2022 Geologic Investigation and Design Data Report for Modifications at St. Mary Canal Diversion Works

Milk River Project, Montana
Missouri Basin Region

Cover Photo: Downstream view of St. Mary Diversion Dam. (Reclamation/Seth Joramo)

U.S. Department of the Interior

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Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

2022 Geologic Investigation and Design Data Report for Modifications at St. Mary Canal Diversion Works

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prepared by

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I. Introduction

1. Purpose

In November of 1999 the U.S. Fish and Wildlife Service (FWS) listed bull trout (Salvelinus confluentus) as a threatened species under the Endangered Species Act. This listing prompted the U.S. Bureau of Reclamation to evaluate methods and to prevent entrainment of fish in the diversion canal and allow fish to move upstream in the St. Mary River past the diversion dam and canal headworks structure [1].

This report details the work completed to collect final design geotechnical data for the proposed replacement of the St. Mary Canal Diversion Works. The work included drilling, installation of a pump well, two observation wells, step-drawdown testing, pump out testing, laboratory testing, and percolation testing. The scope of the borrow investigation was reduced to only rip-rap testing and will be completed by the Technical Service Center (TSC) Geology Lab and Field Support (GLFS) in Denver, CO. (Appendix I FER).

2. Location

The Milk River Project starts with impounded water in Lake Sherburne Dam which is located 5.6 miles to the west of the St. Mary Canal Diversion Works near Babb, MT. The supply of this water is fed from glaciers and snow melt within Glacier National Park along the eastern flank of the Continental Divide of the Sawtooth Range of the Rocky Mountains. Water is released into Swiftcurrent Creek and flows into Lower St. Mary Lake. From there water flows into the St. Mary River which flows into Canada and eventually drains into Hudson Bay. Milk River Project water is diverted about 0.75 miles downstream of Lower St. Mary Lake at the St. Mary Canal Diversion Works and flows into the diversion canal. The canal carries water for 29 miles and eventually spills into the North Fork of the Milk River [1].

3. Design and Construction

The St. Mary Canal Diversion Works was constructed in 1915. Photos of the completed structure can be found in Appendix A, and original design drawings can be found in Appendix C. It consists of a 198-foot-long concrete uncontrolled overflow weir spillway section and a three bay 56-foot-long sluiceway section. The diversion headworks for the St. Mary Canal Diversion Works is immediately upstream on the left bank of the St. Mary River. There is also a 2-span abandoned truss bridge located across the river at this location sitting atop the diversion dam [2].

The diversion dam and headworks structure are made of reinforced concrete and have substantial freeze-thaw damage including exposed rebar and disintegrating concrete. The metalwork associated with the sluiceway gate, diversion slide gates, lifting stems and guard railings has been repaired several times [2].

4. Proposed Modification

The St. Mary Canal Diversion Works Replacement Project includes the proposed construction of a new diversion dam as well as a fish protection structure that will comply with the Endangered Species Act. The main features of the project will be a low head diversion dam, fish rock ramp for upstream passage, new headworks structure, canal fish screen, check structure, fish bypass, O&M and control buildings, and auxiliary features [1].

5. Topographic Database and Surveys (Appendix D)

The 2022 drill holes were field surveyed May 17, 2022, by Bureau of Reclamation employees from the Montana Area Office (MTAO). Survey control was established, and survey data was collected utilizing Trimble R10 Model 2 Receivers using a fixed height pole and one direct survey control grade measurement (180 observations). All surveys used for this report use the survey information listed in Appendix F (Survey Data).

II. Regional Geology

In the Late Cretaceous, collision of the North American Plate and the Farallon Plate resulted in the Sevier orogeny and uplift of the Rocky Mountains. The bedrock units of the Precambrian Belt series were subjected to both shear and compressive stresses caused by the advance of the Lewis Overthrust Fault from the west. Locally, smaller thrust faults of the Disturbed Belt are locally buried beneath Quaternary surficial, alluvial, landslide, and glacial deposits (Figure 2). The 281-mile-long (estimate) Lewis Overthrust fault has at least 40 miles of eastward displacement (estimated, in some locations). The Lewis Overthrust Fault is located to the west and can be seen from near the St. Mary Canal Diversion Works site. Chief Mountain, composed of Precambrian Belt rocks, lies near the Canadian border, and marks the eastern most local remnant of eastward displacement [3].

The bedrock underlying the St. Mary Canal Diversion Works is mapped as Cretaceous sedimentary Two Medicine Formation (Ktm), typically consisting of alternating beds of sandstone and shale.

The Two Medicine Formation (Ktm) (100.5-66.0 ma) was deposited between the western shoreline of the Late Cretaceous Interior Seaway and the eastward advancing margin of the Lewis Overthrust Belt. The Two Medicine Formation is mostly deposited by rivers and deltas consisting of greenish-gray, fine-grained, hard sandstone and/ or siltstone containing clay with local nodular limestone. This sedimentary rock unit can be massive to cross-bedded, and locally may contain some coal. Cementation is primarily calcium carbonate but may also include silica [2].

The Cretaceous age sedimentary marine mudstone of the Marias River Shale Formation (Km) is located along the west valley. The valley walls are covered by unconsolidated Quaternary deposits. Sliding of the unconsolidated deposits over bedrock is common [3].

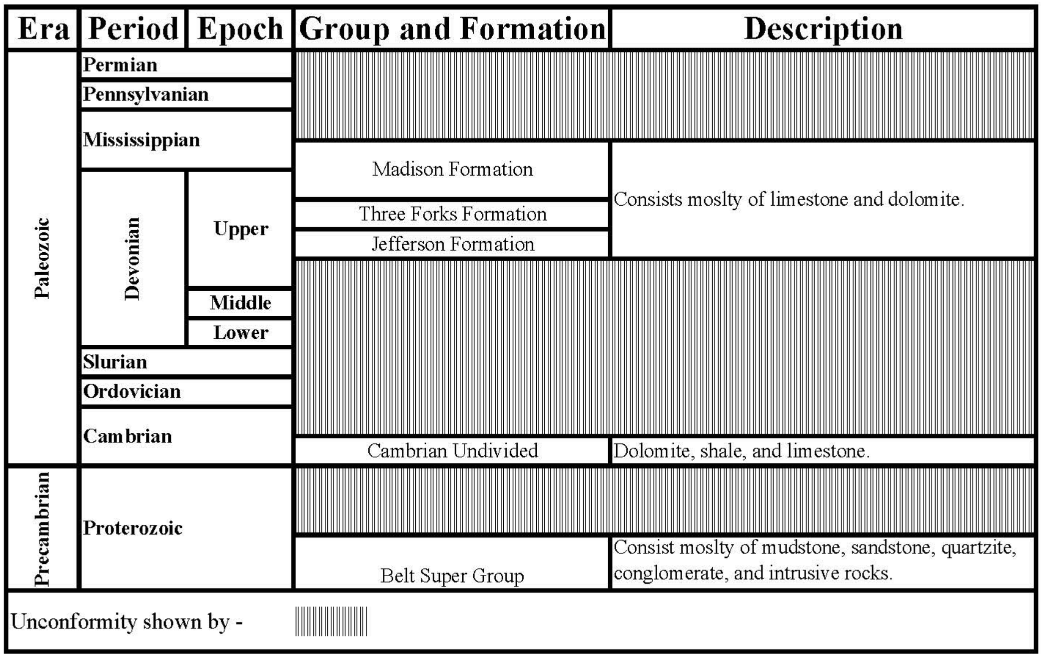
During the Late Tertiary, Pliocene, and Pleistocene), a series of alpine glaciers advanced from the west while continental glaciers advanced from the north and east. Glacial terminal moraines, deposited at different stages of the glaciation, blocked the valleys, and resulted in glacial lakes. Glacial advance down the valley eroded and steepened the existing valley bedrock slopes.

Pleistocene glacial moraines along the valley walls are subject to a constant creep downslope over Cretaceous bedrock creating hummocky topography along the margins of the valley. Extensive sliding events may occur when precipitation or snow melt increase pore pressures along the contact of unconsolidated sediment and underlying bedrock [3].

Between the St. Mary Diversion Works and the mountains to the west, Swift Current Creek has deposited a large alluvial fan and flows into the St. Mary River 1 mile upstream of the diversion works. Downstream of Lower St. Mary Lake, the modern St. Mary River has deposited a thick, alluvial sequence in the deeply dissected u-shaped glacial valley that has aggraded in a restricted, low gradient valley depositional system that has remained mostly unchanged since the end of the Pleistocene. The thick sequence of alluvium has accumulated in beds up to 188 feet thick and is composed of fine to coarse-grained sand, silt, clay, cobbles, and boulders. The St. Mary Canal Diversion Works is founded on this Quaternary Alluvium (Qal).

1. Stratigraphy

Era	Period	Epoch	Group and Formation		Description
Cenozoic	Quaternary	Recent	Alluvium		Unconsolidaed gravel, sand, silt, and clay benoeath floodplains of major streams. Includes some outwash gravel and sand from piedmont glaciers
		Pleistocene	Till Deposited by Pinedale Glaciers		Gravelly to clayey till in ground moraine and in terminal, recessional, and lateral moraines. Includes gravel depositis in narrow butied channels and meltwater channels.
			Terrace Gravel		Chiefly coarse gravel and rounded to sub-angular cobbles with some sand and silt.
	Tertiary	Pliocene	▨	▨	▨
		Miocene	Tertiary Sediments		
		Oligocene	▨	▨	▨
		Eocene	▨	▨	▨
		Paleocene	Willow Creek Formation		Variegated mudstone with some thin beds of sandstone
Mesozoic	Cretaceous	Upper	St. Mary River Formation		Mostly greenish-gray to grayish olive mudstone interbedded with thin beds of fine-grained sandstone.
			Montana Group	Horsethief Formation	Gray to gray-brown, fine to medium-grained marine sandstone
				Bearpaw Formation	Mosity dark-gray marine shale with ferruginous concretions, some bentonite beds, and thin layers of sandstone.
				Two Medicine Formation	Mostly gray-green to gray nonmarine mudstone with some sandstone.
				Virgell Sandstone and Telegraph Creek Formation	Light-gray, moderately thick-bedded, fine-grained marine sandstone.
			Colorado Group	Marias River Formation	Chiefly dark-gray, marine mudstone.
				▨	▨
		Lower		Blackleaf Foramtion	Gray, marine mudstone and interbedded sandstone
			Kootenai Formation		Gray-green and maroon mudstone and many greensih-gray sandstone beds.
			▨	▨	▨
	Jurrasic	Upper	Mount Pablo Formation		Nonmarine Limestone, mudstone, and sandstone in upper part, mudstone interbedded with sandstone in middle part, and sandstone and conglomerate in lower. Includes the morrison formation.
			Ellis Group		Very-fined to fine-grained sandstone, gray shale, with thin beds of hard limestone.
		Middle	▨	▨	▨
		Lower	▨	▨	▨
	Triasic		▨	▨	▨
Era	**Period**	**Epoch**	**Group and Formation**		**Description**



Era	Period	Epoch	Group and Formation	Description
Paleozoic	Permian		▥	▥
	Pennsylvanian			
	Mississippian			
			Madison Formation	Consists moslty of limestone and dolomite.
	Devonian	Upper	Three Forks Formation	
			Jefferson Formation	
			▥	▥
		Middle		
		Lower		
	Slurian			
	Ordovician			
	Cambrian			
			Cambrian Undivided	Dolomite, shale, and limestone.
Precambrian	Proterozoic		▥	▥
			Belt Super Group	Consist moslty of mudstone, sandstone, quartzite, conglomerate, and intrusive rocks.
Unconformity shown by -	▥			

Figure 1 Generalized Stratigraphy of Geologic Units

2. Structure

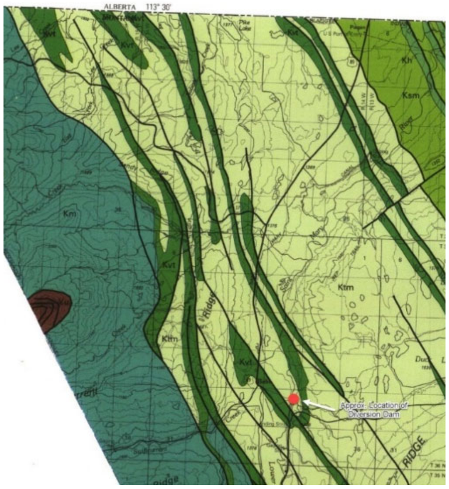


Figure 2 Cropped image from USGS HA-737 Bedrock geology, Geology and Ground-water Resources of the Blackfeet Idina Reservation, Northwestern Montana, 1996. Mapped faults in the vicinity of the St. Mary Canal Diversion Works. Black lines on figure 2 represent faults. Northwest trending faults are thrust faults with upper plate on western side. Northeast trending faults are normal faults or tear faults. Geologic units shown are the Horsethief Sandstone Formation (Kh), Two Medicine Formation (Ktm), Virgelle Sandstone and Telegraph Creek Formation (Kvt), Marias River Shale Formation (Km), and St. Mary Formation (Ksm) [4].

