Unified:

Sieve Analysis

SIEVE	WEIGHT RETAINED	PERCENT RETAINED	PERCENT PASSING	TARGET / SPECS	SIEVE
1"	0	0.0	100.0		25mm
3/4"	0	0.0	100.0		19mm
1/2"	0	0.0	100.0		12.5mm
3/8"	0	0.0	100.0		9.5mm
#4	0	0.0	100.0		4.75mm
#8	0	0.0	100.0		2.36mm
#10	0	0.0	100.0		
#16	0	0.0	100.0		1.18mm
#20	0	0.0	100.0		
#30	0	0.0	100.0		600um
#40	0	0.0	100.0		
#50	0	0.0	100.0		300um
#80	0	0.0	100.0		
#100	0	0.0	100.0		150um
#200	1.13	20.8	79.2		75um
#-200	4.3	79.2	0.0		-75um
TOTAL	5.43				

TESTED BY: Ked R. Nielsen **Bottle # 20 Sampled 4-26 Rec 5-6 Tested 5-6**

REMARKS: **Silt and clay Turbidity = 690.9 Wet Volume = 30mL/L**

LAB SUPERVISOR: Ked R. Nielsen

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Murray, UT 84107
Phone: 801-262-7299
Fax: 801-262-7378

Date: 05/20/08

Jones and DeMille Engineering
attn: Tim Jones
1535 South 100 West
Richfield, UT 84701

This is the final report for project: 90408
Individual pages or sections of this report may not be separated when using the information for regulatory compliance.

The analyses presented on this report were performed in accordance with National Environmental Laboratory Accreditation Program (NELAP), Section 5.13.

Please feel free to contact us at (801) 262-7299 or (801) 262-7378 (fax) if you have questions or comments regarding this report. Our web site is located at www.chemtechford.com.

Dave Gayer
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Linda Daniels
Customer Representative
linda@chemtechford.com

Approved By: ______________________
Dave Gayer, Laboratory Director

Chemtech-Ford Laboratories

Certificate of Analysis

Lab No.: 08 05541
Lab Group No.: 90408

Name:	Jones and DeMille Engineering	***Sample Date:***	5/6/2008 6:30 AM
Sample Site:	Mayfield Diversion	***Receipt Date:***	5/6/2008 2:00 PM
Sample ID:	08 05541	***Sampler:***	WILLDEN
System No:		***Sample Source:***	
Sample Type:	Drinking Water	***Project:***	Twelve Mile Water Quality Study

Parameter	Sample Result	Mimimum Reporting Limit	Units	Method	Analysis Date	Analysis Time	Analyst Initials	Flag
Group A - Inorganic								
Alkalinity - Bicarbonate	525	1	mg/L	SM 2320B	5/8/2008	10:00	JSH	
Alkalinity - Carbon Dioxide	382	1	mg/L	SM 2320B	5/8/2008	10:00	JSH	
Alkalinity - Carbonate	4	1	mg/L	SM 2320B	5/8/2008	10:00	JSH	
Alkalinity - Hydroxide	ND	1	mg/L	SM 2320B	5/8/2008	10:00	JSH	
Ammonia as N	ND	0.4	mg/L	SM 4500 NH3	5/6/2008	14:30	TSM	
Apparent Color	35	0	CU	EPA 110.2	5/6/2008	16:00	JSH	
Chloride, IC	3	1	mg/L	EPA 300.0	5/7/2008	10:00	TSM	
Conductivity	407	1	umhos/cm	EPA 120.1	5/7/2008	16:30	MAH	
Cyanide, Free	ND	0.01	mg/L	ASTM D2036	5/7/2008	17:00	PNM	
Fluoride, IC	0.2	0.1	mg/L	EPA 300.0	5/7/2008	10:00	TSM	
Hardness, as CaCO3	493	1	mg/L	SM 2340B	5/13/2008	10:30	Calc	
Langelier Index (@ 20 C)	+ 1.5	0.01	None	Calc	5/13/2008	10:30	Calc	
Nitrate as N, IC	0.2	0.1	mg/L	EPA 300.0	5/7/2008	10:00	TSM	
Nitrite as N, IC	ND	0.1	mg/L	EPA 300.0	5/7/2008	10:00	TSM	
Odor	0	0	0-5 Scale	SM 2150B	5/6/2008	16:00	JSH	
pH	8.29	0.5	units	EPA 150.1	5/6/2008	16:00	JSH	SPH
Phosphate, Ortho as PO4	ND	0.01	mg/L	SM 4500 PE	5/7/2008	14:00	TSM	
Solids, Total Dissolved (TDS)	292	5	mg/L	SM 2540C	5/8/2008	8:45	JSH	
Sulfate, IC	9	1	mg/L	EPA 300.0	5/7/2008	10:00	TSM	
Surfactants (MBAS)	ND	0.08	mg/L	SM 5540C	5/7/2008	8:30	PNM	
Turbidity	1600	2	NTU	EPA 180.1	5/7/2008	13:07	JSH	
Group B - Metals								
Aluminum, Total, ICP	26.3	0.1	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Antimony, Total, ICP/MS	ND	0.0005	mg/L	EPA 200.8	5/13/2008	14:08	MJB	
Arsenic, Total, ICP/MS	0.0014	0.0005	mg/L	EPA 200.8	5/13/2008	14:08	MJB	
Barium, Total, ICP	0.438	0.005	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Beryllium, Total, ICP	0.002	0.001	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Boron, Total, ICP	ND	0.05	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Cadmium, Total, ICP/MS	ND	0.0005	mg/L	EPA 200.8	5/13/2008	14:08	MJB	
Calcium, Total, ICP	137	0.2	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Chromium, Total, ICP	0.019	0.005	mg/L	EPA 200.7	5/12/2008	10:47	MJB	

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Certificate of Analysis

Lab No.: 08 05541
Lab Group No.: 90408

Name:	Jones and DeMille Engineering	***Sample Date:***	5/6/2008 6:30 AM
Sample Site:	Mayfield Diversion	***Receipt Date:***	5/6/2008 2:00 PM
Sample ID:	08 05541	***Sampler:***	WILLDEN
System No:		***Sample Source:***	
Sample Type:	Drinking Water	***Project:***	Twelve Mile Water Quality Study

Parameter	Sample Result	Mimimum Reporting Limit	Units	Method	Analysis Date	Analysis Time	Analyst Initials	Flag
Group B - Metals								
Copper, Total, ICP	0.025	0.005	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Iron, Total, ICP	15.9	0.02	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Lead, Total, ICP/MS	0.0243	0.0005	mg/L	EPA 200.8	5/13/2008	14:08	MJB	
Magnesium, Total, ICP	36.4	0.2	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Manganese, Total, ICP	0.529	0.005	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Mercury, Total, ICP/MS	ND	0.0002	mg/L	EPA 200.8	5/13/2008	14:08	MJB	
Nickel, Total, ICP	0.022	0.005	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Potassium, Total, ICP	3.7	0.2	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Selenium, Total, ICP/MS	ND	0.0005	mg/L	EPA 200.8	5/13/2008	14:08	MJB	
Silica, (as SiO2) Total, ICP	83.4	0.1	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Silver, Total, ICP/MS	ND	0.0005	mg/L	EPA 200.8	5/13/2008	14:08	MJB	
Sodium, Total, ICP	26.0	0.5	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Thallium, Total, ICP/MS	ND	0.0005	mg/L	EPA 200.8	5/13/2008	14:08	MJB	
Zinc, Total, ICP	0.05	0.01	mg/L	EPA 200.7	5/12/2008	10:47	MJB	
Group F - Carbamates								
3-Hydroxycarbofuran	ND	2	ug/L	EPA 531.1	5/12/2008	15:30	RB	
Aldicarb	ND	1	ug/L	EPA 531.1	5/12/2008	15:30	RB	
Aldicarb sulfone	ND	2	ug/L	EPA 531.1	5/12/2008	15:30	RB	
Aldicarb sulfoxide	ND	2	ug/L	EPA 531.1	5/12/2008	15:30	RB	
Carbaryl	ND	2	ug/L	EPA 531.1	5/12/2008	15:30	RB	
Carbofuran	ND	2	ug/L	EPA 531.1	5/12/2008	15:30	RB	
Methomyl	ND	1	ug/L	EPA 531.1	5/12/2008	15:30	RB	
Oxamyl (Vydate)	ND	2	ug/L	EPA 531.1	5/12/2008	15:30	RB	
Group J - Herbicides								
2,4,5-TP (Silvex)	ND	0.44	ug/L	EPA 515.2	5/14/2008	15:24	RJ	
2,4-D	ND	0.22	ug/L	EPA 515.2	5/14/2008	15:24	RJ	
Dalapon	ND	2.2	ug/L	EPA 515.2	5/14/2008	15:24	RJ	
Dicamba	ND	1	ug/L	EPA 515.2	5/14/2008	15:24	RJ	
Dinoseb	ND	0.44	ug/L	EPA 515.2	5/14/2008	15:24	RJ	
Pentachlorophenol	ND	0.088	ug/L	EPA 515.2	5/14/2008	15:24	RJ	
Picloram	ND	0.22	ug/L	EPA 515.2	5/14/2008	15:24	RJ	

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Certificate of Analysis

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Lab Group No.: 90408

Name:	Jones and DeMille Engineering	***Sample Date:***	5/6/2008 6:30 AM
Sample Site:	Mayfield Diversion	***Receipt Date:***	5/6/2008 2:00 PM
Sample ID:	08 05541	***Sampler:***	WILLDEN
System No:		***Sample Source:***	
Sample Type:	Drinking Water	***Project:***	Twelve Mile Water Quality Study

Parameter	Sample Result	Mimimum Reporting Limit	Units	Method	Analysis Date	Analysis Time	Analyst Initials	Flag
Group K - PCB's								
PCB-1221	ND	0.2	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
PCB-1232	ND	0.2	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
PCB-1242	ND	0.5	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
PCB-1248	ND	0.5	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
PCB-1254	ND	0.5	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
PCB-1260	ND	0.5	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
Group L - Pesticides								
Endrin	ND	0.022	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
Heptachlor	ND	0.088	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
Heptachlor Epoxide	ND	0.044	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
Lindane	ND	0.044	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
Methoxychlor	ND	0.22	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
Toxaphene	ND	2.2	ug/L	EPA 508.1	5/13/2008	9:43	RJ	
Group N - Semi-Volatile Compounds								
a-Chlordane	ND	0.44	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Alachlor	ND	0.44	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Aldrin	ND	2	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Atrazine	ND	0.22	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Benzo (a) pyrene	ND	0.044	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
bis (2-Ethylhexyl) adipate	ND	1.3	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
bis (2-Ethylhexyl) phthalate	ND	1.3	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Butachlor	ND	0.5	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Dieldrin	ND	1	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
g-Chlordane	ND	0.44	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Hexachlorobenzene	ND	0.22	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Hexachlorocyclopentadiene	ND	0.22	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Metolachlor	ND	0.5	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Metribuzin	ND	0.5	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Propachlor	ND	0.5	ug/L	EPA 525.2	5/12/2008	10:24	MAH	
Simazine	ND	0.15	ug/L	EPA 525.2	5/12/2008	10:24	MAH	

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Certificate of Analysis

Lab No.: 08 05541
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Name:	Jones and DeMille Engineering	***Sample Date:***	5/6/2008 6:30 AM
Sample Site:	Mayfield Diversion	***Receipt Date:***	5/6/2008 2:00 PM
Sample ID:	08 05541	***Sampler:***	WILLDEN
System No:		***Sample Source:***	
Sample Type:	Drinking Water	***Project:***	Twelve Mile Water Quality Study

Parameter	Sample Result	Mimimum Reporting Limit	Units	Method	Analysis Date	Analysis Time	Analyst Initials	Flag
Group P - Volatile Organic Compounds								
1,1,1,2-Tetrachloroethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,1,1-Trichloroethane	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,1,2,2-Tetrachloroethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,1,2-Trichloroethane	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,1,2-Trichlorotrifluoroethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,1-Dichloroethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,1-Dichloroethylene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,1-Dichloropropene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,2,3-Trichlorobenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,2,3-Trichloropropane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,2,4-Trichlorobenzene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,2,4-Trimethylbenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,2-Dichlorobenzene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,2-Dichloroethane	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,2-Dichloropropane	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,3,5-Trimethylbenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,3-Dichlorobenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,3-Dichloropropane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
1,4-Dichlorobenzene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
2,2-Dichloropropane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
2-Chlorotoluene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
4-Chlorotoluene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
4-Isopropyltoluene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Benzene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Bromobenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Bromochloromethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Bromodichloromethane	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Bromoform	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Bromomethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Carbon Tetrachloride	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Chlorobenzene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Chloroethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	