3. Seismicity

The following seismicity information is from the closet studied dam in the area, Lake Sherburne Dam, located approximately 5 miles to the west of the St. Mary Canal Diversion Works. No earthquakes greater than magnitude 5.0 have been recorded within 80 kilometers of Lake Sherburne Dam since 1914. The seismic curve developed for Lake Sherburne Dam is dominated by a random earthquake source. According to the probabilistic seismic hazard analysis (PSHA) for Lake Sherburne Dam, the peak horizontal acceleration (PHA) for the 1,000-year return period earthquake is 0.17 g. The PHA for the 50,000-year return period earthquake is 0.56 g [3].

III. Geologic Investigations

1. Preconstruction Geologic investigation

There is no known documentation of preconstruction or construction geologic investigations for the St. Mary Canal Diversion Works. Work began on the diversion dam and canal in 1907 and was completed in 1915. Nearby Lake Sherburne Dam was also under construction and finished in 1921. It was modified in 1980 providing some geologic information regarding a nearby borrow area [2].

2. Post Construction Geologic Investigations

a. 1980 (Lake Sherburne Dam Borrow Source Investigation)

Borrow source investigations for a modification to Lake Sherburne Dam in 1980, explored a small borrow area about 0.1 miles west of the St. Mary Canal Diversion Works. The borrow area land belongs to the Blackfeet Tribe. This area was designated as Borrow Area F in the modification specifications, and 14 test pits (TP80-501 through -514) were excavated there. The borrow area is also designated as pit No. 849 by the Montana Department of Transportation (MDT) [2].

b. 2002 (North Central Montana Feasibility Study, Milk River Project, MT)

In the spring of 2002, six drill holes (DH02-DDO, -DDL, -DDC, -DDR -FSN and -FSS) were advanced to explore the foundation conditions around the St. Mary Canal Diversion Works. These borings were drilled using a 5-7/8-inch tri-cone roller-rock bit followed by 6-inch-diameter steel casing to keep the drill holes open to the target depths. Logging was accomplished by observing rock chips from drill cuttings, but no laboratory testing was done. Advancement of every drill hole was slow and rough due to cobbles and boulders in the very coarse foundation material [2].

Water testing in select drill holes (DH02-DDL, -DDC and -DDR), was accomplished by pouring a metered amount of water into the top of the casing while maintaining a constant head (static head test). The only outlet was the bottom of the casing. Water losses in the intervals tested ranged from 0.07 to 7.85 gallons per minute (gpm). Material classifications from cuttings included Clayey Sand with Gravel (SC)g, Poorly Graded Sand with Gravel, Cobbles and Boulders (SP)gcb, Poorly Graded Gravel with Sand, Cobbles and Boulders (GP)scb, and Well Graded Gravel with Sand, Cobbles and Boulders (GW)scb. One test in DH02-DDR was in the sandstone bedrock with a water loss of 0.5 gpm [2].

Two holes DH02-DDC and DH02-DDR, reported contact with bedrock. DH02-DDC was drilled from the island downstream of the diversion structure in the middle of the St. Mary River and encountered sandstone at a depth of 37.0 feet (elevation 4432.0 el.). DH02-DDR was drilled from the right bank of the river and encountered sandstone at 8.4 feet deep (elevation 4472.5 el.) [2].

c. 2011 (Borrow Source and Site Investigation)

As part of the design data collection for the St. Mary Canal Diversion Works modifications, five test pits were excavated in June 2011. Three test pits (TP11-1BC, -2BC and -3BC) were excavated along a proposed temporary bypass channel alignment evaluate determine permeability of the foundation materials. Two test pits (TP11-1-OBP and -2-OBP) were excavated in Borrow Area F. Location of tests pits can be found in Appendix B Drawing No. 15-600-60073. Laboratory testing included physical properties, specific gravity, absorption, and alkali-silica reaction [2].

Groundwater was encountered in the three temporary bypass channel test pits (TP11-1BC, -2BC, and -3BC) located close to existing unlined canal was carrying water at the time of excavation. These test pits were terminated at a depth from 9.0 to 12.5 feet before the backhoe equipment reached its excavation limit due to excessive sloughing of pit walls and flowing water. Estimated visual flow rates into test pits TP11-1BC and -3BC were 50 gpm, while test pit TP11-2BC was estimated at 30 gpm [2].

The plus 3-inch diameter material was estimated between 15 and 55 percent of the total volume of material processed, with a maximum size observed of 15-inch diameter. The fines content was tested at between 5% and 10%. The predominant field classification was Poorly Graded Gravel with Sand and Cobbles (GP)sc [2].

d. 2013 and 2015 (Geologic Investigation Program St. Mary Diversion Dam and Headworks Structure Geologic Data for Modifications)

Field investigations completed in the summer and fall of 2013 consisted of ten drill holes (OW-13-A, OW-13-B, OW-13-B2, OW-13-C, OW-13-D, OW-13-E, OW-13-F, OW-13-G, OW-13-H, PW-13-A, and SPT-13-A) and two test pits (TP13-1 and TP13-2) to better define foundation physical properties and obtain groundwater data related to dewatering for construction activities [2].

Foundation materials in the vicinity of the new St. Mary Canal Diversion Works are Quaternary Alluvium (Qal). These materials are a heterogeneous mixture of soil with a large percentage of cobbles and boulders in the upper 20 to 30 feet of the foundation. The minus 3-inch diameter fraction, recovered during drilling, is predominately Poorly Graded Gravel with Sand and Cobbles (GP)sc or Poorly Graded Sand with Gravel and Cobbles (SM)gc or Silty Gravel with Sand and Cobbles (GM)sc. Alluvial deposits at shallower depths (above10-feet deep) in the test pits were classified as Cobbles and Boulders with Gravel and Sand (GP-GC)sg. A laboratory gradation of this material was 5% boulders, 41% coarse cobbles, 31% fine cobbles, with 10.8% gravel, 7.3% sand and 4.9% fines. Many of the sample intervals tested above groundwater level had a strong reaction to hydrochloric acid (HCl) [2].

On-site testing and analysis of data show that dewatering efforts will need to be robust. The river will provide large amounts of recharge into the excavations and may require some type of cutoff and cofferdams [2].

The groundwater levels in observation wells adjacent to the St. Mary River or to the St. Mary Diversion Canal are influenced by each of these features. When comparing water elevations across the site, groundwater across the site is at a consistent elevation, and mirrors the river elevation [2].

During the investigation program in 2013, an attempt was made to use one of the observation wells, OW-13-B2 as a pump well to conduct a pump out permeability test. A low capacity Grundfos model MP1 submersible pump was lowered into the 2-inch PVC observation well. Readiflow transducers were installed in that well and four observation wells to monitor any change in groundwater level [2].

A small capacity pump, passing about 4.2 gpm, was used and was too small to stress the aquifer. The pump produced about 0.25 feet or 3 inches of drawdown in OW-13-B2, but it was difficult to discern any drawdown in OW-13-C, located 150 feet away.

While pumping OW-13-B2, the drawdown in OW-13-A (50 ft away) was approximately 0.014 feet and recovery was immediate. Overall, no transmissivity values can be calculated from this testing because the aquifer was not sufficiently stressed [2].

In 2015 drill hole PW-15-1 was advanced adjacent to the backfilled drill hole PW-13-A and a pump well installed. A pump out permeability test was performed in September of 2015 using PW-15-1 as the pump well and a larger capacity pump than previously used in 2015. Observation wells (OW-13-A, -B2, - C, -D and –E) were used to monitor groundwater during the pump out test using In-Situ Level Troll 700 pressure transducers. Prior to the pump out test, the transducers were allowed to temperature normalize and a 2-hour pump rate test was performed. The purpose of this rate test was to see where the pump was most efficient while maintaining a constant water level in the well. The results of this test established a pump rate of around 200 gpm. The pump out test was then performed for a total of 29 hours. A total of 355,330 gallons of water was run through the pump in 29 hours yielding an average of 204.2 gpm for the test interval [2].

3. 2022 Geologic Investigation

a. Field Exploration Request (FER) Summary (Appendix I)

The current geologic investigations were performed to study the foundation and groundwater conditions of the underlying Quaternary Alluvium (Qal) and evaluate potential borrow sources for final design of the proposed modification to the St. Mary Canal Diversion Works.

The 2022 field investigation included drilling and installing a pump well and two observation wells. Pump well, PW-22-1 and a companion well, PW-22-1A were drilled west of the headworks structure. And DH-22-02 was drilled next the canal northeast of the headworks structure. PW-22-1 was advanced with ODEX for the installation of the pump well. Companion hole, PW-22-1A, was advanced with a sonic drill to geologically log, collect geologic samples, and install an observation well. Drill hole, DH-22-02 was advanced using a CME-85. The hole was geologically logged and an observation well was installed. The program also included three hand excavated test holes to perform a percolation testing for a proposed septic system at the project site.

The scope of the borrow source investigations outlined in the FER (Appendix I) was reduced to only rip-rap testing. Rip-rap samples were collected and delivered to the TSC Geotechnical Laboratory and Field Support (GLFS) in Denver, CO. A Technical Memorandum will be completed by TSC GLFS documenting the results of the testing.

Drilling was conducted from March 31 to May 13, 2022. Geologic logs and well diagrams from the 2022 investigation are in Appendix D. Representative soil samples from each lithologic unit were collected in 5-gallon buckets and/or double bagged and submitted for laboratory testing. Moisture content samples were retained in moisture tins. Soil samples collected from the drill holes were sent to the Provo Area Office Materials Laboratory in Provo, UT for physical properties and to the GLFS in Denver, CO for dispersion testing. Lab results from the Provo Area Office Materials Lab can be found in Appendix G.

b. Dill Hole Summary (Appendix C)

DH-22-02 (Auger Drill Hole)

Drilling was performed with a truck mounted CME-85 drill (blue) using 6.25-inch inside diameter (ID) hollow stem augers (HSA) and a 5.38-inch ID split spoon core barrel attached to hex rods.

Quaternary Alluvium (Qal) was encountered from 0 (4484.2 el.) to the total depth of 85.4 feet (4398.8 el.). Visual USCS classifications of the geologic material encountered includes Silty Gravel with Sand and Cobbles (GM)sc, Poorly-graded Gravel with Silt, Sand, and Cobbles (GP-GM)sc, Poorly-graded Sand with Gravel and Cobbles (SP)gc, Silt Sand (SM), Clayey Gravel with Sand and Cobbles (GC)sc, Poorly-graded Gravel with Clay, Silt, Sand, and Cobbles (GP-GC)sc, Clayey Sand (SC), Poorly-graded Gravel with Sand (GP)s, Poorly-graded Sand with Silt, Gravel, and Cobbles (SP-SM)gc, Silty Sand with Gravel (SM)g, Poorly-graded Sand with Silt and Gravel (SP-SM)g, Poorly-graded Sand with Gravel (SP)g, and Silty Gravel with Sand (GM)s.

DH-22-02 was completed as an observation well with a screened interval of schedule 40 PVC 0.030-inch slotted screen from 81.6 feet to 51.6 feet bgs surrounded by #8-12 filter sand from 85.4 feet to 15.0 feet bgs. It was then sealed by placing 3/8-inch bentonite chips over the filter pack around PVC casing to two feet bgs. A 6-inch diameter by 48-inch-long protective steel standpipe was concreted in placed with sand and cobbles at the bottom for drainage.

PW-22-1 (ODEX Drill Hole)

Drilling was performed with a truck mounted Atlas Copco T2W-III rotary drill using a 12.0-inch down the hole hammer (ODEX) and 12.75-inch outside diameter schedule 40 weld down casing. This method of drilling did not provide samples for visual classifications and lab testing. PW-22-1 was advanced to a total depth of 84.5 feet.

PW-22-1 was backfilled with Pel Plug bentonite pellets from 84.5 feet to 67.0 feet bgs and then completed as a pump well. A 10-inch inside diameter 304 wire wrapped stainless steel 0.020-inch screen from 64.3 to 12.0 feet bgs surrounded by #8-12 filter sand from 67.0 feet to 10.5 feet bgs. It was then sealed by placing 3/8-inch bentonite chips over the filter pack around PVC casing to three feet bgs. A 12-inch diameter schedule 40 steel protective standpipe was concreted in placed with #8-12 filter sand at the bottom for drainage.

PW-22-1A (Sonic Drill Hole)

PW-22-1A was drilled as a companion hole approximately 9.2 feet from PW-22-1 to geologically log materials for correlation with drill hole PW-22-1. Drilling was performed with a Gus Pech GP-3000 CHR drill rig equipped with a Sonic Core drill head using 7.0-inch inside diameter sonic core barrel and 8.0-inch inside diameter casing and carbide rock bit.

Quaternary Alluvium (Qal) was encountered from 0 feet (4478.6 el.) to a total depth of 80.0 feet (4398.6 el.). Visual USCS classifications of the material encountered includes Poorly-graded Gravel with Sand (GP)s, Poorly-graded Gravel with Clay and Sand (GP-GC)s, Lean Clay (CL), Poorly-graded Sand with Gravel (SP)g, Sandy Lean Clay with Gravel s(CL)g, Clayey Gravel with Sand (GC)s, Clayey Sand with Gravel (SC)g, and Silty Sand (SM).

PW-22-1A was backfilled with bentonite chips from 80.0 feet to 58.0 feet bgs and then completed as an observation well. A 2-inch inside diameter schedule 40 PVC 0.020-inch slotted screen was installed from 54.1 feet to 44.1 feet bgs surrounded by #8 filter sand from 58.0 feet to 10.0 feet bgs and It was then sealed by placing bentonite chips over the filter pack and around the 2-inch ID schedule 40 PVC casing to one foot bgs. A square 4-inch by 48-inch-long protective steel standpipe was concreted in place.

Percolation Test (PT-1, PT-2, PT-3)

Three test holes, PT-1, PT-2, and PT-3 were excavated with a shovel for the purpose of a percolation test to meet Montana State Department of Environmental Quality (DEQ) requirements for septic design. The material encountered in all test holes were USCS visually classified as Well-graded Gravel with Sand, Cobbles, and Boulders (GW)scb. To meet state requirements, the materials were also classified using the USDA classification system and were classified as Gravelly Sandy Loam. Testing procedures include excavating the hole and installing a perforated PVC pipe with a gravel pack around the pipe. The pipe was filled with water to 12-inches above the gravel pack, and the time for the water level to percolate into the soil was recorded. PT-1 was excavated to a depth of 3.5 feet and 1.2 feet wide. The percolation rates for PT-1 were from 0.13 minutes per inch (mpi) to 0.25 mpi. PT-2 was excavated to a depth of 2.7 feet and 1.5 feet wide. The percolation rates for PT-2 were from 0.20 mpi to 0.25 mpi. PT-3 was excavated to a depth of 2.6 feet and 1.1 feet wide. Percolation rates for PT-3 were from 0.47 mpi to 0.69 mpi. Montana DEQ Circular DEQ 4 testing procedures detail if both the first and second filling have percolation rates faster than 3 mpi then the test can be stopped. All the test holes had rates much faster than 3mpi and the testing was stopped (Appendix H).

IV. Site Geology

1. Geologic Units

a. Fill (fill)

During original construction of the St Mary Canal Diversion Works, fill derived from excavation of the canal, was placed between the canal and river channel, and can be seen in drawing no.'s 15-600-60070 and 15-600-60071 in Appendix B. It was estimated at approximately 8 feet to 10-feet thick in the 2017 geologic report. The material excavated from the canal is Quaternary Alluvium (Qal).

USCS visual classifications are Poorly-graded Gravel with Sand, Cobbles, and Boulders (GP)scb, Silty Gravel with Sand and Cobbles (GM)sc, Poorly-graded Gravel with Sand and Cobbles (GP)sc, Silty Gravel with Sand (GM)s, Silty Sand with Gravel and Cobbles (SM)gc, Poorly-graded Sand with Gravel and Cobbles (SP)gc, Poorly-graded Sand with Gravel, Cobbles, Boulders (SP)gcb, Well-graded Gravel with Sand and Cobbles (GW)sc, Clayey Sand with Gravel (SC)g, Clayey Gravel with Sand and Cobbles (GC)sc.

Soils range from 15 to 60% fine to coarse sand, 5 to 25% nonplastic to low plasticity fines, and 15 to 75% gravel. Percentage by volume is 10 to 60% fine to coarse cobbles and a trace to 5% boulders. Maximum size recovered ranges from 0.75 inches to 15 inches. The material was light brown to brown, tan, and gray, dry to moist, soft, and no reaction to strong reaction with HCl.

b. Quaternary Alluvium (Qal)

Quaternary Alluvial (Qal) consists of alluvial fan. Lake sediment, and glacial deposits. Qal was encountered in all site explorations for the St. Mary Canal Diversion Works. Based on the description of Qal on USGS 1996 Surfical Geology Quad Map HA-737, Qal is estimated to be up to 188 feet thick in the valley section. Based upon site investigations, Qal thins to 8- and 10-feet over bedrock respectively in recent Reclamation borings on the right side of the river [4].

Alluvium consists of predominantly coarse-grained sand and gravel beds interbedded with less dominant fine-grained units. Qal overlies the Two Medicine Formation (Ktm) upstream and downstream of the diversion dam and headworks structure. Qal is approximately 8 to 10 feet thick overlying Ktmin borings DH02-DDR and SPT13-A to the right and 140 feet downstream of the existing diversion dam. The thickness of Qal left of the dam structure is currently unknown as investigations have not encountered the underlying Two Medicine Formation (Ktm) at maximum depth of 80.0 feet bgs. Geologic section A-A’ on drawing no. 15-600-60070 shows the extent of Qal in the foundation downstream of the diversion dam. Section B-B’ on drawing no. 15-600-60071 and section C-C’ on drawing no.15-600-60072 shows the estimated extent of Qal at the left side of the diversion dam and headworks structure. (Appendix B)

Quaternary Alluvium (Qal) visual USCS classifications are: Poorly-graded Sand with Gravel, Cobble, and Boulders (SP)gcb, Poorly-graded Sand with Silt, Gravel, and Cobbles (SP-SM)gc, Silty Sand (SM), Silty Sand with Gravel and Cobbles (SM)gc, Silty Gravel with Sand (GM)s, Well-graded Gravel with Sand, Cobbles, and Boulders (GW)scb, Poorly-graded Gravel with Sand, Cobbles, and Boulders (GP)scb, Poorly-graded Gravel with Silt, Sand, and Cobbles (GP-GM)sc, Poorly-graded Gravel with Clay, Silt, Sand, and Cobbles (GP-GC)sc, Silty Gravel with Sand, Cobbles, and Boulders (GM)scb, Clayey Sand with Gravel (SC)g, Sandy Lean Clay with Gravel s(CL)g, Clayey Gravel with Sand and Cobbles (GC)sc, Lean Clay with Sand (CL)s, Fat Clay (CH), and Silt with Sand (ML)s.

The gravel units were encountered with a sand percentage ranging from 15 to 50% and non-plastic to low plasticity fines ranging from 5 to 30%. Medium plasticity fines encountered in gravelly units range from 5 to 45%. One interval with high plasticity fines was encountered in drill hole PW-22-1A at a depth of 9.0 to 29.7 feet. The gravel encountered in sandy units ranges from a trace to 40% and the nonplastic to low plasticity fines range from 5 to 25%. Medium plasticity fines encountered in predominately sandy soils range from 15 to 40%. Fine grained soils range from non-plastic to medium plasticity and had 0 to 35% sand. Gravel was encountered in two samples of fine-grained soils with a range from 5 to 15%.

The percentage of cobbles and boulders by volume ranges from 25 to 65% fine to coarse cobbles and a trace to 5% boulders across the site. Maximum size recovered was 21-inches. Liquid limits of fines range from non-plastic to 26.0%. Plasticity indexes of clay material ranges from 1.8% to 17.2%. Soil color ranges from light to dark gray in the upper saturated zone grading to dark brown or yellowish brown. It is moist above the phreatic surface and saturated below, soft and loose to firm, and has no reaction to strong reaction with HCl.

c. Upper Cretaceous Two Medicine Formation (Ktm)

The Two Medicine Formation (Ktm)underlies Qal. The Two Medicine Formation has been eroded within the valley with depth to Ktm decreasing on the right abutment of the St. Mary Canal Diversion Works. Ktm outcropes to the east of the river and along Duck Lake road. Geologic Sections A-A’ show the possible top of the Two Medicine Formation (Ktm) on drawing no. 15-600-60070 in Appendix B. The Two Medicine Formation (Ktm) was intersected in one boring (DH02-DDC) in the river section and two borings (DH02-DDR & SPT13-A) on the right abutment. The Two Medicine Formation (Ktm) contact with overlying Qal in drill hole DH02-DDC in the river channel was at 37.0 feet bgs. The contact on the right abutment in drill hole SPT-13A was 10.0 feet bgs. The contact in drill hole DH02-DDR was 8.4 feet bgs.. The Two Medicine Formation (Ktm) contact drops off from the right abutment of the diversion dam at an estimated horizontal to vertical (h:v) slope of 5:1 (h:v). Based upon current information, the 5:1 (h:v) slope continues to a depth of greater than 80.0 feet based on the deepest drillhole, PW-22-1A which did not encounter the Two Medicine Formation (Ktm). It is not known if there are any faults that could result in a diviation of the projected top of rock.

Ktm is composed of medium- to predominately fine-grained, moderately hard (H4) to hard (H3) sandstone; containing sedimentary grains of quartz, feldspar, hornblende, and nodular limestone; light to medium gray with dark gray to black mineral grains; massive; moderately weathered

(W5). Fracture surfaces are moderately rough (R3) and range from clean to containing very thin (< 1mm) infilling of calcium carbonate. The material has a strong reaction with HCl throughout.

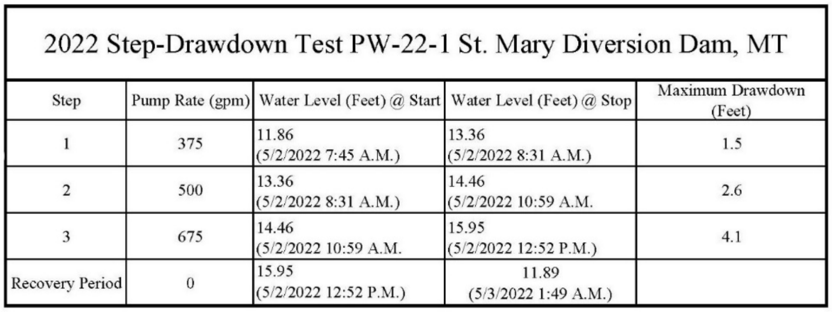
2. Groundwater

Groundwater data was collected in each of the investigations to date (1980, 2002, 2011, 2013, 2022). Most of these investigations recorded groundwater within about one foot of the water surfaced elevations within the St. Mary River or within the St. Mary Diversion Canal. Groundwater levels will rise during times of increased river flows during spring runoff or precipitation events.

2022 Step-Drawdown Testing and Pump Out Testing

The first attempt at a step-drawdown test was conducted in PW-21-02 from April 25 to April 26, 2022. A 6-inch diameter Grundfos 40 HP 700-gpm pump was used, with the pump intake from 57.4 feet to 58.0 feet bgs. The test consisted of a "quiet period" on April 25 to the morning of April 26. In the morning the step test began by turning on the pump which caused many issues. The system was almost immediately over pressured by trying to reduce the flow. Glued fittings began to fail. The 90-degree angle attached to the top of the casing broke. The PVC casing down hole broke at one of the connections after repairing the glued fittings. It was determined to stop the pump test and reinstall the system using steel pipe.

The final step-drawdown test was conducted from May 1 to May 2, 2022. A 6-inch diameter Grundfos 40 HP 700-gpm pump was used, with the pump intake from 57.4 feet to 58.0 feet bgs. The test consisted of a "quiet period" on May 1 for approximately 10 hours. The "quiet period" was followed by 3 drawdown steps (see Table 1) on May 2 and a recovery period from May 2 to May 3. Data was recorded with In-Situ LT700 transducers placed beneath the pump within the pump well casing and in observation well PW-22-1A, as well as manually with a water level indicator.