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Certificate of Analysis

Lab No.: 08 05541
Lab Group No.: 90408

Name:	Jones and DeMille Engineering	***Sample Date:***	5/6/2008 6:30 AM
Sample Site:	Mayfield Diversion	***Receipt Date:***	5/6/2008 2:00 PM
Sample ID:	08 05541	***Sampler:***	WILLDEN
System No:		***Sample Source:***	
Sample Type:	Drinking Water	***Project:***	Twelve Mile Water Quality Study

Parameter	Sample Result	Mimimum Reporting Limit	Units	Method	Analysis Date	Analysis Time	Analyst Initials	Flag
Group P - Volatile Organic Compounds								
Chloroform	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Chloromethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
cis 1,3-Dichloropropylene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
cis-1,2,-Dichloroethylene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Dibromochloromethane	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Dibromomethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Dichlorodifluoromethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Ethylbenzene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Hexachlorobutadiene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Isopropylbenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Methylene Chloride	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
MTBE	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Naphthalene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
n-Butylbenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
n-Propylbenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
sec-Butylbenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Styrene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
tert-Butylbenzene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Tetrachloroethylene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Toluene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
trans-1,2-Dichloroethylene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
trans-1,3 Dichloropropylene	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Trichloroethylene	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Trichlorofluoromethane	ND	1	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Vinyl Chloride	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	
Xylene - Total	ND	0.5	ug/L	EPA 524.2	5/8/2008	8:36	RB	

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Murray, UT 84107
801-262-7299 Office
801-262-7378 Fax

Chemtech-Ford Laboratories

Certificate of Analysis

Lab No.: 08 05541
Lab Group No.: 90408

Name:	Jones and DeMille Engineering	***Sample Date:***	5/6/2008 6:30 AM
Sample Site:	Mayfield Diversion	***Receipt Date:***	5/6/2008 2:00 PM
Sample ID:	08 05541	***Sampler:***	WILLDEN
System No:		***Sample Source:***	
Sample Type:	Drinking Water	***Project:***	Twelve Mile Water Quality Study

Parameter	Sample Result	Mimimum Reporting Limit	Units	Method	Analysis Date	Analysis Time	Analyst Initials	Flag

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit.
1 mg/L = one milligram per liter = 1 part per million.
1 ug/L = one microgram per liter = 1 part per billion.

Flag Descriptions

APH = The test was performed past the EPA specified holding time.
H = A high bias is suspected.
I = The analysis experienced a matrix interference which may have affected the results.
J = The result is positive and estimated. The result falls between the Minimum Reporting Limit and the Method Detection Limit.
L = A low bias is suspected.
O = The analysis was performed by an outside contract laboratory.
R = The value represents a reanalysis.
SPH = The sample was submitted for analysis past the EPA specified holding time.

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Murray, UT 84107
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CHEMTECH - FORD ANALYTICAL LABORATORY

CHAIN OF CUSTODY

COMPANY: Jones & DeMille Engineering
ADDRESS: 1535 S. 100 W.
CITY/STATE/ZIP: Richfield, UT 84701
PHONE #: (435) ~~52~~ 896-8266 FAX: (435) 896-8268
CONTACT: Garrick Willden EMAIL: garrick@jonesanddemille.com
PROJECT: Twelve Mile Water Quality Study SYSTEM #:

BILLING ADDRESS: same
BILLING CITY/STATE/ZIP:
PURCHASE ORDER #:
TURNAROUND REQUIRED:*
* *Expedited turnaround subject to additional charge*

- Mark 'X' here if you want a copy sent to DEQ Division of Drinking Water.

LAB ID#	SAMPLE LOCATION	SAMPLE DATE	SAMPLE TIME	Number of Containers	MATRIX: Drinking Water / Waste Water	Water / Ground Water	Soil / Other Solid	Sludge [Solid] / Sludge [Liquid]	Oil / Solvent	Other: [specify]	ANALYTICAL TESTS REQUESTED: PSA + Organics ad 5/6	NO RADS ad 5/6	per bottle order
5541	1. Mayfield Diversion	5/6/2008	6:30 am										
	2.												
	3.												
	4.												
	5.												
	6.												
	7.												
	8.												
	9.												
	10.												

Sampled by: [print] Garrick Willden
Sampled by: [signature] Garrick Willden
(ON ICE) NOT ON ICE

Special Instructions:

Relinquished by: [signature]	Date/Time	Received by: [signature]	Date/Time
Garrick Willden	5/6/2008 6:30 am	April Davis	5.6.08 1400

SAM LE RECEIVING CHECKL T

DATE / TIME: 5.6.08 1400 **Lab ID #s:** 5541

RECEIVED BY: ad **MATRIX:** Water, (DW), GW, ~~(WW)~~

Sample/s on ice? (Yes) / No Soil / Solid / Oil

Sample/s Sealed? Yes / (No) Sludge: Watery, Solid Other:

	Laboratory ID #	Bottle Temp: Degrees C	Bottle Prep ID #	Comments (See Below:)
1	5541 J1-6	10	721	
2	U1-2	↓	719	
3	V1-2	↓	668	
4	A1/2	↓	—	
5	C	↓	643	
6	N	↓	725	
7	M	↓	709	
8	G	↓	—	
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				

Bottle Identification

Plastic	Glass
A- Plastic Unpreserved	D- 625
A1/2, AQ, AP, A1/2pt	G- Glass Unpreserved
B- Miscellaneous Plastic	H- HAA's
C- Cyanide	J- 508/515/525
F- Sulfide	O- Oil & Grease
M- Metals	P- Phenols
N- Nutrients	T- TOC/TOX
R- Radiologicals	U- 531
S- Sludge Cup/Tubs	V- 524 & THM's
Q- Plastic Bags	W- 8260
Special	X- Vial Unpreserved
L- Lab Subsample	Y- 624/504
1,2,3 etc.- Multiples (B1, B2,)	Z- Miscellaneous Glass

Sample Receiving Comments:
1- Preserved in Receiving.
2- Vials submitted with headspace.
3- Sample received past holding time.

Chemtech-Ford, Inc.

APPENDIX E

HYDROGEOLOGICAL STUDY

WELL SITING ASSESSMENT FOR GUNNISON AND MAYFIELD IRRIGATION COMPANIES SANPETE COUNTY, UTAH

September 3, 2008

Prepared for:

Mr. Brian Barton
Jones & DeMille Engineering
1535 South 100 West
Richfield, UT 84701

WELL SITING STUDY FOR GUNNISON AND MAYFIELD IRRIGATION COMPANIES SANPETE COUNTY, UTAH

File No.: 92092.3

Prepared by:

LICENSED PROFESSIONAL GEOLOGIST JOHN W. DIAMOND 5959080-2250 STATE OF UTAH JWD 9/3/08

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September 3, 2008

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1. INTRODUCTION

This report presents the results of a preliminary well sighting assessment for a proposed new source of irrigation water for the Gunnison and Mayfield Irrigation Companies in Sanpete County, Utah. Kleinfelder West, Inc. (Kleinfelder) has performed this assessment in response to a request from Mr. Brian Barton, P.E., of Jones & DeMille Engineering (Jones & DeMille) and in accordance with our proposal dated January 7, 2008 (Kleinfelder Document No. SLC8P003).

Based on our review of the request for proposal (RFP) and our discussions with Brian Barton, we understand that landslides in the Twelvemile Creek drainage beginning approximately in 1983 have resulted in high sediment loads to the drainage. These loads have caused extensive and costly damage to the Gunnison and Mayfield Irrigation Companies system as well as to crops and lands that are irrigated with water from this system.

2. OBJECTIVES AND SCOPE OF WORK

The objective of our assessment was to present a report detailing our understanding and assessment of the feasibility for developing groundwater sources that are capable of producing enough water to meet the capacity and quality requirements of the Gunnison and Mayfield Irrigation Companies. Based on information provided to us by Jones & DeMille, we understand that approximately 160 cubic feet per second (CFS) is needed to meet the water supply needs of the Gunnison and Mayfield Irrigation Companies.

This well sitting assessment is a component of Jones & DeMille's effort to prepare a Geotechnical Planning and Economic Cost-Benefit Analyses for control of sediment in irrigation water from Twelvemile Creek. The intent of this assessment is to review readily available information about local geology and hydrogeology to: 1) assess the hydrogeology of the area; 2) develop a conceptual hydrogeologic model of groundwater occurrence; and 3) assess, on a preliminary basis, the potential of geologic units in the area to meet the future water needs of the Gunnison and Mayfield Irrigation Companies.

A phased approach is being used to assess the feasibility of developing new groundwater supply wells for the Gunnison and Mayfield Irrigation Companies. The first phase consists of conducting a preliminary well sighting study. This is the only phase of the project that has been authorized by Jones & DeMille at the present time. This initial well sighting assessment report includes a review and compilation of readily available regional hydrogeologic and water supply information including:

- Published geologic and hydrogeologic reports and aerial photographs of the area;

- Geologic, construction, yield, and water quality data for wells and springs in the area from the files of the Utah Division of Water Rights (DWR, also known as the Office of the State Engineer), and the Division of Drinking Water (DDW); and

- Discussions with representatives of the Utah Geological Survey (UGS), Utah Department of Water Quality, representatives of the Gunnison and Mayfield Irrigation Companies, and Jones & DeMille Engineering.

This assessment included providing a reconnaissance level understanding of potential well sites by completing a large scale hydrogeologic assessment and large scale fracture trace mapping within the study area that was identified by Jones & DeMille and shown on Figure 1. The scope also included identification of preliminary well locations and target completion depths with the potential to provide the best groundwater yields to the Gunnison and Mayfield Irrigation Companies.

3. SUMMARY OF LOCAL GEOLOGY AND HYDROGEOLOGY

3.1 GEOLOGIC UNITS AND STRUCTURE

The project area is located in the Arapien Valley in Sanpete County, Utah, near the town of Mayfield, on the western edge of the Wasatch Plateau. The study area extends from the town of Mayfield approximately 3 miles north, 2 miles south, 3 miles east, and 2 miles west as illustrated on Figure 1. Geologic units in the area consist of both unconsolidated and consolidated bedrock units. The unconsolidated deposits in the area consist of alluvial-fan deposits along the edges of the valleys and flood-plain deposits near the center of the valleys (Robinson, 1971). The western edge of the Wasatch Plateau is located directly east of the Arapien Valley and the consolidated rock surrounding the valley is characterized by complex geologic structure and rock units that have been deformed and faulted.

Figure 2 is a geologic map of the area that was compiled from mapping by Witkind et al. (1987). Figure 3 is a geologic cross section through the study area that was drawn based on mapping by Witkind et al. (1987). A brief lithologic description of the geologic units in the area is listed below.

- **Alluvium (Qal).** Dark brown to gray unconsolidated clay, silt, sand, gravel, pebbles, and some cobbles. Alluvial deposits in the area consist of fluvial sediments that form broad even surfaces of low relief.

- **Colluvium (Qcl).** Brown to dark brown heterogeneous mixture of unconsolidated to semi-consolidated debris. Thickness typically ranges from 1 inch up to 50 feet.

- **Slope Wash (Qsw).** Light to dark gray; thin- to thick-bedded fluvial sediments consisting of clay, silt, sand, and some pebbles. Unconsolidated to weakly cemented locally with thickness ranging from a thin film to as much as 25 feet.

- **Alluvial Fan Deposits (QTcf).** Light brown to brown, locally gray; unconsolidated to semi-consolidated fluvial sediments consisting of silt, sand, pebbles, and cobbles at the mouth of streams. Thickness is uncertain but typically less than 50 feet.

- **Earthflow Deposits (Qe).** Brown to dark brown; sand, pebbles, cobbles, and boulders in an unsorted matrix of clay and silt. These deposits range from unconsolidated to semi-consolidated. Thickness varies widely but probably up to 150 feet thick locally.

- **Mass-Wasting Deposits (Qmw).** Brown to dark brown heterogeneous masses of mixed country rock, of diverse sizes and shapes that have slid down slope repeatedly as both small slumps and large debris flows. Locally these deposits include small earthflows and rock falls. The thickness of these deposits varies widely but probably does not exceed 200 feet thick.

- **Alluvial Fan Deposits (Qf and Qof).** Gray to dark gray; thin- to thick-bedded; unconsolidated fluvial sediments consisting of silt, sand, pebbles, and small cobbles. Contains small, thin interbedded lenses of crossbedded coarse sand. Thickness of these deposits range from 50 feet to as much as 200 feet.