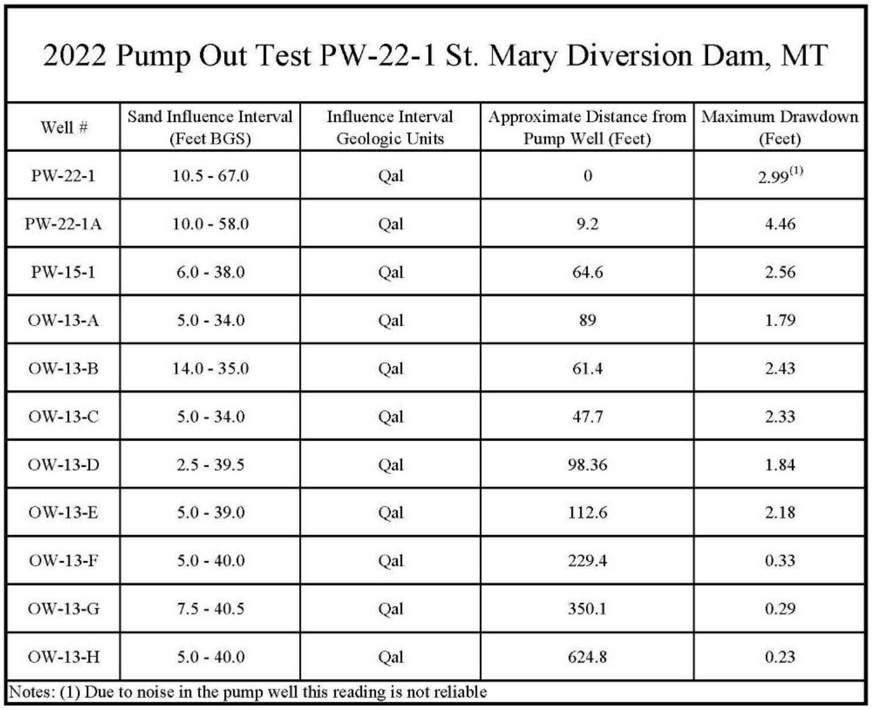


2022 Step-Drawdown Test PW-22-1 St. Mary Diversion Dam, MT				
Step	Pump Rate (gpm)	Water Level (Feet) @ Start	Water Level (Feet) @ Stop	Maximum Drawdown (Feet)
1	375	11.86 (5/2/2022 7:45 A.M.)	13.36 (5/2/2022 8:31 A.M.)	1.5
2	500	13.36 (5/2/2022 8:31 A.M.)	14.46 (5/2/2022 10:59 A.M.	2.6
3	675	14.46 (5/2/2022 10:59 A.M.	15.95 (5/2/2022 12:52 P.M.)	4.1
Recovery Period	0	15.95 (5/2/2022 12:52 P.M.)	11.89 (5/3/2022 1:49 A.M.)	

Table 1 PW-22-1 Step-Drawdown Test Data

The 18-hour pump out test was conducted after completing the step-drawdown test (see Table 2). In-Situ transducers were installed in the PW-22-1 pump well casing and each observation well to monitor groundwater levels. Manual readings were taken hourly. Groundwater was at an elevation between 4465 el. and 4469 el. across the site. Well locations can be found on the Geology Plan drawing no. 15-600-60068 in Appendix B. The test began on May 3, 2022, at 11:54 a.m. with a pump rate of approximately 668 gpm. Groundwater reached a steady-state condition at 16.44 feet bgs with a total drawdown in PW-22-1A of 4.45 feet, and the pump was shut down at 5:54 A.M. on May 4, 2022. Transducers continued to collect groundwater information until 10:40 A.M. on May 5, 2022, when the groundwater level recovered.

The St. Mary Canal was flowing water the entire duration of the pump out test. The 6-inch diameter Grundfos 40 HP 700-gpm pump reached its maximum pumping rate at 682 gpm. The capacity of the pump well hasn't been tested. Maximum drawdown was 4.45 feet in an observation well approximately 9.2 feet away from the pump well after 18 hours of operation. Observation well OW-13-H was the furthest well from the pump well with a drawdown of 0.23 feet.



2022 Pump Out Test PW-22-1 St. Mary Diversion Dam, MT

Well #	Sand Influence Interval (Feet BGS)	Influence Interval Geologic Units	Approximate Distance from Pump Well (Feet)	Maximum Drawdown (Feet)
PW-22-1	10.5 - 67.0	Qal	0	2.99(1)
PW-22-1A	10.0 - 58.0	Qal	9.2	4.46
PW-15-1	6.0 - 38.0	Qal	64.6	2.56
OW-13-A	5.0 - 34.0	Qal	89	1.79
OW-13-B	14.0 - 35.0	Qal	61.4	2.43
OW-13-C	5.0 - 34.0	Qal	47.7	2.33
OW-13-D	2.5 - 39.5	Qal	98.36	1.84
OW-13-E	5.0 - 39.0	Qal	112.6	2.18
OW-13-F	5.0 - 40.0	Qal	229.4	0.33
OW-13-G	7.5 - 40.5	Qal	350.1	0.29
OW-13-H	5.0 - 40.0	Qal	624.8	0.23

Notes: (1) Due to noise in the pump well this reading is not reliable

Table 2 Pump Out Test Data

3. Surface Water

Local Hydrologic Features

There are several significant hydrologic features that could affect river flows in the St. Mary River, groundwater levels, and constructability at the site. There are several tributaries that enter the St. Mary River just upstream and at the diversion dam. They could all impact construction particularly in times of spring runoff and major precipitation events.

Duck Lake Creek enters the valley at the right abutment of the diversion dam.

Boulder Creek and Swiftcurrent Creeks enter the valley 1 mile upstream of the diversion dam. While Swiftcurrent Creek is regulated by Lake Sherburne Dam, Boulder Creek is not.

St. Mary Lake is located only 1 mile upstream of the diversion dam.

St. Mary River Valley Hydrologic Features

St. Mary River: Flows in the St. Mary River are primarily dependent on snowpack, melting, spring runoff, influx of groundwater, and precipitation. River is subject to very large flow volumes during spring runoff.

St. Mary Lake is located 1 mile upstream of the diversion dam.

Duck Lake and Duck Lake Creek: Duck Lake is 2.5 miles east of the dam and enters the St. Mary River at the right abutment. Very small catch basin, without large fluctuations of flow.

Small unnamed pond and creek: Enters the St. Mary River where it merges with Duck Lake Creek at the right abutment of the diversion dam. This pond is one of many nested in the surficial glacial deposits on the right side of the valley. Numerous small pothole ponds occur southeast of the diversion dam.

Swiftcurrent Creek and Lake Sherburne: Swiftcurrent Creek enters the St. Mary River near the outlet of St. Mary Lake approximately 1 mile upstream of the diversion dam. Flows in Swiftcurrent Creek are controlled by releases from Lake Sherburne Dam. Relatively larger catch basin.

Boulder Creek: Enters the St. Mary River near the outlet of St. Mary Lake approximately 1 mile upstream of the diversion dam. Boulder Creek and Swiftcurrent Creek merge at the outlet of St. Mary Lake where they discharge into the St. Mary River.

Kennedy Creek: Enters the St. Mary River 4 miles downstream of the diversion dam so there would not be any impact to the site.

4. Climate

The mean annual precipitation of the boreal snow fully humid warm summer climate is 17.76 inches with most precipitation occurring from May to August [4]. Frost free days equal 80 to 100 days. Typical frost depth for northern Montana used in engineering designs is 5 feet. Mean annual air temperature is 39 degrees to 45 degrees Fahrenheit [5].

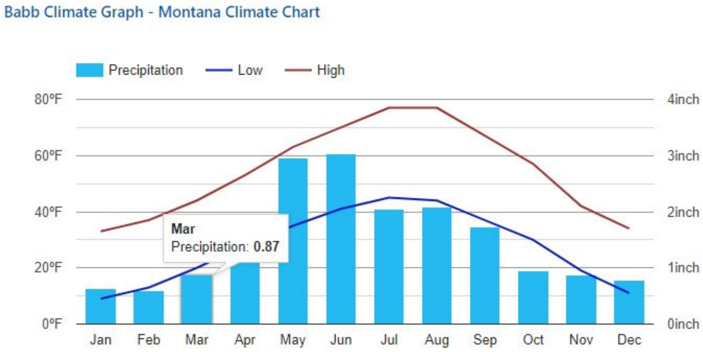


Figure 3 Babb Climate Graph *[5]*

V. Construction Considerations

The predominant geologic materials to be dewatered and excavated across the site are coarse grained alluvial sands, gravels, cobbles, and boulders and fine grained nonplastic silts to medium plasticity clays with low to high liquid limits. These materials are mostly saturated below a fluctuating phreatic surface elevation of approximately 4465 el. to 4469 el. The target elevation for dewatering is approximately 3 feet below the invert of excavation (4463 el.) for the proposed headworks at 4460 el.

Groundwater is heavily influenced by Lower St. Mary Lake, Swiftcurrent Creek, Boulder Creek, St. Mary River, canal operations, and Duck Lake Creek. Lower St. Mary Lake is approximately 1 mile upstream of the diversion dam and ground water is likely directly connected to the aquifer at the diversion dam. Observation wells have not been monitored over an entire season. As a result, it is currently unknown how groundwater responds after the irrigation season and during low river flow times. A partially confining layer or confining layer has not been identified in the drill holes but could be present. Based on visual observations while drilling PW-22-1, the water level in the casing was higher after advancing through a silt layer from approximately 59.0 to 72.0 feet bgs. Indicating there could be a partially confined aquifer at the site.

The permeability of the Ktm was not tested, but the sandstone unit would likely produce less water than Qal. On-site testing and analysis of data show that dewatering efforts will need to be robust as there will be large amounts of rapid recharge into all excavations.

All planned excavations are planned in OSHA Type C soils for sloping standards with a maximum allowable slope of 1.5 (h:v) without shoring or benching. Test pits conducted in the planned bypass channel were terminated before the backhoe equipment reached its excavation limit due to excessive sloughing of pit walls and inflowing water. Caving of excavation slopes at the maximum allowable slope will occur without proper dewatering of the saturated loose soil. Excavations below the water table will fill with water without dewatering. If the loose soil is saturated while using ditches and sumps to move water out of excavation they will likely collapse.

Excavation of the right abutment for the diversion dam wing walls is planned to elevation 4465 el. and may encounter the Ktm. It is an intensely to moderately weathered (W5-W7) sandstone that ranges from soft to hard (H3-H6).

Anticipated foundation conditions for concrete placement are loose and saturated with beds of cobbles and boulders. Drilling at the site is challenging due to the high percentages of gravel, cobbles, and boulders. The ground surface has the potential to be frozen for greater than 200 days of the year. Frost depth ranges up to 5-feet. The planned compacted backfill is sourced from excavated material. This on-site material may not be suitable for compacted backfill and after processing the quantity may not entirely fulfill construction needs. The rip rap material is also planned to be sourced from excavated on-site material and quantities may not be great enough for this project.

References

[1] "St. Mary Diversion Dam, Milk River Project, Missouri Basin Region Ver. 1.0," USBR, Billings, MT, June 2022.

[2] "Exploration Program St. Mary Diversion Dam and Headworks Structure Geologic Data for Modifications, Milk River Project, Great Plains Region," USBR, Denver, CO, September 2017.

[3] "Comprehensive Review Lake Sherburne Dam, Milk River Project, Great Plains Region," USBR, Denver, CO, December 2017.

[4] M. G. C. B. B. R. a. F. R. Kottek, "World Map of teh Koppen-Geiger Climate Classification Updated," 2006. [Online]. Available: http://koeppen-geiger.vu-wien.ac.at/present.htm. [Accessed 12 9 2022].

[5] "U.S. Climate Data," [Online]. Available: https://www.usclimatedata.com/climate/babb/montana/united-states/usmt0013. [Accessed 15 9 2022].

[6] M. Cannon, "Geology and Ground-water Resources of the Blackfeet Indian Reservation, Northwestern Montana, Bedrock Geology HA-737," USGS, Denver, CO, 1996.

[7] M. Cannon, "Geology and Ground-water Resources of the Blackfeet Indian Reservation, Northwestern Montana Surficial Geology," USGS, Denver, CO, 1996.

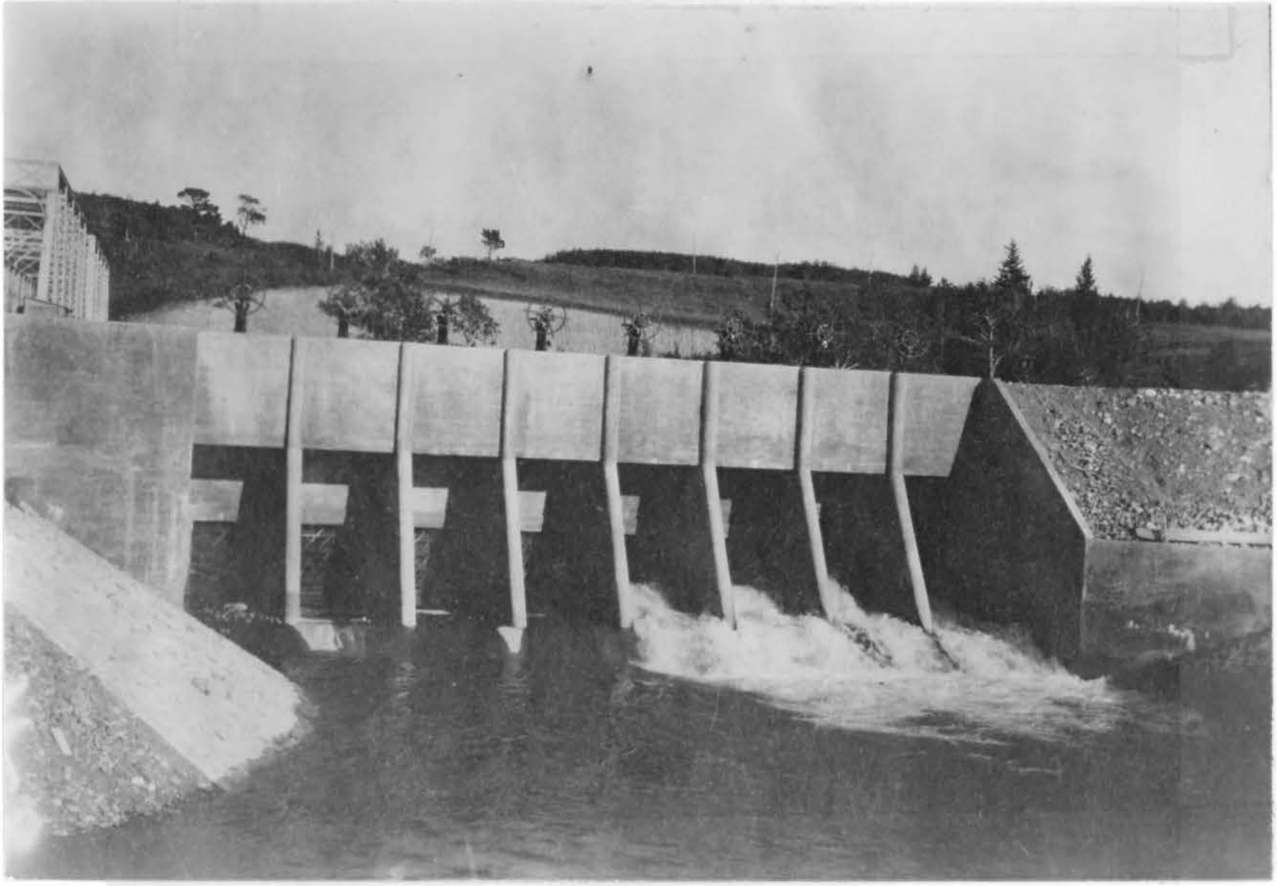
Appendix A – Photographs

19.

Temporary No. 349.

Headworks and Diversion.

H. L. S. December 8, 1915.



Headworks, St. Mary Canal

Appendix B – Current Investigation Geologic Drawings

15-D-T0003 – Vicinity Map

15-600-60068 – Geology Plan

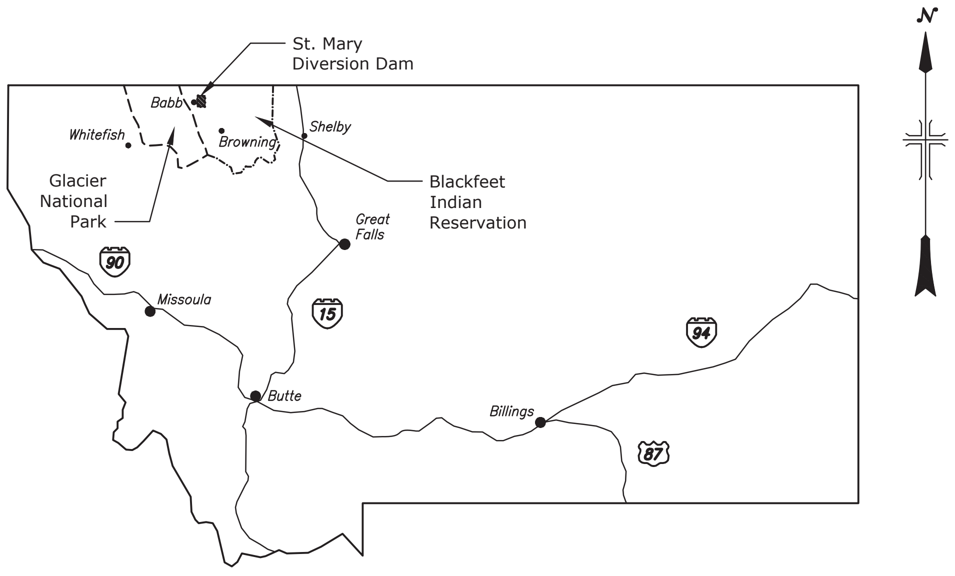
15-600-60069 – Legend and Geologic Explanation

15-600-60070 – Cross Section A-A’

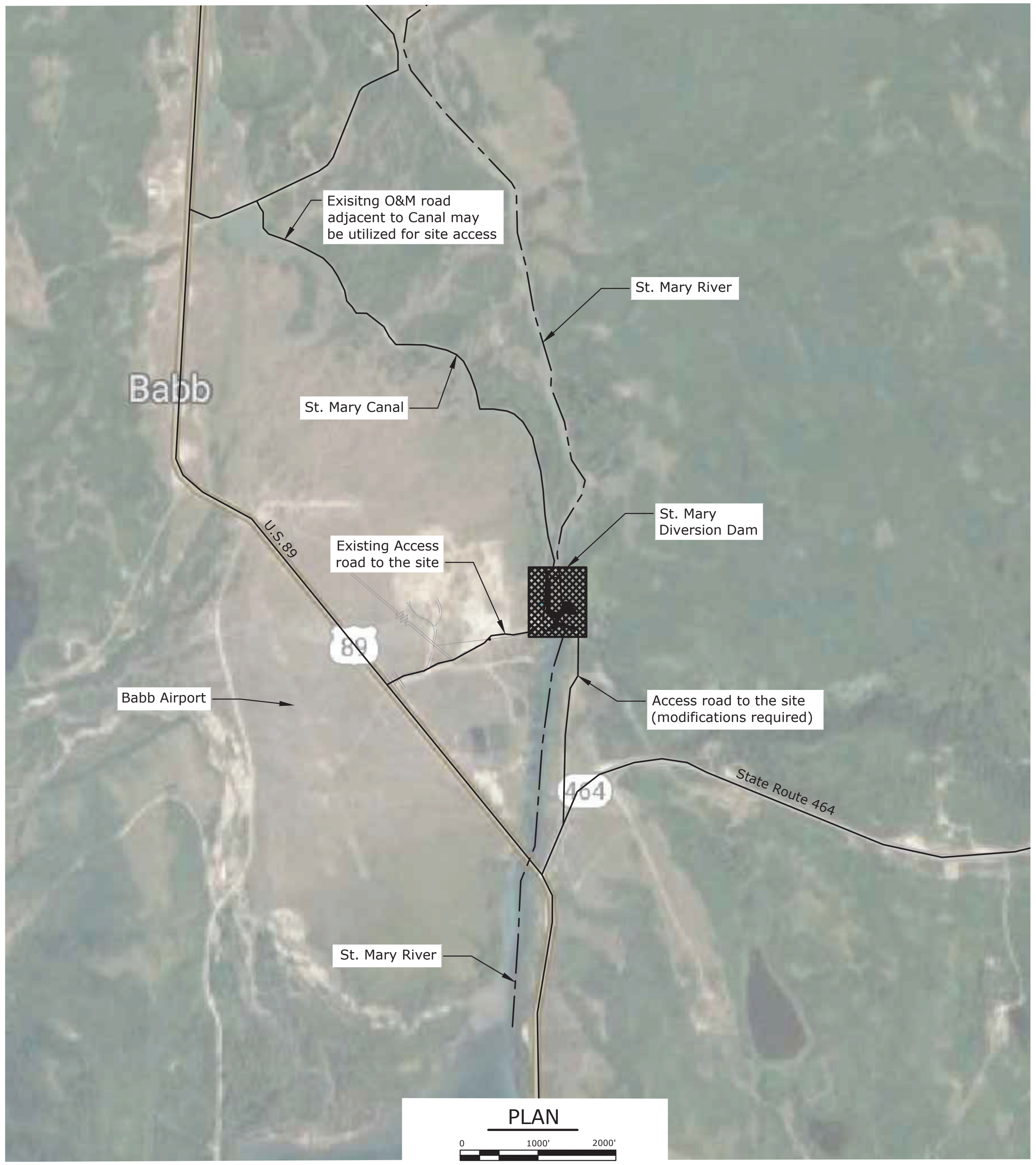
15-600-60071 – Cross Section B-B’

15-600-60072 – Cross Section C-C’

15-600-60073 – Geology General Map



KEY MAP



PLAN

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ST. MARY STORAGE DIVISION

ST. MARY CANAL DIVERSION WORKS
DAM REPLACEMENT AND FISH MODIFICATIONS

DANIEL GIBAS
DESIGNED
JON MULLIGAN
DRAWN
RYAN KENT
CHECKED

TECH. APPR.

APPROVED
PEER REVIEWER -

DENVER, CO 2022-11-09

VICINITY MAP

PLAN

15-D-T0003
SHEET 1

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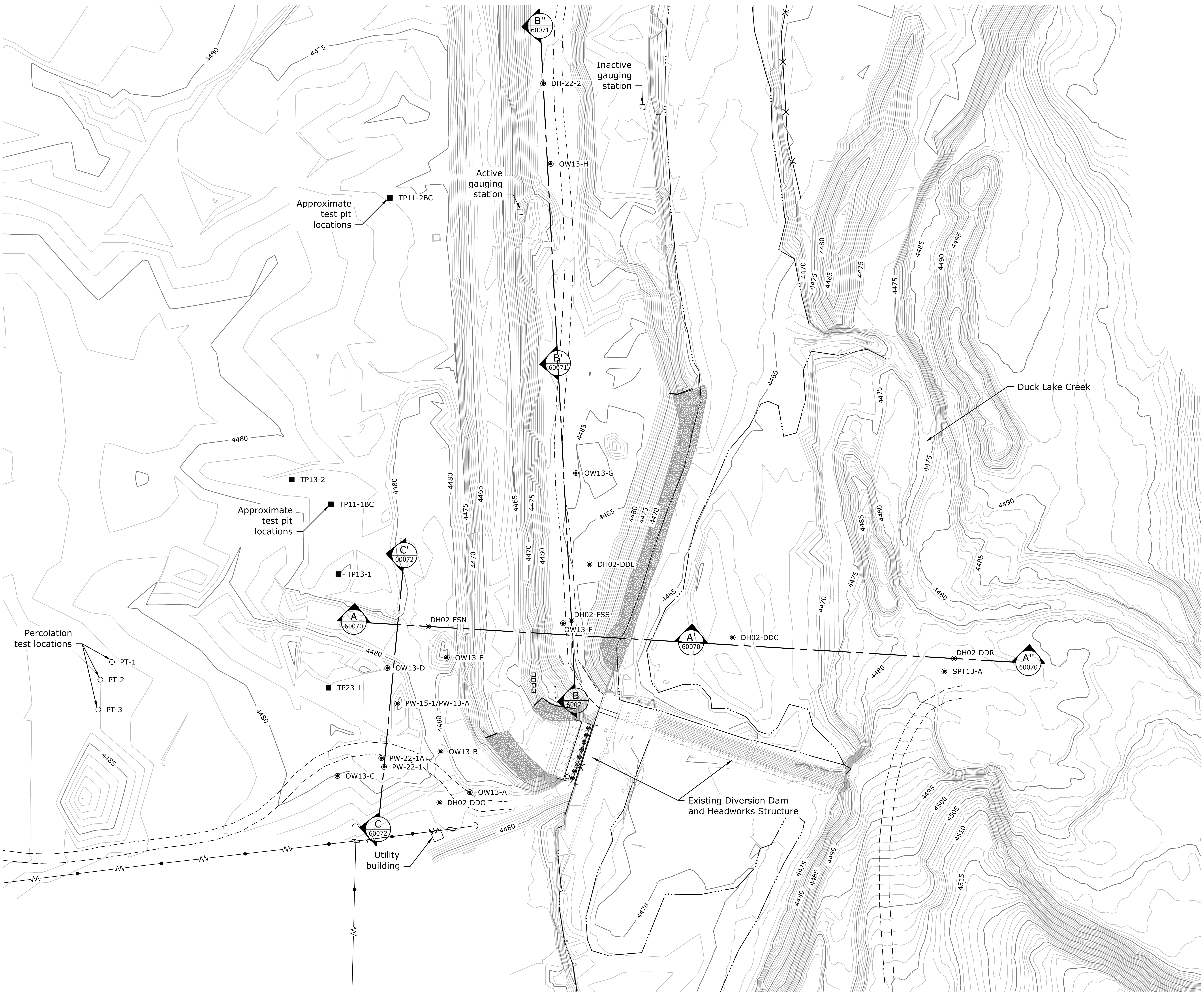
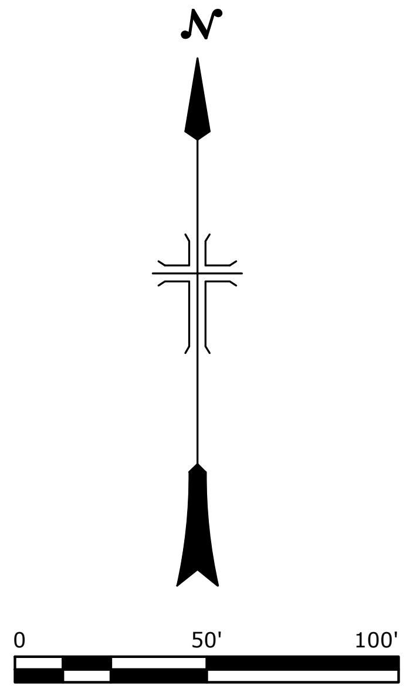