- **Landslide Deposits (Ql).** Brown to dark brown and gray heterogeneous mixture of fragments of diverse sizes. Hummocky topography with concentric ridges locally. Thickness varies widely but may be up to 150 feet thick locally.

- **Coalesced Alluvial Fan Deposits (Qtcf).** Brown to dark brown or gray; thin- to thick-bedded, commonly crossbedded; unconsolidated to semi-consolidated fluvial sediments consisting of silt, sand, pebbles, cobbles, and boulders. These deposits are characterized by overlap and interfingering of adjacent alluvial fans that form broad, low, sloping aprons at the foot of adjacent highlands. The thickness of these deposits is uncertain but possibly as thick as 100 feet locally.

- **Crazy Hollow Formation (Tch).** Red to reddish-brown, light yellow-brown, and locally white sandstone, shaly siltstone, and some conglomerate. In some places the Crazy Hollow Formation contains gray, pink, and dark gray to black, thin, dense limestone beds. Conglomerate lenses contain distinctive black, well-rounded chert pebbles. The Crazy Hollow Formation typically ranges from 0 to 160 feet thick.

- **Green River Formation (Tg).** Fresh water lacustrine deposit consisting of a limestone unit underlain by a shale unit. The total thickness of this unit varies widely but probably ranges from about 500 to 1,200 feet thick.

- **Colton Formation (Tc).** Commonly claystone and mudstone variegated in shades of reddish brown, light gray, or light greenish-gray. Locally includes beds of yellowish-gray to yellowish-brown siltstone and sandstone, and reddish-brown conglomerate. The Colton Formation contains sparse, thin, interlayered beds of platy, light gray, dense, finely crystalline limestone. Typical thickness of the Colton Formation ranges from 325 to 850 feet.

- **Flagstaff Limestone (Tf).** Light gray to yellowish-gray to light brown limestone that is locally dolomitic. The Flagstaff Limestone is thin to thick bedded, locally massive; fine-grained, dense, and contains some algal nodules and interbedded dark-gray, gray, and greenish-gray shale. The Flagstaff Limestone was originally deposited in a freshwater lacustrine environment and forms resistant ledges and prominent hogbacks. The thickness of the Flagstaff Limestone ranges from 0 feet in the central part of the Gunnison Plateau to about 1,000 feet thick near Ephraim.

- **Crazy Hollow Formation (Tch).** Red to reddish-brown, light yellow brown and locally white sandstone, shaly siltstone, and conglomerate. In a few places the Crazy Hollow Formation contains gray, pink, and dark-gray to black, thin, dense limestone beds. The Crazy Hollow Formation ranges in thickness from 0 to 1,000 feet.

- **Castlegate Sandstone (Kc).** Sandstone that is light brown to brownish gray; locally conglomeratic, irregularly bedded, massive, and fine to coarse grained. Locally includes some thin, dark gray shaly siltstone units and some carbonaceous material. The Castlegate Sandstone ranges in thickness from 50 to 500 feet.

- **Sixmile Canyon Formation (Ksx).** A fine- to coarse-grained sandstone with interbedded coal and shale layers and some minor conglomerate. The Sixmile Canyon Formation may be as much as 4,000 feet thick in some areas.

- **Blackhawk Formation (Kbh).** Sandstone, shaly siltstone, shale, carbonaceous shale, and coal. Sandstones are light gray, light brown, and brownish gray, locally reddish-brown, thin- to medium-bedded, and fine- to medium-grained. Many thin to thick coal zones are present in the lower part. The Blackhawk Formation ranges in thickness from about 700 to 1,000 feet.

- **Funk Valley Formation (Kfv).** The Funk Valley Formation consists of sandstone with interbedded layers of shale. Approximate total thickness ranges from approximately 3,100 feet to 3,200 feet thick.

- **Allen Valley Shale (Kav).** Gray, fossiliferous marine shale with thin layers of bentonitic mudstone, siltstone, and limey siltstone. The Allen Valley Shale is approximately 600 feet thick.

- **Sanpete Formation (Ksp).** Grayish-orange weathering, marginal marine sandstone with shale interbeds that are as thick as 100 feet. Total thickness of the Sanpete Formation is estimated to be approximately 2,100 feet.

- **Basal Formation of the Indianola Group (Kb).** Reddish brown and gray, thick bedded to massive, well cemented conglomerate with interbeds of sandstone and some mudstone. Contains well rounded cobbles and boulders up to 6 feet in diameter. Thickness ranges from 800 to 1,100 feet.

- **Cedar Mountain Formation (Kcm).** Mudstone variegated in shades of red-orange, yellowish gray, gray, purple, and green. Massive to thick bedded with a few lenses and thin layers of limy sandstone. Contains a few pebble and cobble conglomerate layers that range from 10 to 30 feet thick. The Cedar Mountain Formation ranges from 1,000 to 1,100 feet thick.

- **Twist Gulch Formation (Jtg).** Reddish brown shale and silty mudstone with some thin to thick beds of reddish gray to light gray gritty sandstone that weathers to light brown. The Twist Gulch Formation ranges from 1,600 to 3,000 feet thick.

- **Arapien Shale (T(Ja)).** Mudstone, calcareous, commonly light gray marked by pale-red blotches. In places wholly drab gray, elsewhere wholly reddish brown. Thin to medium bedded; even-bedded thin lenticular beds and seams of yellowish-gray to light-brown siltstone and sandstone and sparse limestone beds. Contains thick beds of halite, gypsum, and other evaporates and selenite crystals are abundant on many outcrops. The Arapien Shale is complexly deformed and shows signs of intense compression. The thickness of this unit is uncertain due to intense deformation but estimates range from about 4,000 feet to as much as 13,000 feet.

- **North Horn Formation (Tkn).** Mudstone, claystone, sandstone, conglomerate and sparse limestone; units alternate irregularly. Mudstones are thick bedded to massive; sandstones range from thin to thick bedded; commonly crossbedded; fine to medium grained and limestone beds are thin and dense. Some minor coal beds are present in this formation along the east flank of the Gunnison Plateau. This formation is typically unstable and marked by many slumps, landslides, earthflows, and other mass-wasting deposits. The North Horn Formation typically ranges in thickness from 500 to 3,000 feet.

3.2 HYDROGEOLOGY AND PRINCIPAL AQUIFERS

According to Robinson (1971) and Gates (1982), groundwater within the study area occurs in both unconsolidated valley fill deposits and in the consolidated rock units surrounding the valley. A discussion of the hydrogeology of the unconsolidated alluvial aquifer and the fractured bedrock aquifers in the area is presented in the following sections.

3.2.1 Unconsolidated Alluvial Aquifers

Unconsolidated deposits in the area generally consist of interfingered and interbedded layers of boulder to clay size sediment. The coarser grained material is typically located near the mountains and finer grained sediments are typically encountered near the central portions of the valleys (Snyder & Lowe, 1998). According to Gates (1982), most water in the area that can be developed by wells is in the unconsolidated valley fill.

Regionally, unconsolidated valley fill deposits in the widest part of Sanpete Valley (north of the study area between Ephraim and Moroni) may to be up to 500 feet thick (Robinson, 1971; Gates, 1982). Logs of wells in the Arapien Valley show that consolidated bedrock is typically encountered at depths ranging from 45 to 170 feet. Unconsolidated alluvial deposits within the Arapien Valley are known to contain groundwater that is typically under unconfined (water table) conditions (Robinson, 1971).

In addition to the alluvial aquifers that are present in the valleys, unconsolidated deposits in the area may form relatively narrow continuous aquifers in the bottoms of mountain canyons and stream valleys. Unconsolidated deposits in mountain canyons are typically very thin (less than 50 feet thick) resulting in low transmissivity values and low production potential for these alluvial aquifers.

3.2.2 Consolidated Rock Aquifers

Groundwater in the area occurs locally in consolidated rocks in the mountains and plateaus as well as in the consolidated rock underlying the valley fill of the Sanpete and Arapien Valleys. Fractured rock aquifers in the area are known to yield water to springs in both the Wasatch Plateau and the San Pitch Mountains, and to some wells in the valleys (Wilberg and Heilweil, 1995).

Consolidated rock formations generally have negligible primary porosity and as a result, groundwater in fractured rock aquifers is primarily transmitted by secondary porosity which includes fractures, faults, solution channels, and bedding planes. Fractures play a major role in controlling groundwater movement within consolidated rock units because they act as conduits for the underground transmission of groundwater. The fracture characteristics that most significantly affect groundwater flow are density, or fracture volume per volume of rock, the aperture or width of the open space between fracture surfaces, and the connectivity of fractures within a rock mass.

Units that are extensively fractured may be very permeable locally and commonly yield the largest quantities of groundwater to wells. Because water moves through consolidated rock along fractures, solution channels, and fault planes, any formation may bear water locally; however, the development of large groundwater supplies from consolidated rock aquifers is dependant on intersecting extensive networks of water-bearing fractures.

Faults are expected to have a significant influence on groundwater flow in bedrock aquifers in the area. Faults are fractures that have accommodated movement within a rock mass. The hydrogeologic characteristics of faults are more complicated than those of fractures. Faults in highly cemented rocks provide a conduit for groundwater flow parallel to the fault plane but may act as barriers to fluid flow if fine-grained material formed within the fault zone during movement. Faults may also influence groundwater movement by displacing individual geologic formations and placing different formations with significantly different hydraulic conductivities adjacent to each other.

According to Robinson (1971), the most important consolidated rock aquifer in the area is the sandstone and oolitic limestone of the Green River Formation. According to Robinson (1971) and Gates (1982), at least one irrigation well yields "large" amounts of water from the Green River Formation near Manti. Well logs from within the study area show that three large capacity wells near the town of Mayfield appear to produce water from the Green River Formation. According to Lowe et al. (2002), the Green River Formation contains elevated TDS concentrations at some locations.

According to Robinson (1971), deep oil and gas wells drilled on the Wasatch Plateau east of the study area have encountered groundwater under artesian pressure. An estimate of potential yield for wells completed in consolidated rock aquifers is difficult because of variation in lithology and unpredictable effects of fracturing.

3.2.3 Existing Wells

According to information on file with the DWR; six wells capable of producing more than 50 gallons per minute (gpm) as well as several small wells that produce less than 50 gpm have been completed within the study area. Wells capable of producing more than 50 gpm typically range from 160 to 400 feet deep and most of these wells appear to have encountered bedrock between 45 and 170 feet below ground surface (bgs). A summary of the completion details for the six wells within the study area that produce more than 50 gpm is outlined in Table 2. Logs of wells located within the study area are included in Appendix A of this report.

Table 1
Summary of Existing Wells

Well Name[a]	Target Formation	Well Depth (ft)[a]	Reported Depth-to-Water (feet)[a]	Reported Test Pumping Rate (gpm)[a]	Perforated or Open Interval (dbgs[b])[a]	Specific Capacity (gpm/ft)[a]
North Mayfield Test Well	Green River Formation	400	ND	150[d]	178-400	ND
Mayfield Town Well	Green River Formation	300	66	205	145-200 200-300	1.37
Mayfield Park Well	Green River Formation	355	46	400	110-210 230-290 318-338	1.64
Mayfield Irrigation Well	Unknown	164	18	475	ND	5.4
Reeves Well	Unconsol-idated Deposits	160	28	65[d]	120-160	1.3
Belnap Well	Arapien Shale	160	39	100[d]	120-160	0.67

a) Data are from well logs on file with the DWR
b) DBGS = Depth below ground surface
c) ND = No Data
d) Reported Airlift Rate

According to information that is on file with the DWR, existing wells in the Arapien Valley typically produce groundwater at rates ranging from several gallons per minute from small domestic and stock water wells up to approximately 475 gpm for larger public water supply and irrigation wells. Larger producing wells appear to typically produce water from both the unconsolidated alluvial deposits and the underlying consolidated rock aquifers.

3.3 GROUNDWATER RECHARGE

According to Gates (1982), groundwater in the area typically moves from recharge areas at higher elevations to discharge areas in the valleys. Recharge to the fractured rock aquifers occurs primarily as a result of infiltration of streamflow and by direct infiltration of snowmelt and precipitation to bedrock at higher elevations. In general, the amount of annual precipitation that falls in the area increases with elevation and according to Robinson (1971), higher elevations in the mountains may receive as much as 25 inches of precipitation annually. Robinson (1971) states that precipitation at higher elevations is the largest source of recharge to the fractured rock aquifers.

As a result of recharge at higher elevations, water in some of the bedrock units underlying the valleys is under artesian pressure (Robinson, 1971). Because groundwater in the consolidated rock units is under pressure, in some areas the consolidated rock probably provides recharge to the overlying unconsolidated deposits.