LEGEND

● Boring
■ Test pit
○ Percolation test
Access road
Overhead powerline
Low flow edge of water
Fence
▨ Riprap

REFERENCE DRAWINGS

GEOLOGIC EXPLANATION	15-600-60069
SECTION A-A'-A''	15-600-60070
SECTION B-B'-B''	15-600-60071
SECTION C-C'	15-600-60072
GENERAL MAP	15-600-60073



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ST. MARY DIVERSION DAM

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Lasater, Jacob A
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Clark, Cody T
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ADMIN APPROVAL -

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GEOLOGY

PLAN

15-600-60068

SHEET 1

GEOLOGIC EXPLANATION

Fill (fill)

Fill material was derived from excavation of the canal and was placed between the canal and river channel. It is estimated at approximately 8 feet to 10-feet thick in the 2017 geologic report. The geologic material excavated from the canal is Quaternary Alluvium (Qal).

USCS visual classifications are Poorly-graded Gravel with Sand, Cobbles, and Boulders (GP)scb, Silty Gravel with Sand and Cobbles (GM)sc, Poorly-graded Gravel with Sand and Cobbles (GP)sc, Silty Gravel with Sand (GM)s, Silty Sand with Gravel and Cobbles (SM)gc, Poorly-graded Sand with Gravel and Cobbles (SP)gc, Poorly-graded Sand with Gravel, Cobbles, Boulders (SP)gcb, Well-graded Gravel with Sand and Cobbles (GW)sc, Clayey Sand with Gravel (SC)g, Clayey Gravel with Sand and Cobbles (GC)sc.

Soils range from 15 to 60% fine to coarse sand, 5 to 25% nonplastic to low plasticity fines, and 15 to 75% gravel. Percentage by volume is 10 to 60% fine to coarse cobbles and a trace to 5% boulders. Maximum size recovered ranges from 0.75 inches to 15 inches. Descriptions include light brown to brown, tan, and gray, dry to moist, soft, and no reaction to strong reaction with HCl.

Quaternary Alluvium (Qal)

Alluvium deposits are variable across the valley with geologic materials that do not have lateral continuity. This unit overlies the Two Medicine Formation (Ktm) and appears to be continuous upstream and downstream of the diversion dam and headworks structure. It is approximately 8 feet to 10 feet thick in borings DH02-DDR and SPT13-A to the right and downstream of the existing structure. The thickness on the left is currently unknown as investigations have not encountered the underlying Ktm at depth.

Quaternary Alluvium (Qal) visual USCS classifications are: Poorly-graded Sand with Gravel, Cobble, and Boulders (SP)gcb, Poorly-graded Sand with Silt, Gravel, and Cobbles (SP-SM)gc, Silty Sand (SM), Silty Sand with Gravel and Cobbles (SM)gc, Silty Gravel with Sand (GM)s, Well-graded Gravel with Sand, Cobbles, and Boulders (GW)scb, Poorly-graded Gravel with Sand, Cobbles, and Boulders (GP)scb, Poorly-graded Gravel with Silt, Sand, and Cobbles (GP-GM)sc, Poorly-graded Gravel with Clay, Silt, Sand, and Cobbles (GP-GC)sc, Silty Gravel with Sand, Cobbles, and Boulders (GM)scb, Clayey Sand with Gravel (SC)g, Sandy Lean Clay with Gravel s(CL)g, Clayey Gravel with Sand and Cobbles (GC)sc, Lean Clay with Sand (CL)s, Fat Clay (CH), and Silt with Sand (ML)s.

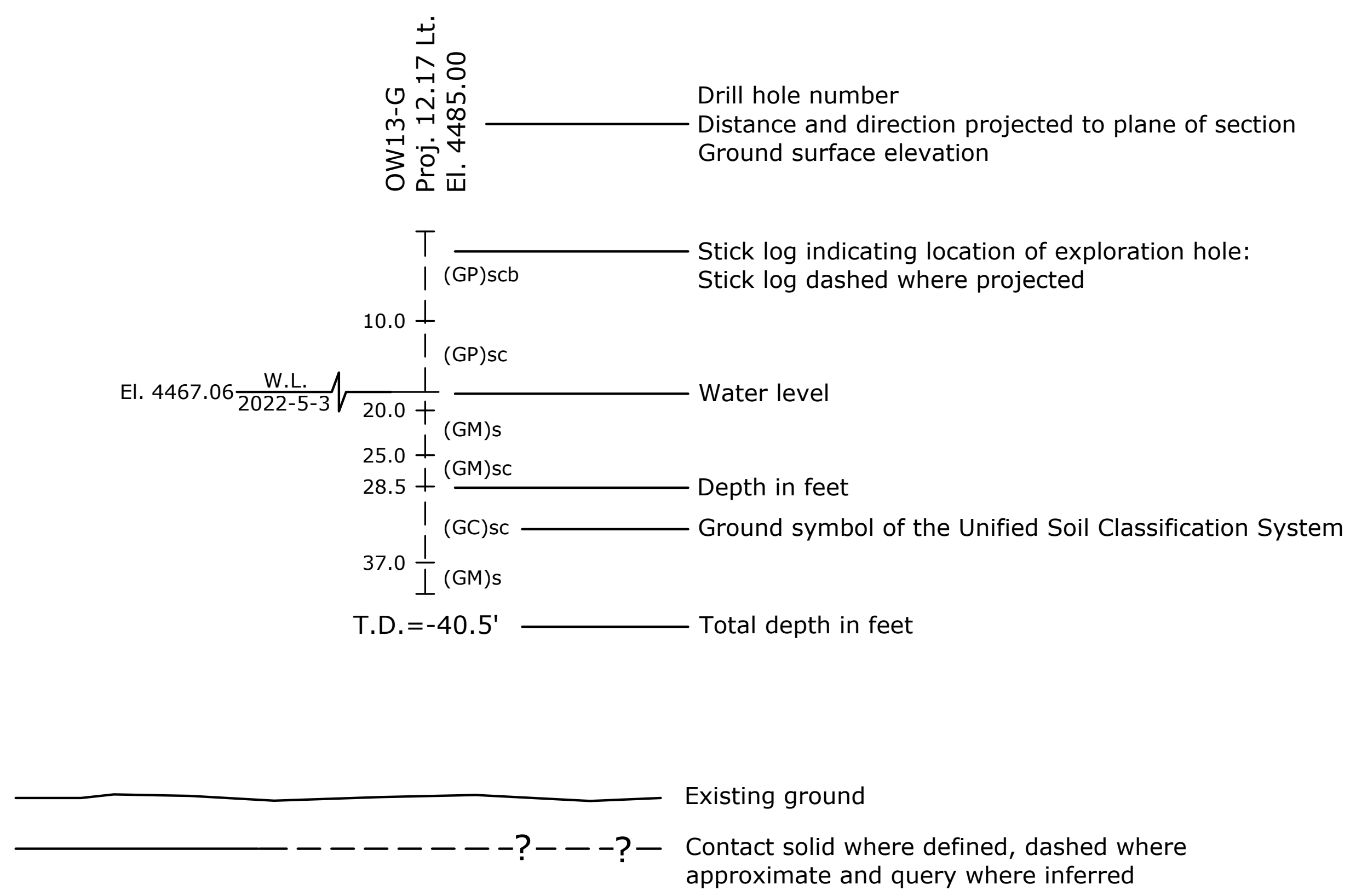
Soils range from 25 to 70% fine to coarse sand, 5 to 60% nonplastic to medium plasticity fines, and 15 to 70% fine to coarse gravel. Percentage by volume is 25 to 65% fine to coarse cobbles and a trace to 5% boulders. Maximum size recovered was 21-inches. Soil color ranges from light to dark gray in the upper saturated zone grading to dark brown or yellowish brown. It is moist to saturated, soft and loose to firm, and has no reaction to strong reaction with HCl.

Upper Cretaceous Two Medicine Formation (Ktm)

The Two Medicine Formation has eroded in the valley and depth to the top of bedrock decreases to the right of the structure with outcrops to the east. Depth to bedrock in previous investigations is 8-10 feet to the right and downstream of the existing structure. On the left side of the structure depth to bedrock is greater than the deepest investigation to date, boring PW-22-1A, of 80 feet.

The formation is composed of medium- to predominately fine-grained, moderately hard (H4) to hard (H3) sandstone; containing sedimentary clasts of quartz, feldspar, hornblende and nodular limestone; light to medium gray with dark gray to black mineral grains; massive; mostly moderately weathered (W5) with depth; moderately rough (R3); fracture surfaces are clean or containing very thin (< 1mm) infilling of calcium carbonate; strong reaction with HCl throughout.

STICK LOG EXAMPLE



REFERENCE DRAWINGS

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SECTION A-A'-A''_ _ _ _ _ _15-600-60070
SECTION B-B'-B''_ _ _ _ _ _15-600-60071
SECTION C-C'_ _ _ _ _ _ _ _15-600-60072
GENERAL MAP _ _ _ _ _ _ _ _15-600-60073

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ST. MARY DIVERSION DAM

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Walsh, Christie S
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Lasater, Jacob A
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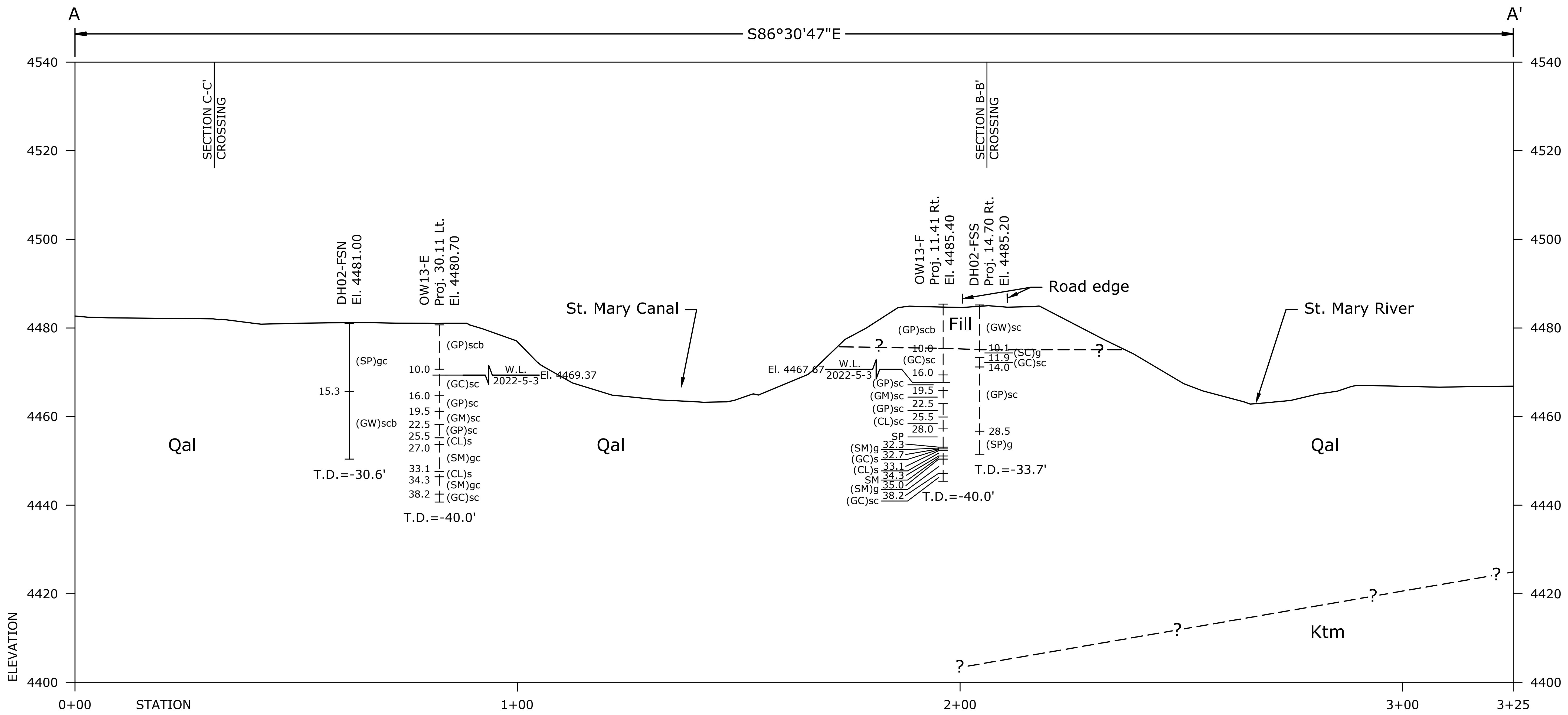
GEOLOGY

GEOLOGIC EXPLANATION

15-600-60069

SHEET 2



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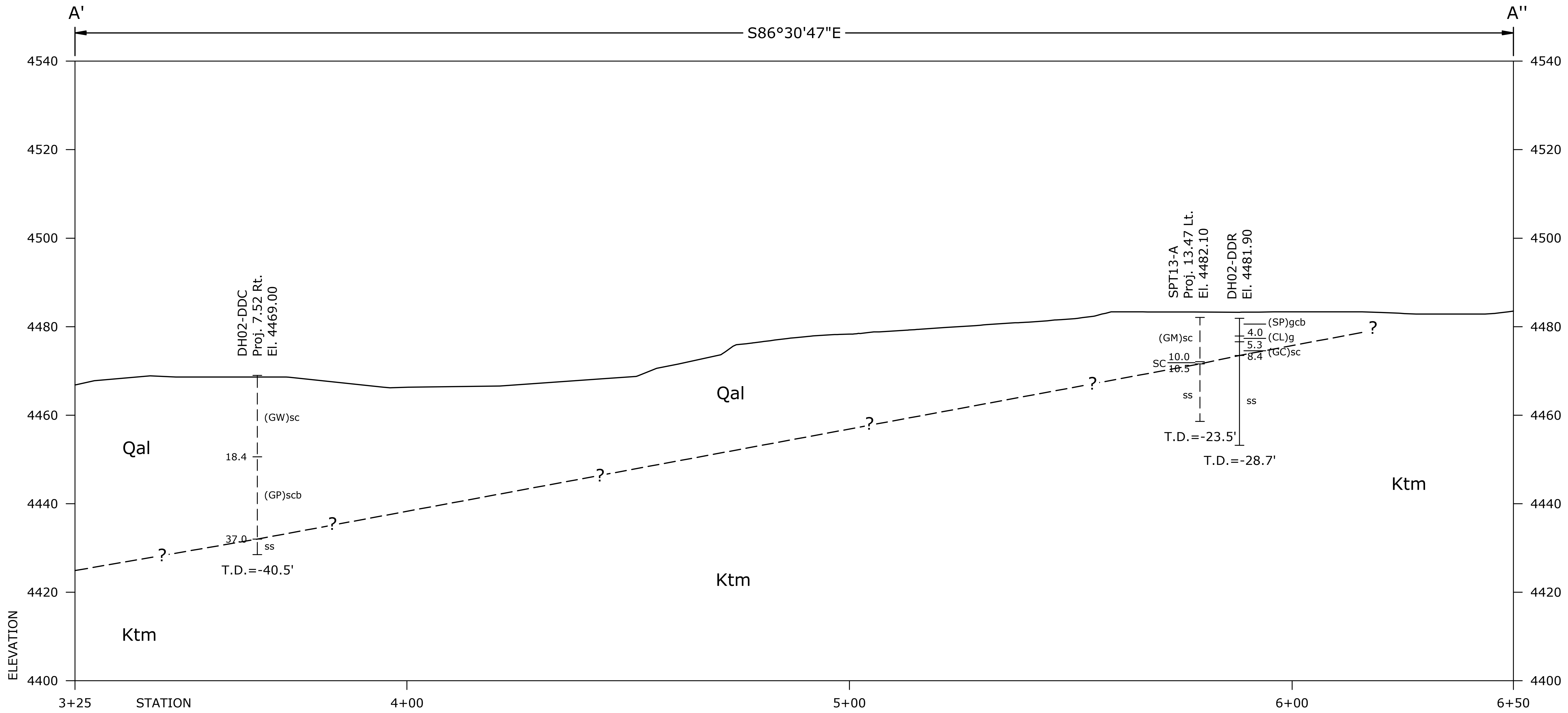

SECTION A'-A''

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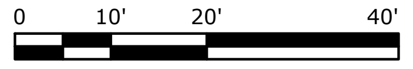
SECTION B-B'-B''_______15-600-60071
SECTION C-C'_________15-600-60072
GENERAL MAP________15-600-60073



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ST. MARY DIVERSION DAM

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ADMIN APPROVAL -

BILLINGS, MT

GEOLOGY

SECTION A-A'-A''

15-600-60070

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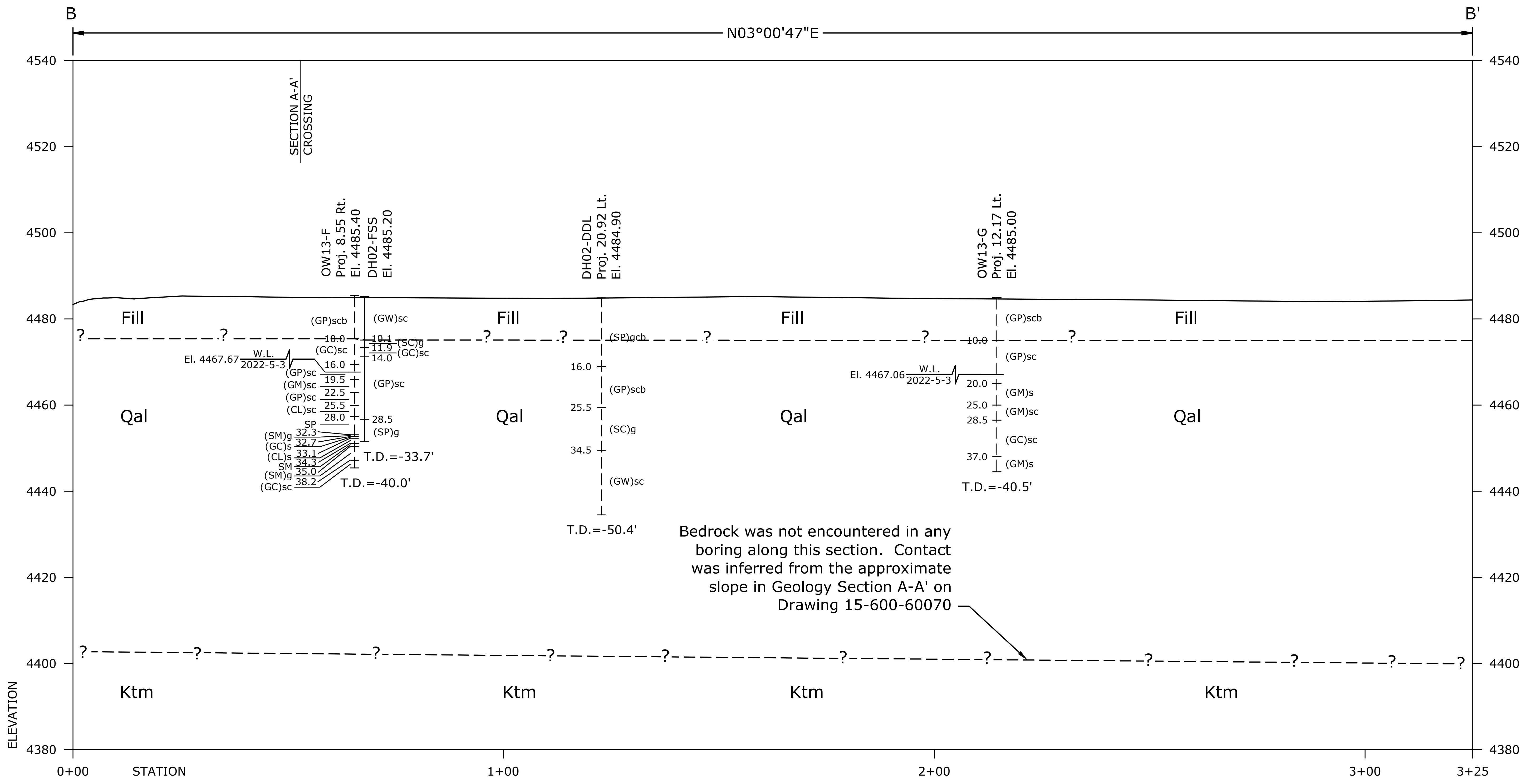
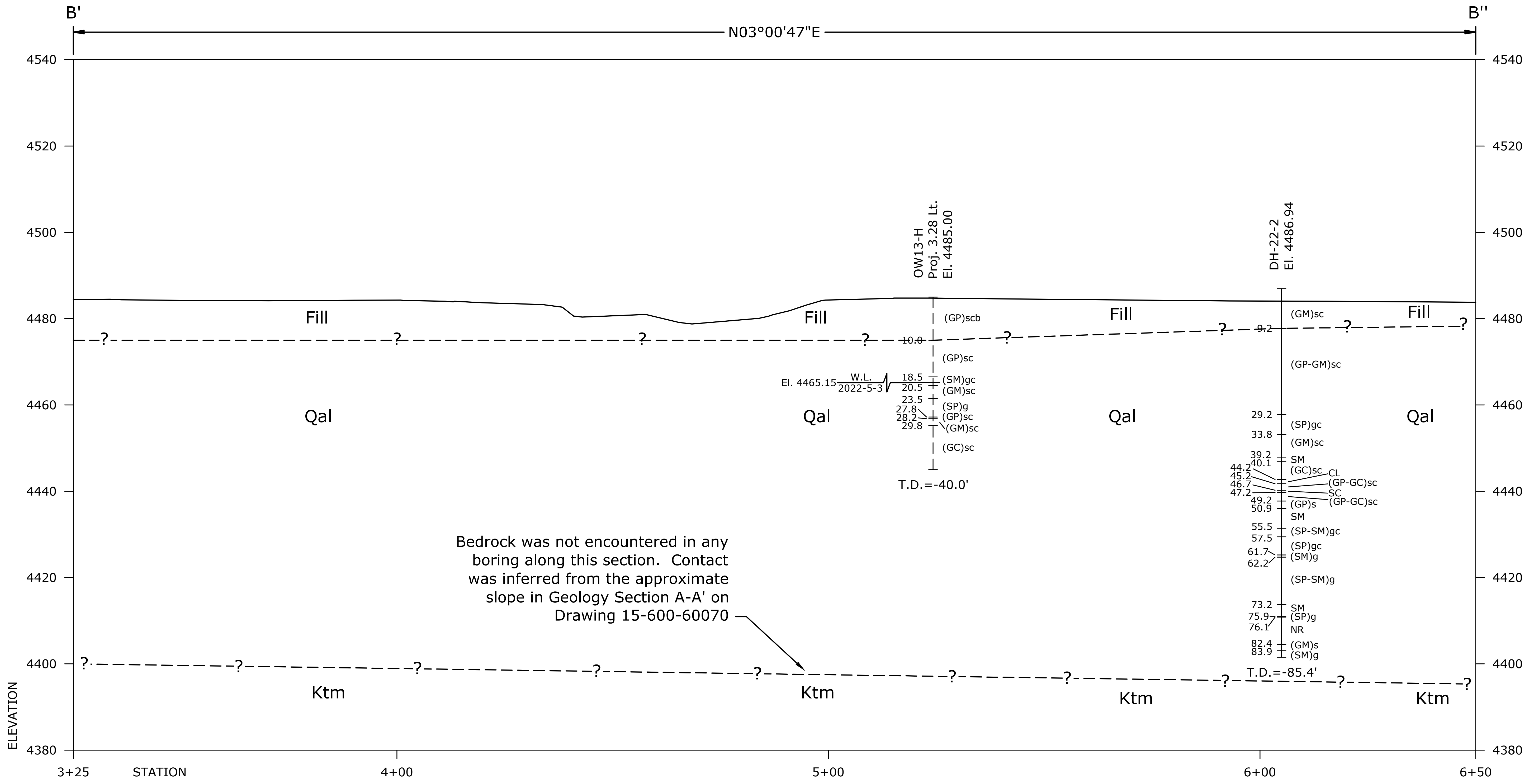


Bedrock was not encountered in any boring along this section. Contact was inferred from the approximate slope in Geology Section A-A' on Drawing 15-600-60070