Most recharge to the valley-fill aquifer in the area occurs near the edge of the valleys as a result of seepage from streams (Gates, 1982; Robinson, 1971). According to Robinson (1971), seepage of water from stream channels as they emerge from canyons onto permeable alluvial fans is probably the largest single source of recharge to the valley fill aquifer. Subsurface inflow of water from bedrock along the valley margins is also expected to provide a significant amount of recharge to the valley fill (Robinson, 1971; Snyder and Lowe, 1998).

According to Robinson (1971) and Gates (1982), recharge to the valley fill also occurs as a result of seepage from canals and irrigated fields as well as from subsurface inflow from other areas and from infiltration of precipitation along the valley margins.

4. WATER QUALITY SUMMARY

According to Lowe et al. (2002) groundwater quality in the valley is generally good although some areas within the study area have elevated total dissolved solids (TDS) concentrations that range from 500 to 2,500 milligrams per liter (mg/L). In general, the highest quality groundwater is found near the mountain recharge areas and in the unconsolidated deposits on the east side of the valley near the Wasatch Plateau. According to Lowe et al. (2002), TDS concentrations in the valley fill aquifer are typically below 1,000 mg/L; however, higher nitrate concentrations (greater than 10 mg/L) exist in the valley fill aquifer northeast of Mayfield.

According to Snyder and Lowe (1998), water quality from fractured rock aquifers varies widely. Groundwater that has been in contact with evaporite layers of the Arapien Shale typically has higher concentrations of dissolved solids (Snyder and Lowe, 1998). According to Robinson (1971), water from wells completed in the Green River and Crazy Hollow Formations beneath the valley fill contains elevated dissolved solids concentrations at some locations.

At least one public water supply well in the Arapien Valley is known to have had corrosion problems. According to information on file with the Utah Division of Drinking Water (DDW), premature corrosion failure of the well pump column has occurred as soon as 20 months after pump installation. Based on laboratory results on file with the DDW, high carbon dioxide concentrations are present in groundwater in the area which could contribute to corrosion problems. A corrosion study that was completed by Corrosion Control Technologies (CCT) (2003), states that the most likely explanation for the corrosion failure was dissimilar metal galvanic corrosion.

5. IDENTIFICATION OF POTENTIAL WELL LOCATIONS AND DEPTHS

Proposed well locations were identified based on anticipated geologic conditions and potential for groundwater production, probability of encountering groundwater that would meet required water quality standards, and proximity to existing Gunnison and Mayfield Irrigation Companies infrastructure. Potential well locations are shown on Figures 4 and 5 and the target aquifers and technical issues associated with each proposed well location are outlined in the following sections.

In general, well locations that target thick coarse grained unconsolidated deposits have less risk of encountering poor yielding aquifer conditions than wells that target consolidated rock aquifers. Well Drillers logs of wells completed within the study area indicated that unconsolidated deposits in the study area are typically relatively thin (less than 150 feet thick). As a result, wells in the area that produce the largest quantities of groundwater appear to typically be completed in both the unconsolidated valley fill and the underlying consolidated rock formations. The aquifers with lower risk of poor yield within the study area appear to be the unconsolidated valley fill deposits and the consolidated rock of the Green River Formation.

A preliminary terrain and fracture trace analysis was completed for the study area that was identified by Jones & DeMille and shown on Figures 1 and 2. Terrain analysis is a critical step in identifying areas with groundwater production potential, particularly in complex geologic terrain. As discussed in Section 3.2.2, hydrogeologic conditions in consolidated rock aquifers are highly variable and are typically characterized by low storativity. Mapping fracture systems is important in bedrock terrain because groundwater flow is generally restricted to secondary porosity in fractures and voids and these features are usually associated with weak zones (Gates, 1997 and 2003). Direct relationships have been identified between the presence of fracture zones and the occurrence of groundwater because the fracture zones act as conduits that transport water within the rock mass (Lattman and Parizek, 1964).

Yields from consolidated rock aquifers are dependent on the character and extent of fracturing and are highly variable. Encountering significant amounts of water in fractured rock is dependant on intersecting zones of intensely fractured rock with single or multiple intersecting fractures (Gates, 1997, 2003).

By performing a reconnaissance level terrain and fracture trace analysis using aerial photographs, we were able to identify primary fracture sets within the study area. A site visit was made on June 25, 2008 in order to observe any anthropogenic features that may have been mistaken for fractures during our aerial photograph analysis. The fracture sets that were identified as part of the terrain and fracture trace analysis generally trended north-south as shown on Figure 4. The results of the terrain and fracture trace analysis made it possible to identify five areas within the study area where fracture sets were present (Figure 4). The areas where fracture sets were identified are expected to have the lowest potential risk for poor groundwater production within the study area.

Based on information provided by Jones & DeMille, we understand that the Gunnison and Mayfield Irrigation Companies would like to develop groundwater sources capable of producing approximately 160 cfs for a minimum of two months (May and June) of each year. Producing 160 cfs for two months would result in an estimated withdrawal of approximately 19,400 acre-ft of groundwater per year. Assuming an average pumping rate of 500 gpm from individual wells, approximately 145 wells would be necessary in order to develop the required capacity. Based on available hydrogeologic information, it is unlikely that aquifers in the area would be capable of supplying this quantity of water to wells within the study area.

Based on our analysis of available information, in the event that groundwater development is pursued, we have identified five locations within the study area with potential for groundwater development based on our understanding of the geology of the area as depicted on Figures 2 and 3 and the results of our terrain and fracture trace analysis as shown on Figure 4. The potential well locations are shown on Figure 4 and the target aquifers and technical issues associated with each proposed well location are outlined in the following sections.

5.1 PROPOSED LOCATION A

Well Location A (Figure 4) targets groundwater in the unconsolidated valley fill deposits and the consolidated rock of the underlying Green River Formation near the mouth of Twelvemile Canyon. Location A was identified based on the mapped geology of the area, the results of our terrain and fracture trace analysis, and the proximity to the existing Gunnison and Mayfield irrigation companies infrastructure.

We expect the unconsolidated deposits at Location A to be coarse grained; however, the thickness of the unconsolidated deposits in this area is not well known and may not be as thick as other locations near the middle of the valley. The results of geologic mapping and our fracture trace analysis show that faults and fracture sets are present in the area which increases the likelihood of encountering fracture networks that contain groundwater. Location A is on the east side of the valley adjacent to the Wasatch Plateau which increases the likelihood of encountering good quality groundwater.

There are several existing wells located within several hundred feet west and east of Location A. Existing wells located west of Location A produce groundwater at rates of up to 475 gpm. According to Well Driller's Reports for these wells that were obtained from the DWR, bedrock was typically encountered at depths ranging from 45 to 141 feet. A well located at Location A has significant potential to influence (i.e. increased drawdown and reduced pumping rate) the existing nearby PWS and private wells.

5.2 PROPOSED LOCATION B

Well Location B (Figure 4) targets groundwater in the unconsolidated valley fill deposits and the consolidated rock of the underlying Green River Formation southwest of the town on Mayfield. Location B was identified based on the mapped geology of the area and the results of our terrain and fracture trace analysis.

We expect the unconsolidated deposits at Location B to range from fine to coarse grained; however, unconsolidated deposits near the middle of the valley at Location B are expected to be thicker than at locations closer to the valley margins. Our fracture trace analysis identified fracture sets in the area which increases the likelihood of encountering fracture networks that contain groundwater. In general, groundwater quality is expected to be better closer to the eastern side of the valley. Groundwater on the west side of the valley has an increased chance of elevated TDS concentrations as a result of contact with the Arapien Shale which is exposed in outcrops in the White Hills. Most existing wells in the area are located several thousand feet north of Location B; however, according to information on file with the DWR, one small stock watering well is located nearby. A well at Location B could potentially interfere with the existing nearby well.

5.3 PROPOSED LOCATION C

Well Location C (Figure 5) is located approximately 3 miles north of the town of Mayfield and targets groundwater in the unconsolidated valley fill deposits and the consolidated rock of the underlying Green River Formation. Location C was identified based on the mapped geology of the area and the results of our terrain and fracture trace analysis.

We expect the unconsolidated deposits at Location C to range from fine to coarse grained. The Arapien Valley is relatively narrow in the vicinity of Location C and we anticipate that the thickness of unconsolidated deposits at Location C may not be as great as at other locations in the valley. The results of geologic mapping and our fracture trace analysis have identified faults and fracture sets in the area, which increases the likelihood of encountering fracture networks that contain groundwater in the underlying consolidated rock formations. Location C is on the east side of the valley adjacent to the Wasatch Plateau which increases the likelihood of encountering good quality groundwater.

Several small domestic and stock watering wells are located within several hundred feet south of Location C. A well located at Location C has the potential to influence these existing wells.

5.4 PROPOSED LOCATION D

Well Location D (Figure 5) targets groundwater in the unconsolidated valley fill deposits and the consolidated rock of the underlying Green River Formation. Location D was identified based on the mapped geology of the area and the results of our terrain and fracture trace analysis.

We expect the unconsolidated deposits at Location D to range from fine- to coarse-grained; however, because this location is near the western margin of the valley, the unconsolidated deposits in this area are expected to be thinner than at other locations near the middle of the valley. Features that appear to be intersecting fracture sets were identified as part of our fracture trace analysis. The presence of intersecting fracture sets increases the likelihood of encountering fracture networks that may contain groundwater in the underlying consolidated rock.

Because Location D is on the west side of the valley, there is an increased chance of elevated TDS concentrations in groundwater as a result of contact with the Arapien Shale which is exposed in outcrops in the White Hills on the west side of the valley. According to Lowe et al. (2002), high nitrate concentrations (greater than 10 mg/L) exist in the valley fill aquifer northeast of Mayfield.

Drilling near the western margin of the valley also increases the risk of encountering the consolidated rock of the Arapien Shale which is not expected to yield significant quantities of groundwater. Several existing wells are located within several hundred feet of Location D. A well at Location D has the potential to influence these existing wells.

5.5 PROPOSED LOCATION E

Well Location E (Figure 5) targets groundwater in the unconsolidated valley fill deposits and the consolidated rock of the underlying Green River Formation. Location E was identified based on the mapped geology of the area and the results of our terrain and fracture trace analysis.

We expect the unconsolidated deposits at Location E to range from fine to coarse grained; however, because this location is near the margin of the valley, the unconsolidated deposits in this area are expected to be thinner than at other locations near the middle of the valley. Published geologic mapping and our terrain and fracture trace analysis both identified faults and fracture sets that appear to be present in the area. The presence of faults and fracture sets increases the likelihood of encountering fracture networks in the underlying consolidated rock that contain groundwater.

Location E is on the east side of the valley adjacent to the Wasatch Plateau, which increases the likelihood of encountering good quality groundwater; however, Lowe et al. (2002) have identified higher nitrate concentrations (greater than 10 mg/L) in the valley fill aquifer northeast of Mayfield. Several existing wells are located within several hundred feet southwest of Location D. A well at Location D has the potential to influence these existing wells.

5.6 OTHER CONSIDERATIONS

As indicated in the preceding paragraphs, each of the five locations identified as having potential for groundwater development have technical issues that need to be considered before proceeding with well drilling. In addition to the technical issues associated with individual well locations, available hydrogeologic information suggests that it is unlikely that aquifers in the area would be capable of supplying the quantity of water that Jones & DeMille has indicated is needed by the irrigation companies. Advantages and disadvantages of each of the potential well locations that have been identified are summarized in Table 2.

Table 2
Well Sighting Summary
Gunnison and Mayfield Irrigation Companies

Proposed Location	Target Aquifer	Advantages	Disadvantages
A	Unconsolidated Deposits/Green River Formation	1) Near area where rock mass appears to be fractured. 2) Water quality on east side of valley is expected to be good. 3) Good proximity to existing irrigation company infrastructure.	1) Groundwater production potential is estimated to be significantly less than desired quantity. 2) Complex subsurface geology. 3) Potential for interference with existing wells. 4) Uncertain aquifer conditions and water quality due to lack of subsurface data. 5) Unconsolidated alluvial deposits are expected to be relatively thin. 6) Hydrogeologic conditions in consolidated rock aquifers are highly variable.
B	Unconsolidated Deposits/Green River Formation	1) Near area where rock mass appears to be fractured. 2) Only one nearby existing well.	1) Groundwater production potential is estimated to be significantly less than desired quantity. 2) Complex subsurface geology. 3) Uncertain aquifer conditions due to lack of subsurface data. 4) Risk of encountering poor quality groundwater. 5) Risk of encountering Arapien Shale. 6) Hydrogeologic conditions in consolidated rock aquifers are highly variable.
C	Unconsolidated Deposits/Green River Formation	1) Near area where rock mass appears to be fractured. 2) Water quality on east side of valley is expected to be good.	1) Groundwater production potential is estimated to be significantly less than desired quantity. 2) Complex subsurface geology. 3) Potential for interference with existing wells. 4) Uncertain aquifer conditions and water quality due to lack of subsurface data. 5) Unconsolidated alluvial deposits are expected to be relatively thin. 6) Hydrogeologic conditions in consolidated rock aquifers are highly variable.

Proposed Location	Target Aquifer	Advantages	Disadvantages
D	Unconsolidated Deposits/Green River Formation	1) Near area where rock mass appears to be fractured. 2) Only one nearby existing well.	1) Groundwater production potential is estimated to be significantly less than desired quantity. 2) Complex subsurface geology. 3) Uncertain aquifer conditions due to lack of subsurface data. 4) Risk of encountering poor quality groundwater. 5) Risk of encountering Arapien Shale. 6) Hydrogeologic conditions in consolidated rock aquifers are highly variable.
E	Unconsolidated Deposits/Green River Formation	1) Near area where rock mass appears to be fractured. 2) Water quality on east side of valley is expected to be good.	1) Groundwater production potential is estimated to be significantly less than desired quantity. 2) Complex subsurface geology. 3) Potential for interference with existing wells. 4) Uncertain aquifer conditions and water quality due to lack of subsurface data. 5) Unconsolidated alluvial deposits are expected to be relatively thin. 6) Hydrogeologic conditions in consolidated rock aquifers are highly variable.

6. SUMMARY AND CONCLUSIONS

6.1 SUMMARY

Based on our assessment of local hydrogeology, there are five locations within the proposed study area that was identified by Jones & DeMille (Locations A, B, C, D, and E) that have potential for groundwater production. Each of the potential well locations target groundwater in the unconsolidated valley fill deposits as well as groundwater in the consolidated rock of the Green River Formation. It is important to note that there are technical issues that need to be considered before proceeding with well drilling at any of the proposed locations. In addition, available hydrogeologic information suggests that aquifers in the area have groundwater production potential, however, it is unlikely that these aquifers would be capable of supplying the desired 160 cfs to wells within the study area.

Each of the potential well locations were identified based on published geologic mapping and by performing a reconnaissance level terrain and fracture trace analysis using aerial photographs. We were able to identify five locations within the study area where fracture sets were present. Our initial analysis indicates that these areas of intersecting fractures probably have the least risk for poor groundwater production from consolidated rock within the study area. Several of the proposed locations are located several thousand feet from any existing irrigation company infrastructure. As a result, the economic feasibility of developing wells at these locations that would also require associated pipeline construction and pumping costs should be evaluated closely.

We recommend that any wells that are developed be located as close to the middle of the valley as possible in order to increase the probability of encountering good quality groundwater, thick unconsolidated deposits, and to reduce the probability of encountering the Arapien Shale which is present in the mountains on the west side of the valley. We recommend that any new wells be located as far as possible from existing wells in order to reduce the potential for interference (i.e. increased drawdown and reduced pumping rate) in nearby existing wells.

The purpose of this study is to provide a reconnaissance level assessment of potential well sites by completing a large scale hydrogeologic assessment and large scale fracture trace mapping. Based on the results of this assessment we have recommended five potential drilling locations on a reconnaissance level basis. If well drilling is pursued, additional detailed geologic and hydrogeologic mapping at sites identified as part of this study may be able to reduce the risk associated with developing a well at specific locations.

Site-specific geologic and fracture mapping at each potential well site was beyond the scope of this initial phase of the project. If well drilling is pursued, we recommend that site-specific geologic and hydrogeologic mapping be completed prior to development of a new well, in order to reduce the risk associated with developing a well at specific locations.

We recommend that, if construction of a water supply well is pursued, and the results of site specific mapping show good potential for groundwater development, groundwater exploration commence with a small diameter (approximately 6.25 inch) test boring targeting the Green River Formation aquifer. We recommend that a small diameter test boring be drilled prior to drilling a production well in order to confirm the conceptual model of the area and to test the production potential and water quality at the proposed site.

6.2 OUTLINE OF WELL COMPLETION PROGRAM

In the event that development of groundwater from wells is pursued, the following section outlines steps in the overall process of developing wells for public water supply. Some of the steps are suggested; however, most are required by regulatory agencies.

Complete Exploration Boring or Exploration Well

We recommend that an exploration boring or exploration well be drilled at any of the potential well locations to confirm the depth to, thickness of, and potential yield and water quality of the target aquifer at each location. An exploration well is recommended for any of the potential well sites in order to confirm the conceptual geologic model for the area.

Hydrogeologic observations should be made and documented including preparation of lithologic logs, documentation of drilling conditions and groundwater occurrence, and collection of water quality samples. Planning and interpretation of airlift tests are also recommended. The information obtained from the exploration program should be evaluated to assess whether the production well should proceed and will provide data for final design and bidding of the production well.

During exploration drilling the contractor may need to be prepared to containerize all drilling fluids and produced waters. Drilling would start by installing and grouting a short temporary 8-inch surface casing to control erosion of the ground surface during drilling. Drilling would then proceed using reverse circulation techniques at a diameter of approximately 6.25 inches to a depth of approximately 500 feet, depending on the location.

Under the direction of a field engineer or geologist, drill cuttings should be collected at intervals of 10 feet or less and examined as drilling proceeds, along with observation of drill rig performance, penetration rate, fluid losses, and other information in order to assess hydrogeologic conditions. Upon reaching total depth, the borehole should be filled with drilling mud and geophysical logging should be completed. After geophysical logging, the borehole should be properly abandoned in accordance with DWR regulations.

Water Rights Permitting

We understand that if development of groundwater from wells is pursued, Jones & DeMille will obtain the necessary water right approvals from the DWR to allow the drilling and testing of an exploration well or new water supply well at any of the proposed locations.

Water Well Construction and Testing

A new water supply well must be drilled, constructed, and tested in accordance with the rules of the DWR. The well must be drilled and completed by a water well driller licensed by the DWR. We recommend that drilling, well construction and testing be observed by a qualified geologist or engineer. Services that the professionals can render include (1) assistance with bidding, (2) coordination with representatives of owner and the drilling contractor, (3) review and approval of invoices, (4) lithologic logging of drilling samples, (5) monitoring of water production and/or water quality during drilling, (6) monitoring of well construction, (7) recommendations for modifications to well design based on conditions encountered during drilling, (8) planning and monitoring of step-discharge and 24-hour constant-rate pumping tests, and (9) collection of water quality samples.

7. CLOSURE

7.1 LIMITATIONS

The recommendations contained in this report are based a reconnaissance level terrain and fracture trace analysis. No subsurface exploration was performed as part of this investigation. It is possible that variations in the soil, rock, and groundwater conditions exist. The nature and extent of variations may not be evident until drilling occurs. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope or well location changes from that described in this report, our firm should also be notified.

This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, express or implied, is made. It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's risk.

This report may be used only by the client and only for the purposes stated within a reasonable time from its issuance. Land use, site conditions (both on- and off-site), or other factors may change over time, and additional work may be required. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else, unless specifically agreed to in advance by Kleinfelder in writing will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party.

7.2 ADDITIONAL SERVICES

The recommendations made in this report are based on the assumption that an adequate program of tests and observations will be made during the construction to verify compliance with these recommendations. These tests and observations should include, but not necessarily be limited to, the following:

- Site-specific geologic reconnaissance;
- Observations and lithologic logging during well drilling and construction; and
- Consultation as may be required during construction.

We also recommend that project plans and specifications be reviewed by us to verify compatibility with our conclusions and recommendations. Additional information concerning the scope and cost of these services can be obtained from our office.

8. REFERENCES CITED

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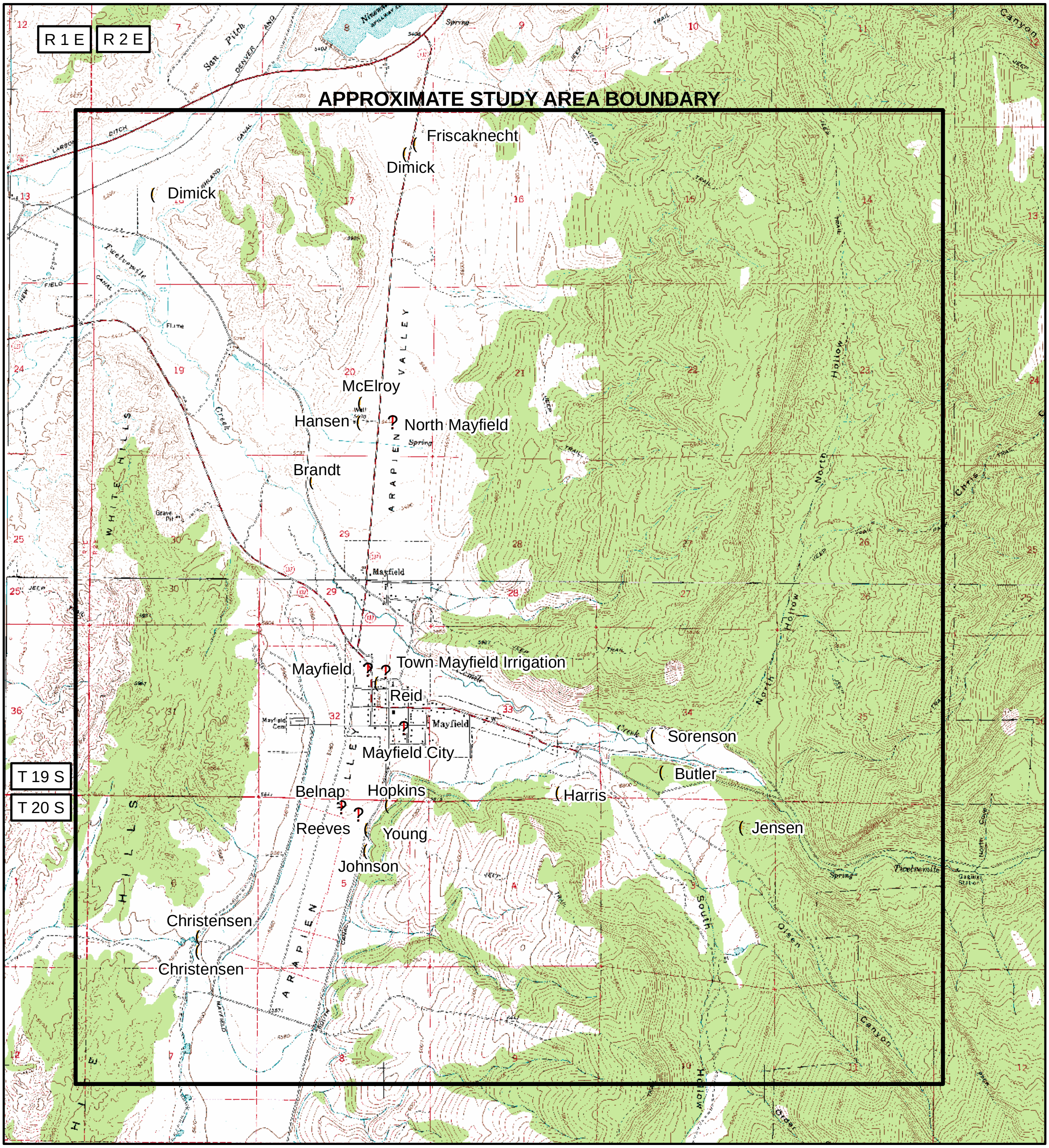
FIGURES



Notes:
1. Base map is modified from the Mayfield and Sterling, Utah, USGS 7.5' Quadrangles.
2. Elevations are in feet.
3. Salt Lake Base and Meridian (SLB&M)
4. All locations are approximate.

0 2,250 4,500 9,000 Feet

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SITE VICINITY MAP

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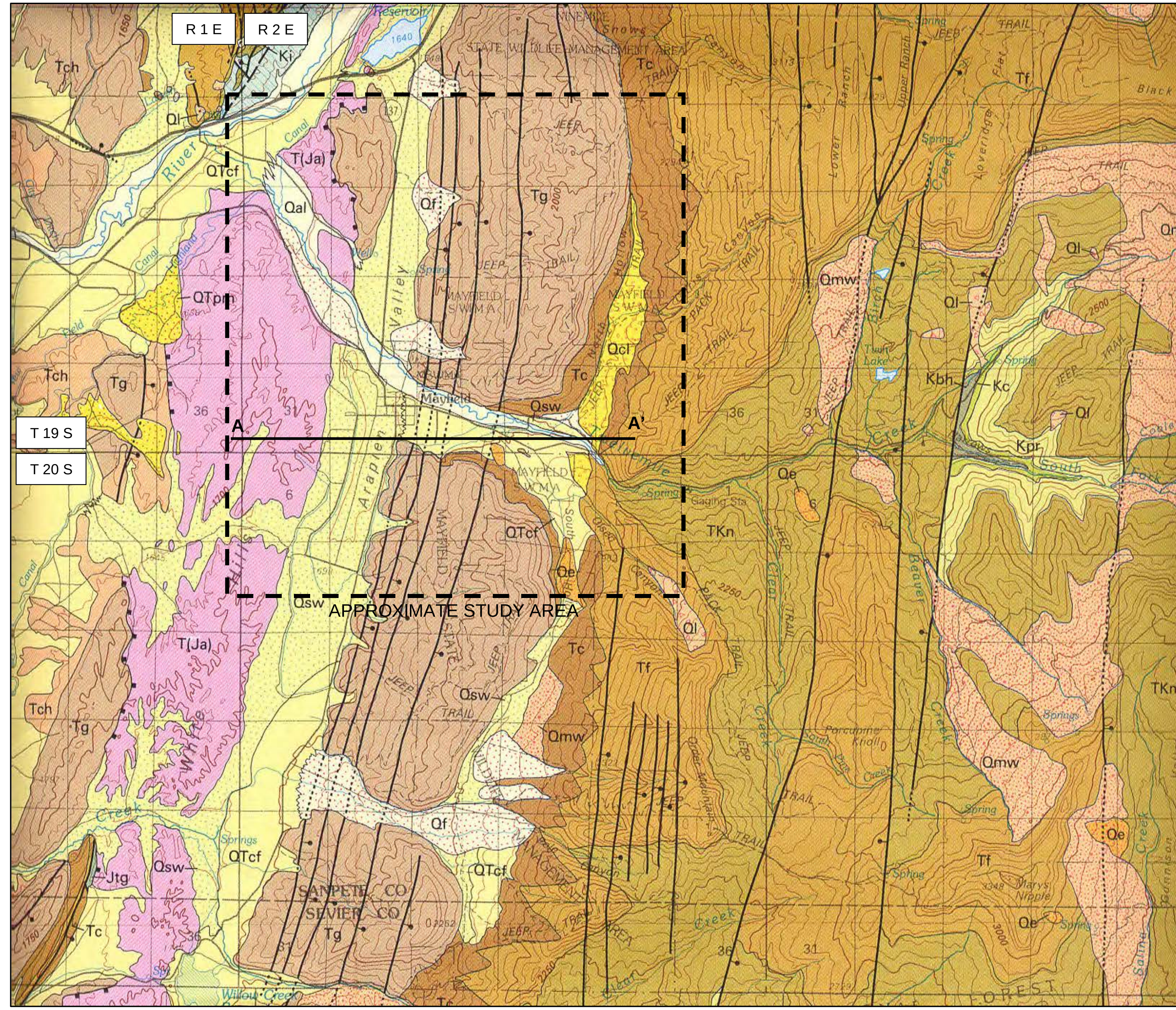
WELL SITING STUDY
SANPETE COUNTY, UTAH

Figure 1

Cartography By: S.C. | 05/09/2008 | Project Number: 92092.003 | File Name: SLC8A083



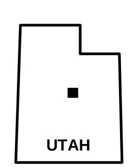
EXPLANATION

Qct - Colluvium
Qal - Alluvium
Qsw - Slope Wash
Qf - Alluvial Fan Deposits
Ql - Landslide Deposits
Qe - Earth Flow Deposits
Qmw - Mass Wasting Deposits
QTcf - Alluvial Fan Deposits
Tch - Crazy Hollow Formation
Tc - Colton Formation
Tf - Flagstaff Limestone
Kc - Castlegate Sandstone
Kbh - Blackhawk Formation
Jtg - Twist Gulch Formation
T(Ja) - Arapien Shale

Notes:
1. Base map modified from Geologic Map of the Manti 30' x 60' Quadrangle Carbon, Emery, Juab, Sanpete and Sevier Counties, Utah, by Irving J. Witkind, Malcolm P. Weiss & Terrace Brown.
2. Elevations are in meters.
3. Salt Lake Base & Meridian (SLB&M).
4. All locations are approximate.

CONTOUR INTERVAL 50 METERS
SUPPLEMENTAL CONTOUR INTERVAL 25 METERS

0 — 5 MILES
0 — 10 KM



QUADRANGLE LOCATION

N

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GEOLOGIC MAP

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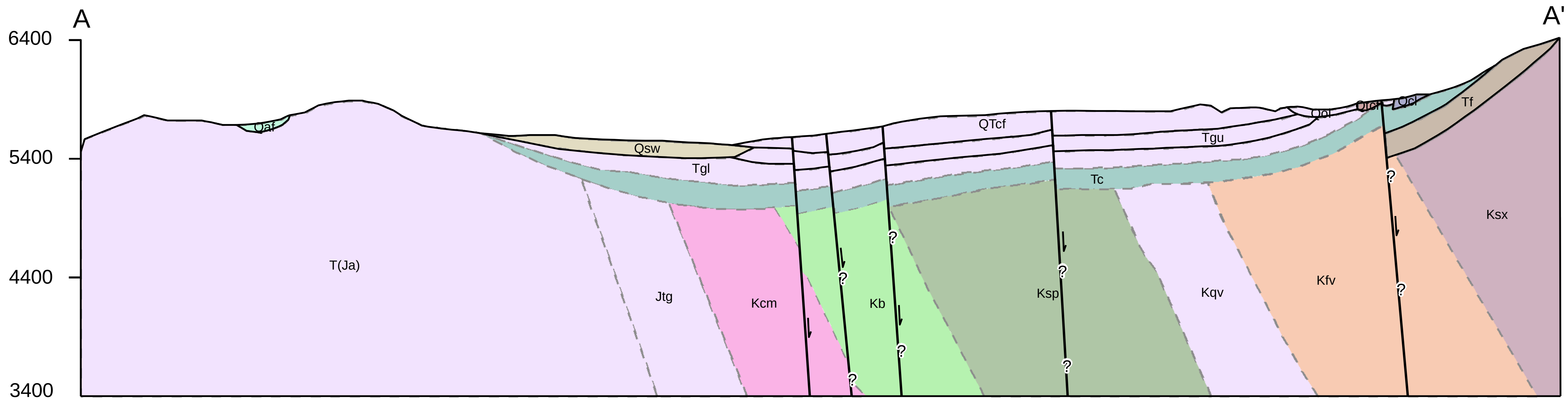
WELL SITING STUDY
SANPETE COUNTY, UT

FIGURE: 2

Drawn by.: S.C.	Date: 05/09/2008	PROJECT NO.: 92092.003	FILE NAME: SLC8Q053-11X17



Vertical Scale: 1" = 1000'
Horizontal scale: 1' = 1000'

EXPLANATION

Qcl	Colluvium	Ksx	Sixmile Canyon Formation
Qal	Alluvium	Kfv	Funk Valley Formation
Qsw	Slope Wash	Kqv	Allen Valley Shale
QTcf	Alluvial fan Deposits	Ksp	Sanpete Formation
Tgu	Upper Green River Formation	Kb	Basal Formation of Indianola Group
Tgl	Lower Green River Formation	Kcm	Cedar Mountain Formation
Tc	Colton Formation	Jtg	Twist Gulch Formation
Tf	Flagstaff Limestone	T(Ja)	Arapien Shale

Geologic Cross-Section drawn from mapping by Witkind & others, 1987

970 485 0 970
Scale Feet

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Cartography By: S.C. Date: 05/12/2008

CROSS SECTION A - A'

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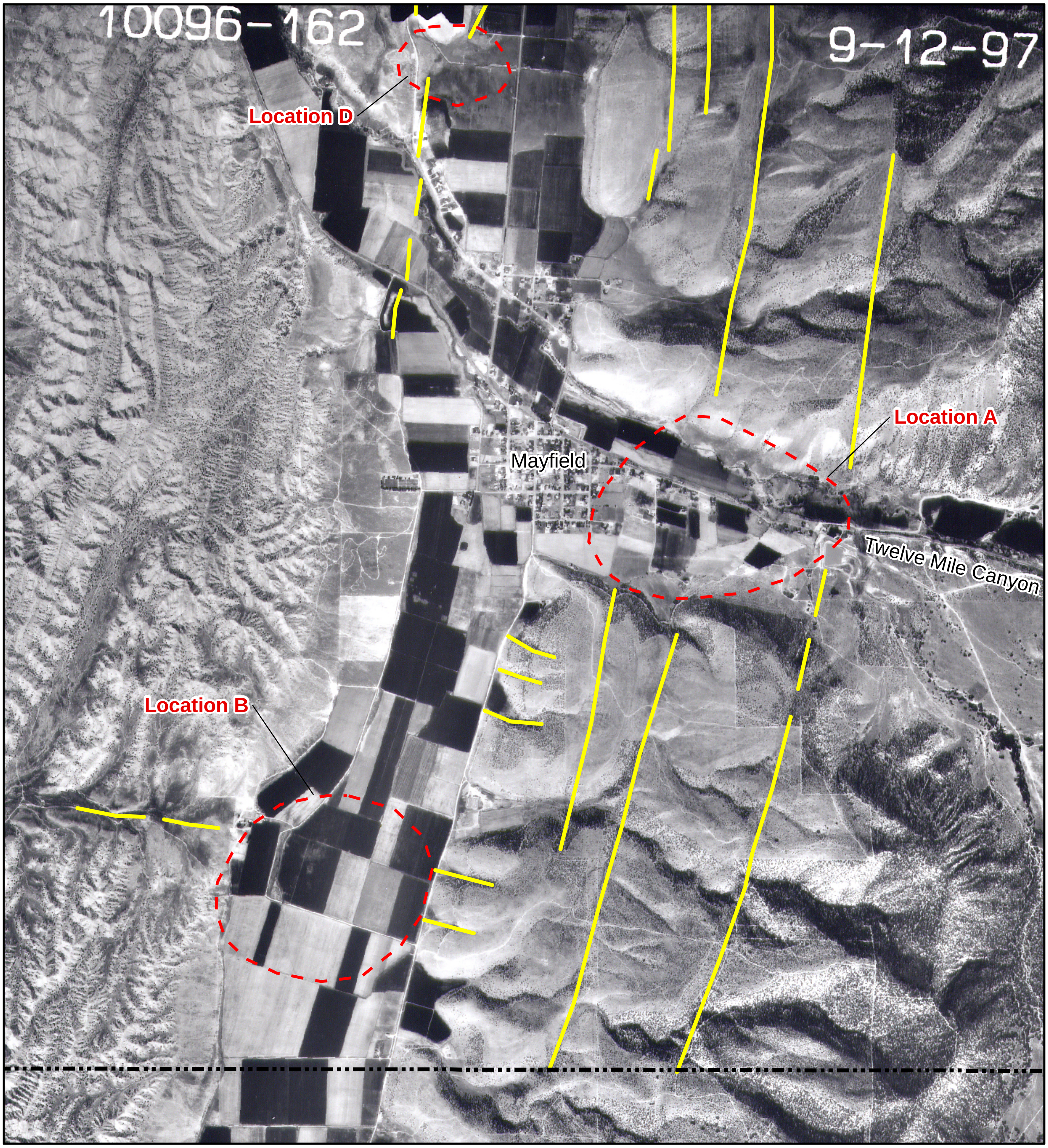
WELL SITING STUDY
SANPETE COUNTY, UTAH

Figure 3

Project Number: 92092.003 File Name: SLC8A093



Base Map:
Olympus Aerial Surveys
9/12/1997
10096-162

0 1,500 3,000 6,000 Feet

Scale: 1: 36,000

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FRACTURE TRACE ANALYSIS

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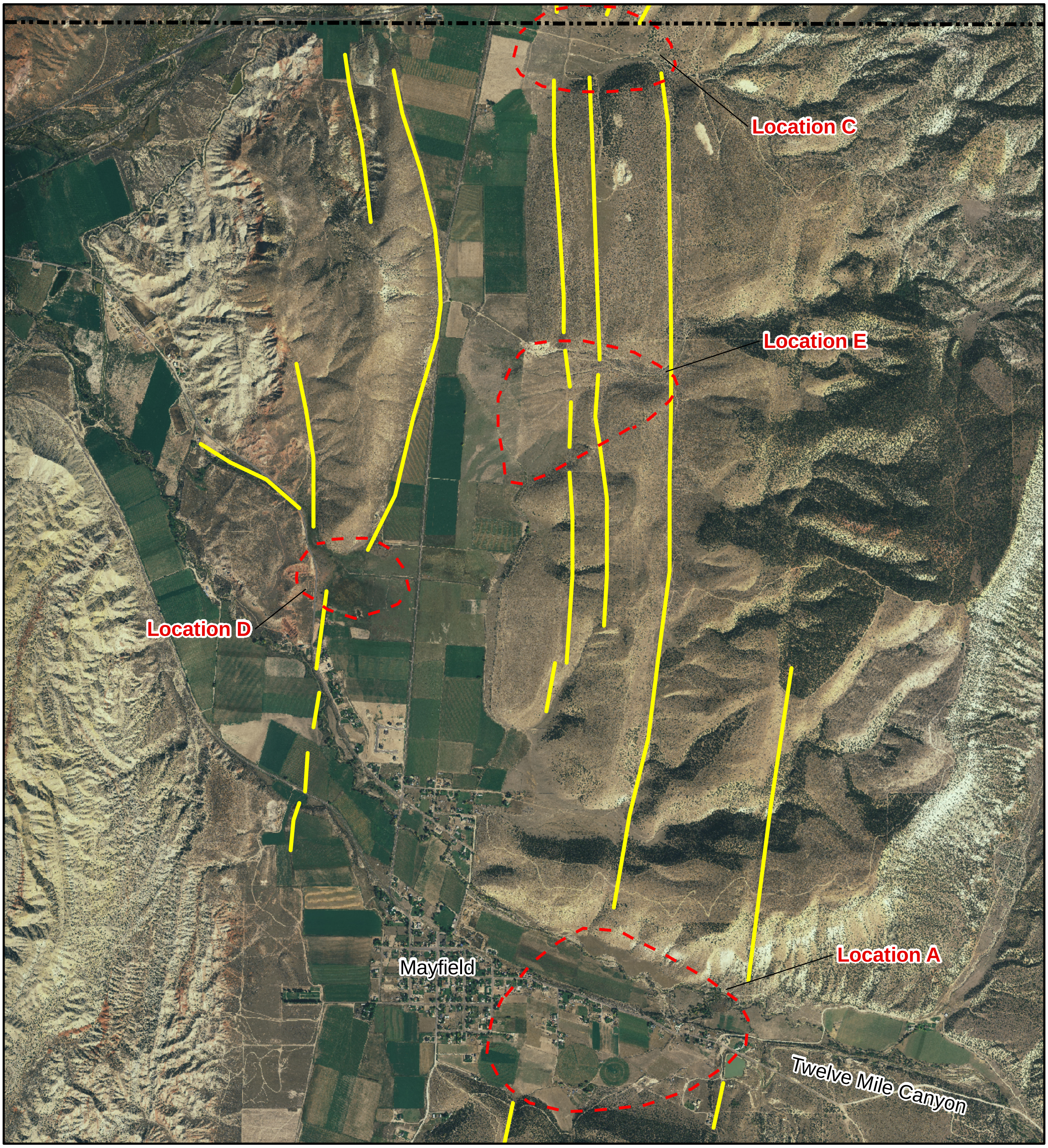
WELL SITING STUDY
SANPETE COUNTY, UTAH

Figure 4

Cartography By: S.C.	05/09/2008	Project Number: 92092.003	File Name: SLC8A098



Base Map:
2006 HRO - 1 foot resolution
From Utah UGRC
12SVJ400320/12SVJ400280
12SVJ360320/12SVJ360280

0 1,500 3,000 6,000 Feet

Scale: 1: 36,000

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FRACTURE TRACE ANALYSIS

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WELL SITING STUDY
SANPETE COUNTY, UTAH

Figure 5

Cartography By: S.C. | 05/09/2008 | Project Number: 92092.003 | File Name: SLC8A096

APPENDIX A

North Mayfield Test Well

B.J.
1-10-05

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification

WIN: 30367

Non-Production Well: 0463002M00

Owner *Note any changes*

Centerfield City and Mayfield town
P.O. Box 220200
130 S Main Street
Centerfield, UT 84622

North Mayfield

Contact Person/Engineer: ____________

Well Location *Note any changes*

N 1160 W 1168 from the SE corner of section 20, Township 19S, Range 2E, SL B&M

Location Description: (address, proximity to buildings, landmarks, ground elevation,local well #)

Drillers Activity Start Date: 9-6-04 Completion Date: 10-4-04

Check all that apply: ☒ New ☐ Repair ☐ Deepen ☐ Clean ☐ Replace ☐ Public Nature of Use: Test Well

If a replacement well, provide location of new well. ________ feet north/south and ________ feet east/west of the existing well.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	78	9 7/8"	Air Rotary	water
78	400	7 7/8"	Air Rotary	water

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE High	PERMEABLE Low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTION AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition density, plasticity, shape, cementation, consistancy, water bearing, ordor, fracturing, minerology, texture,degree of weathering, hardness, water quality, etc.)
0	5				X	X							Grey	
5	18	X		X	X								Tan	
18	53	X		X	X			X					Tan	
53	134	X	X				X	X						
134	170	X		X	X		X	X					Tan	
170		X	X								X	Limestone	Dark Grey	Fractured limestone

RECEIVED
JAN 10 2005
WATER RIGHTS
SALT LAKE

Static Water Level

Date 10-4-04 Water Level ________ feet Flowing? ☐ Yes ☒ No

Method of Water Level Measurement ________ If Flowing, Capped Pressure ________ PSI

Point to Which Water Level Measurement was Referenced ________ Elevation ________

Height of Water Level reference point above ground surface ________ feet Temperature ________ degrees ☐C ☐F

Well Log

Construction Information

DEPTH (feet)		CASING			DEPTH (feet)		☐SCREEN ☐PERFORATIONS ☐OPEN BOTTOM		
FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	FROM	TO	SCREEN SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
+1.5	178'	Steel A53-B	.250	8"					

Well Head Configuration: steel plate welded to casing

Access Port Provided? ☐Yes ☒No

Casing Joint Type: welded

Perforator Used: ______

Was a Surface Seal Installed? ☒Yes ☐No

Depth of Surface Seal: 42 feet

Drive Shoe? ☐Yes ☒No

Surface Seal Material Placement Method: poured from surface

DEPTH (feet)		SURFACE SEAL / INTERVAL SEAL / FILTER PACK / PACKER INFORMATION		
FROM	TO	SEAL MATERIAL, FILTER PACK and PACKER TYPE and DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal., # bag mix, gal./sack etc.)
0	42'	Bentonite Hole Plug	350#	Dry

Well Development and Well Yield Test Information

DATE	METHOD	YIELD	Units Check One: GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
10-4-04	compressed Air	150 approx	X			

Pump (Permanent)

Pump Description: ______ Horsepower: ______ Pump Intake Depth: ______ feet

Approximate Maximum Pumping Rate: ______

Well Disinfected upon Completion? ☐Yes ☐No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary Circumstances, abandonment procedures. *Use additional well data form for more space.*

water Tested excessive Nitrates, pump test has not been done as of yet. Owner considering using well for secondary water.

Well Driller Statement

This well was drilled and constructed under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name WRIGHT DRILLING (Person, Firm, or Corporation - Print or Type)

License No. 333

Signature Ken Wright (Licensed Well Driller)

Date 10-16-04

Mayfield City

Moyfield Town well

Area 63 a-9779

Form 113-534-12-60

Examined JUL 10 1978 TM

Recorded: B. C. ________ T. B. TM

Inspection Sheet ________

Copied ________

REPORT OF WELL DRILLER

STATE OF UTAH

Application No. Change 9779 63-2517

Claim No. ________

Coordinate No. (D-19-2)32 adi

GENERAL STATEMENT: Report of well driller is hereby made and filed with the State Engineer, in accordance with the laws of Utah. (This report shall be filed with the State Engineer within 30 days after the completion or abandonment of the well. Failure to file such reports constitutes a misdemeanor.)

(1) WELL OWNER:

Name Mayfield City

Address Mayfield, Ut 84643

(2) LOCATION OF WELL:

County Sanpete Ground Water Basin ________ (leave blank)

~~North~~ South 2800 feet, ~~East~~ West 700 feet from NE Corner

of Section 32 T. 19 ~~N.~~ S., R. 2 E SLBM ~~W USM~~ (strike out words not needed)

(3) NATURE OF WORK (check): New Well ☒ Replacement Well ☐ Deepening ☐ Repair ☐ Abandon ☐

If abandonment, describe material and procedure: ________

(4) NATURE OF USE (check): Domestic ☒ Industrial ☐ Municipal ☐ Stockwater ☐ Irrigation ☐ Mining ☐ Other ☐ Test Well ☐

(5) TYPE OF CONSTRUCTION (check): Rotary Air ☒ Dug ☐ Jetted ☐ Cable ☐ Driven ☐ Bored ☐

(6) CASING SCHEDULE: Threaded ☐ Welded ☒

8 5/8 OD " Diam. from 0 feet to 200 feet Gage .277

6 5/8 OD " Diam. from 200 feet to 300 feet Gage .280

____ " Diam. from ____ feet to ____ feet Gage ____

New ☒ Reject ☐ Used ☐

(7) PERFORATIONS: Perforated? Yes ☒ No ☐

Type of perforator used Machine

Size of perforations 3/8 inches by 3 inches

6" 100 perforations from 200 feet to 300 feet

8" 451+ perforations from 145 feet to 200 feet

____ perforations from ____ feet to ____ feet

____ perforations from ____ feet to ____ feet

____ perforations from ____ feet to ____ feet

(8) SCREENS: Well screen installed? Yes ☐ No ☐

Manufacturer's Name ________

Type ________ Model No. ________

Diam. ____ Slot size ____ Set from ____ ft. to ____

Diam. ____ Slot size ____ Set from ____ ft. to ____

(9) CONSTRUCTION:

Was well gravel packed? Yes ☐ No ☐ Size of gravel: ________

Gravel placed from ____ feet to ____ feet

Was a surface seal provided? Yes ☒ No ☐

To what depth? 100 feet

Material used in seal: Cement

Did any strata contain unusable water? Yes ☐ No ☐

Type of water: ________ Depth of strata ________

Method of sealing strata off: ________

Was surface casing used? Yes ☐ No ☐

Was it cemented in place? Yes ☐ No ☐

(10) WATER LEVELS:

Static level 66 feet below land surface Date 3-4-78

Artesian pressure ________ feet above land surface Date ________

LOG RECEIVED: R JUN 13 1978

(11) FLOWING WELL:

Controlled by (check) Valve ☐ Cap ☐ Plug ☐ No Control ☐

Does well leak around casing? Yes ☐ No ☐

(12) WELL TESTS: Drawdown is the distance in feet the water level is lowered below static level.

Was a pump test made? Yes ☒ No ☐ If so, by whom? Clair H Stephenson

Yield: 205 gal./min. with 150 feet drawdown after 6 hours

Bailer test ____ gal./min. with ____ feet drawdown after ____ hours

Artesian flow ________ g.p.m. Date ________

Temperature of water ________ Was a chemical analysis made? No ☐ Yes ☐

(13) WELL LOG: Diameter of well 8 5/8 OD inches

Depth drilled 300 feet. Depth of completed well 300 feet.

NOTE: Place an "X" in the space or combination of spaces needed to designate the material or combination of materials encountered in each depth interval. Under REMARKS make any desirable notes as to occurrence of water and the color, size, nature, etc., of material encountered in each depth interval. Use additional sheet if needed.

From	To	Clay	Silt	Sand	Gravel	Cobbles	Boulders	Hardpan	Conglomerate	Bedrock	Other	REMARKS
0	3											Top Soil
3	45	X					X					
45	300											Broken Lime Stone
												Water 145-300

Work started 3-1, 1978 Completed 3-10, 1978

(14) PUMP:

Manufacturer's Name ________

Type: ________ H. P. ________

Depth to pump or bowles ________ feet

Well Driller's Statement:

This well was drilled under my supervision, and this report is true to the best of my knowledge and belief.

Name Clair H Stephenson Drlg. Co. (Person, firm, or corporation) (Type or print)

Address Box 1108 Fillmore, Ut 84631

(Signed) Clair H. Stephenson (Well Driller)

License No. 120 Date 6-13, 1978

USE OTHER SIDE FOR ADDITIONAL REMARKS

Mayfield Park Well

WELL DRILLER'S REPORT

State of Utah
Division of Water Rights
For additional space, use "Additional Well Data Form" and attach

RECEIVED
JAN 04 2001
WATER RIGHTS
SALT LAKE

Well Identification CHANGE APPLICATION: a22382(63-2517)

Owner *Note any changes*

Mayfield Town
P.O. Box 541
Mayfield, UT 84643

Contact Person/Engineer: ____________________

Well Location *Note any changes*

COUNTY: Sanpete
SOUTH 1330 feet WEST 1320 feet from the NE Corner of
SECTION 32, TOWNSHIP 19S, RANGE 2E, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) ____________________

Drillers Activity Mayfield Town
Start Date: 9-6-00 Completion Date: 12-26-00

Check all that apply: ☒ New ☐ Repair ☐ Deepen ☐ Clean ☐ Replace ☐ Public Nature of Use: Municipal

If a replacement well, provide the location of the new well. _____ feet north/south and _____ feet east/west of the existing well.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0'	100'	26"	Cable Tool	water
100'	356'	20"	cable Tool	Water

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition, density, plasticity, shape, cementation, consistancy, water bearing, odor, fracturing, minerology, texture, degree of weathering, hardness, water quality, etc.)
0	3					X	X						Tan	
3	8				X			X					Dark Brown	
8	29				X					X			light Brown	
29	52	X		X	X			X		X			light Brown	
52	101	X	X		X			X		X			light Brown	10% clay, first water at 52'
101	120'	X	X				X	X	X	X			light Brown	light clay Matrix
120'	141	X	X				X	X	X	X				clean semi rounded gravels
141	147'	X		X							X	Limestone	light Brown	Hard solid limestone
147	306	X		X							X	Limestone	yellowish Brown	Fractured getting 6"-gravel from fracture
306	355	X		X	X			X				Limestone	Yellowish Brown	Fractured w/ some clay & Gravel

Static Water Level

Date 12-26-00 Water Level 46 feet Flowing? ☐ Yes ☒ No

Method of Water Level Measurement Tape If Flowing, Capped Pressure ________ PSI

Point to Which Water Level Measurement was Referenced Ground Surface Ground Elevation (If known) ________

Height of Water Level reference point above ground surface 0 feet Temperature ______ ☐ °C ☐ °F

Construction Information

DEPTH (feet) FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)
+1'	100'	Steel A53-B	.375	26"
+3'	352'	Screen & Casing Steel A53-B	.375	16"
+1.5'	141'	steel A53-B	.375	20"

☐ SCREEN ☐ PERFORATIONS ☐ OPEN BOTTOM

DEPTH (feet) FROM	TO	SCREEN SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
~~26" casing~~ 140'	140'	1/2"	3"	15/c"
110'	210'	.050	16"	stainless steel
230'3"	290'3"	.050	16"	" "
318' ~~8~~	338'4"	.050	16"	" "

Well Head Configuration: Steel cap welded

Casing Joint Type: welded Access Port Provided? ☒ Yes ☐ No

Perforator Used: mills knife on 20" casing

Was a Surface Seal installed? ☒ Yes ☐ No Depth of Surface Seal: 100 feet Drive Shoe? ☒ Yes ☐ No

Surface Seal Material Placement Method: pumped grout thru Tremi pipe

Provide Seal Material description below:

DEPTH (feet) FROM	TO	SURFACE SEAL / INTERVAL SEAL / FILTER PACK / PACKER INFORMATION: SEAL MATERIAL, FILTER PACK and PACKER TYPE and DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal.,# bag mix, gal./sack etc.)
0	100'	13 bag sand & cement mix	9 cu. yds	14.5 #s per gallon
0	355	8-12 mesh silica sand	180 cu. ft.	

Well Development and Well Yield Test Information

Date	Method	Yield	GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
12-~~14~~-00	Test pump	200	X		69	[illegible]
12-15 ~~12-~~ ~~thru~~	Test Pump	350	X		35	[illegible]
12-14-00	Test Pump	~~400~~	X		244	24 hrs.

Pump (Permanent)

Pump Description:________ Horsepower:________ Pump Intake Depth:________ feet

Approximate maximum pumping rate:________ Well disinfected upon completion? ☐ Yes ☐ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment procedures. *Use additional well data form for more space.*

Total Test pumping Time [illegible] hours including well development with pump

Well Driller Statement

This well was drilled and constructed under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name Wright Drilling Inc. (Person, Firm, or Corporation - Print or Type) License No. 333

Signature [signature] (Licensed Well Driller) Date 12-23-00

RECEIVED
JAN 04 2001
WATER RIGHTS
SALT LAKE

ADDITIONAL WELL DATA FORM

Water Right # (63-2517) a22382

OWNER NAME Mayfield Town

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (e.g. relative %, grain size, sorting, angularity, bedding, grain composistion, density, plasticity, shape, cementation, consistancy, water bearing, odor, fracturing, minerology, texture, degree of weathering, hardness, water quality, etc.)
355											X	Shale	Reddish Brown	Sticky

Mayfield Irrigation Well

isted on well record
isted by counties
opied mp 9-16-41
xam. & Recorded 7-24 & M.Y. 9-15-41
xam. for filing ... 9-16-41
inal Copy checked EP mp 9-16-41
isted & No. Assigned
ndexed ... 9-17-41
ngr. tied well
ngr. set BM
vell No.

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Report No. 2256
Filed 9-12, 1941
Rec. By Counter U.W.
Ret'd

Report of Well and Tunnel Driller

STATE OF UTAH

(Separate report shall be filed for each well or tunnel)

GENERAL INFORMATION:

Report of well or tunnel driller is hereby made and filed with the State Engineer, in accordance with Sections 100-3-22, Revised Statutes of Utah 1933, as amended by Session Laws of 1935. (This report shall be filed with the State Engineer within 30 days after the completion or abandonment of well or tunnel. Failure to file such report constitutes a misdemeanor.)

1. Name and address of person, ~~company or corporation boring or drilling~~ Pumping well ~~or tunnel~~ (Strike words not needed) C.W. Anderson Manti Utah
2. Name and address of owner of well ~~or tunnel~~ (Strike words not needed) Mayfield Irrigation Co Mayfield Utah
3. Source if supply is in Sanpete County; drainage area; (Leave blank) artesian basin (Leave blank)
4. The number of approved application to appropriate water is 14220 Lapsed Replaced by 27378
5. Location of well ~~or mouth of tunnel~~ is situated at a point S. 1192 ft. & W. 822 ft. from NE Cor. Sec. 32 T. 19 S., R. 2 E., SLB&M. (Describe by course and distance with reference to U. S. Government Survey Corner — Copy description from well owner's approved application)
6. Date on which work on well ~~or tunnel~~ was begun Aug 14-1941 (Strike words not needed)
7. Date on which work on well ~~or tunnel~~ was completed ~~or abandoned~~ Aug 16-1941 (Strike words not needed)
8. Maximum quantity of water ~~flowing,~~ pumped ~~or dipped~~ on completion of well ~~or tunnel~~ in sec. (Strike words not needed) ft.; or in gals. per minute 475 1.058 Sec. Ft.; Date Aug 16-1941

DETAIL OF COLLECTING WORKS:

9. **WELL:** It is a drilled, ~~dug, flowing or~~ pump well. Temperature of water 56½ °F. (Strike words not needed)
   - (a) Total depth of well is 164' ft. below ground surface.
   - (b) If flowing well, give water pressure (hydrostatic head) above ground surface ft.
   - (c) If pump well, give depth from ground surface to water surface before pumping 18'; during pumping 88'
   - (d) Size and kind of casing 164' of 12" Stove pipe casing (If only partially cased, give details)
   - (e) Depth to water bearing stratum Unknown (If more than one stratum, give depth to each)
   - (f) If casing is perforated, give depth from ground surface to perforations Unknown
   - (g) Log of well Unknown

this well drillers report removed from filed 14220 which lapsed.

   - (h) Well was equipped with cap, ~~valve, or~~ (Strike words not needed) to control flow.

RECEIVED SEP 12 1941 STATE ENGINEER COUNTER

(Over)

Reeves well

WL1

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification CHANGE APPLICATION: t22200(63-4233)

RECEIVED
JUL 13 1998
WATER RIGHTS
SALT LAKE

Owner *Note any changes*

Reeves, David & Lucy
2785 South 1300 East
Salt Lake City, UT 84106

Contact Person/Engineer:

Well Location *Note any changes*

COUNTY: Sanpete
SOUTH 380 feet EAST 775 feet from the N¼ Corner of
SECTION 5, TOWNSHIP 20S, RANGE 2E, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) 0.5 mile south of Mayfield

Drillers Activity Start Date: 6/2/98 Completion Date: 6/2/98

Check all that apply:
☒ New ☐ Repair ☐ Deepen ☐ Abandon ☐ Replace ☐ Public Nature of Use:

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	160	9	Mud Rotary	Bentonite

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
0	4					X								
4	22				X			X						
22	65				X									
65	80				X			X						
81	110				X	X								
110	160	X			X			X						

SCANNED

Static Water Level

Date 6/2/98 Water Level 28 feet Flowing? ☐ Yes ☐ No

Method of Water Level Measurement ______ If Flowing, Capped Pressure ______ PSI

Point to Which Water Level Measurement was Referenced ______

Height of Water Level reference point above ground surface ______ feet Temperature ______ ☐ °C ☐ °F

Construction Information

DEPTH (feet)		CASING			DEPTH (feet)		SCREEN ☐		PERFORATIONS ☐
FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	FROM	TO	SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
0	160	PVC		6	120	160	1/8	3	4 x 18"

Well Head Configuration: Cap Access Port Provided? ☐ Yes ☐ No

Casing Joint Type: Glue Perforator Used: Saw

DEPTH (feet)		FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL		
FROM	TO	ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal.,# bag mix, gal./sack etc.)
0	30	Cement	6 Cu ft	
30	160	Gravel pack		

Well Development / Pump or Bail Tests

Date	Method	Yield	Units Check One GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
6/2/98	Air	65	✓		50	2

Pump (Permanent)

Pump Description: Grundfos Submersible Horsepower: 1 1/2 Pump Intake Depth: 44 feet

Approximate maximum pumping rate: 25 Well disinfected upon completion? ☒ Yes ☐ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

SCANNED

Well Driller Statement

This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name Unzicker & Wells License No. 328

(Person, Firm, or Corporation – Print or Type)

Signature [signature] Date 6/30/98

(Licensed Well Driller)

WL1

Belnap well

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification

CHANGE APPLICATION: a24116(63-4304)

Owner *Note any changes*

Belnap, Brett L. and Sherry H.
P.O. Box 220612
Centerfield, UT 84622

Contact Person/Engineer:

RECEIVED
APR 05 2000
WATER RIGHTS
SALT LAKE

Well Location *Note any changes*

COUNTY: Sanpete
SOUTH 135 feet EAST 590 feet from the N4 Corner of
SECTION 5, TOWNSHIP 20S, RANGE 2E, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) South of Mayfield

Drillers Activity Start Date: 3/10/00 Completion Date: 3/11/00

Check all that apply: [x] New [ ] Repair [ ] Deepen [ ] Abandon [ ] Replace [ ] Public Nature of Use:

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	160	9	Mud Rotary	Bentonite

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on water quality if known.)
0	35				X									
35	85	X					X	X						
85	95										X	Limestone		
95	120	X						X			X	Decomposed Limestone		
120	135										X	Limestone		
135	160	X						X			X	Decomposed Limestone		

Static Water Level

Date 3/11/00 Water Level 39 feet Flowing? [ ] Yes [ ] No

Method of Water Level Measurement ________ If Flowing, Capped Pressure ________ PSI

Point to Which Water Level Measurement was Referenced Ground

Height of Water Level reference point above ground surface — feet Temperature ______ [ ] °C [ ] °F

Well Log

Construction Information

DEPTH (feet) FROM	TO	CASING: CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	DEPTH (feet) FROM	TO	SCREEN ☐ PERFORATIONS ☑ SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
0	160	PVC	200#	6	120	160	1/8	3	4 X 18"

Well Head Configuration: Cap Access Port Provided? ☑ Yes ☐ No

Casing Joint Type: Glue Perforator Used: Saw

DEPTH (feet) FROM	TO	FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL: ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal.,# bag mix, gal./sack etc.)
0	50	Cement	8 cu.ft.	
50	160	Gravel		

Well Development / Pump or Bail Tests

Date	Method	Yield	Units Check One: GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
3/10	AiR	100	✓		150	1 hr.

Pump (Permanent)

Pump Description:________ Horsepower:________ Pump Intake Depth:________feet

Approximate maximum pumping rate:________ Well disinfected upon completion? ☑ Yes ☐ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

Well Driller Statement

This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name Uazicker & Wells Drilling License No. 398
(Person, Firm, or Corporation – Print or Type)

Signature [signature] Date 3/11/00
(Licensed Well Driller)