SECTION B-B'



Bedrock was not encountered in any boring along this section. Contact was inferred from the approximate slope in Geology Section A-A' on Drawing 15-600-60070

SECTION B'-B''

REFERENCE DRAWINGS

PLAN	15-600-60068
GEOLOGIC EXPLANATION	15-600-60069
SECTION A-A'-A''	15-600-60070
SECTION C-C'	15-600-60072
GENERAL MAP	15-600-60073

0 30' 60'

LAST SAVED DATE
2023-04-28
LAST SAVED BY
CWALSH

CAD SYSTEM
AutoCAD 24.0S (LMS TECH)
CAD FILENAME
15-600-T12732-MX-0.DWG

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MILK RIVER PROJECT
ST. MARY STORAGE DIVISION

ST. MARY DIVERSION DAM

Joramo, Seth M
DESIGNED
Walsh, Christie S
DRAWN
Lasater, Jacob A
CHECKED
Joramo, Seth M
TECH. APPR.
Clark, Cody T
APPROVED
ADMIN APPROVAL -

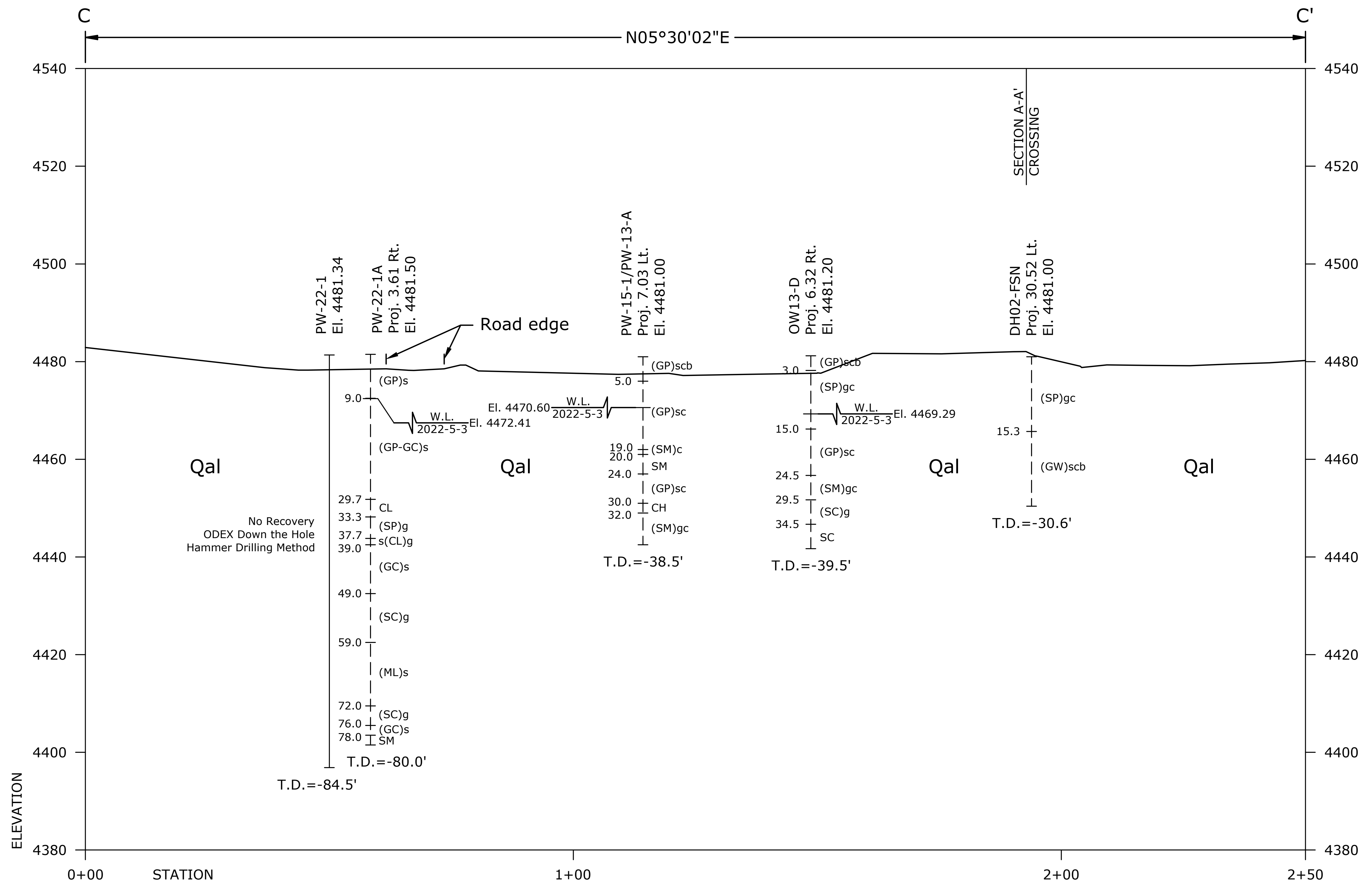
BILLINGS, MT

GEOLOGY

SECTION B-B'-B''

15-600-60071

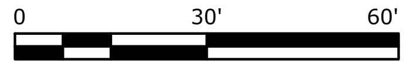
SHEET 4



SECTION C-C'

REFERENCE DRAWINGS

PLAN	15-600-60068
GEOLOGIC EXPLANATION	15-600-60069
SECTION A-A'-A''	15-600-60070
SECTION B-B'-B''	15-600-60071
GENERAL MAP	15-600-60073



LAST SAVED DATE
2023-04-28
LAST SAVED BY
CWALSH

CAD SYSTEM
AutoCAD 24.0S (LMS TECH)
CAD FILENAME
15-600-T12732-MX-0.DWG

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RECLAMATION

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MILK RIVER PROJECT
ST. MARY STORAGE DIVISION

ST. MARY DIVERSION DAM

Joramo, Seth M
DESIGNED
Walsh, Christie S
DRAWN
Lasater, Jacob A
CHECKED
Joramo, Seth M
TECH. APPR.
Clark, Cody T
APPROVED
ADMIN APPROVAL -

BILLINGS, MT

GEOLOGY

SECTION C-C'

15-600-60072

SHEET 5

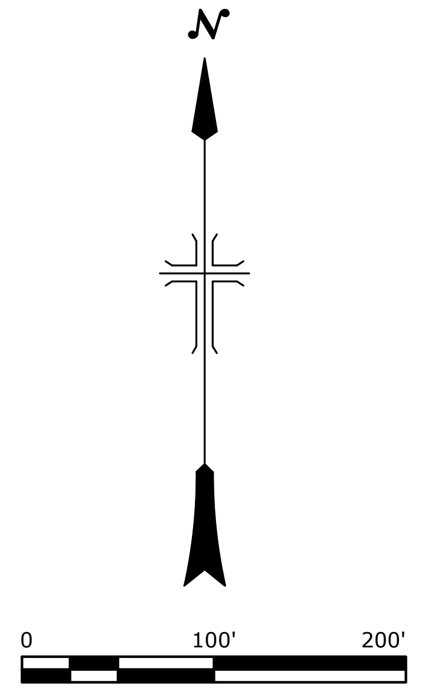
Released

LEGEND

◉	Boring
■	Test pit
○	Percolation test
– – – – –	Access road
—•—⩘—	Overhead powerline
—··—	Low flow edge of water
—×—×—	Fence
▨	Riprap

REFERENCE DRAWINGS

PLAN_______________15-600-60068
GEOLOGIC EXPLANATION___15-600-60069
SECTION A-A'-A''_________15-600-60070
SECTION B-B'-B''_________15-600-60071
SECTION C-C'___________15-600-60072



BUREAU OF RECLAMATION

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MILK RIVER PROJECT
ST. MARY STORAGE DIVISION

ST. MARY DIVERSION DAM

Joramo, Seth M
DESIGNED
Walsh, Christie S
DRAWN
Lasater, Jacob A
CHECKED
Joramo, Seth M
TECH. APPR.
Clark, Cody T
APPROVED
ADMIN APPROVAL - Supervisory Geologist

BILLINGS, MT

GEOLOGY

GENERAL MAP

15-600-60073

SHEET 6

LAST SAVED DATE
2023-04-28
LAST SAVED BY
CWALSH

CAD SYSTEM
AutoCAD 24.0S (LMS TECH)
CAD FILENAME
15-600-T12732-MX-0.DWG

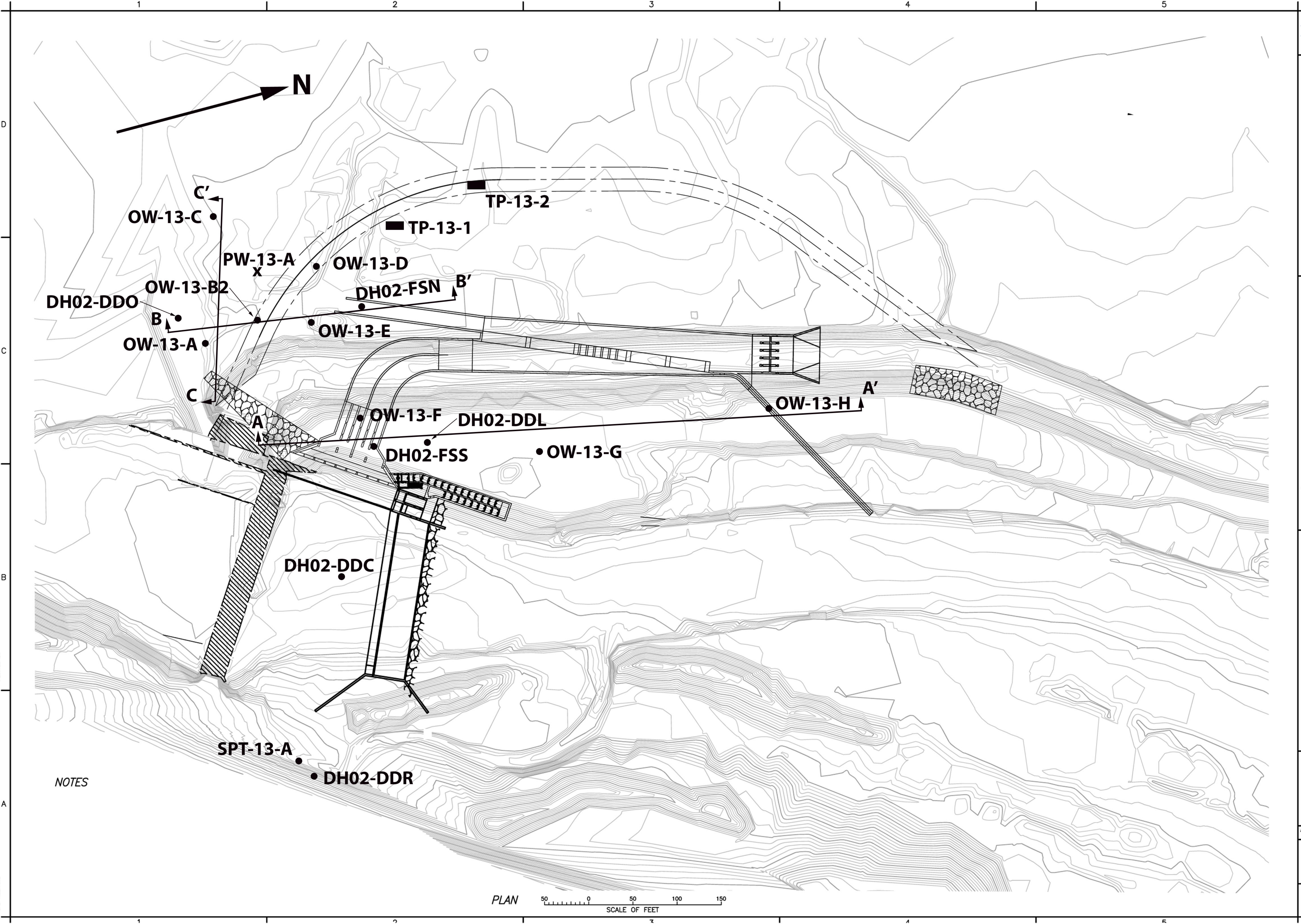
Appendix C – Previous Drawings

Figure 1 – Geology Plan

Figure 2 – Cross Section A-A’

Figure 3 – Cross Sections B-B’ & C-C’

Original Construction Specifications Drawings



DATE AND TIME PLOTTED
PLOTTED BY
CAD SYSTEM
CAD FILENAME

RECLAMATION
Managing Water in the West

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MILK RIVER PROJECT – MONTANA
MILK RIVER STORAGE DIVERSION

SAINT MARY DIVERSION DAM REPLACEMENT
60% DESIGN REVISIONS

SITE PLAN

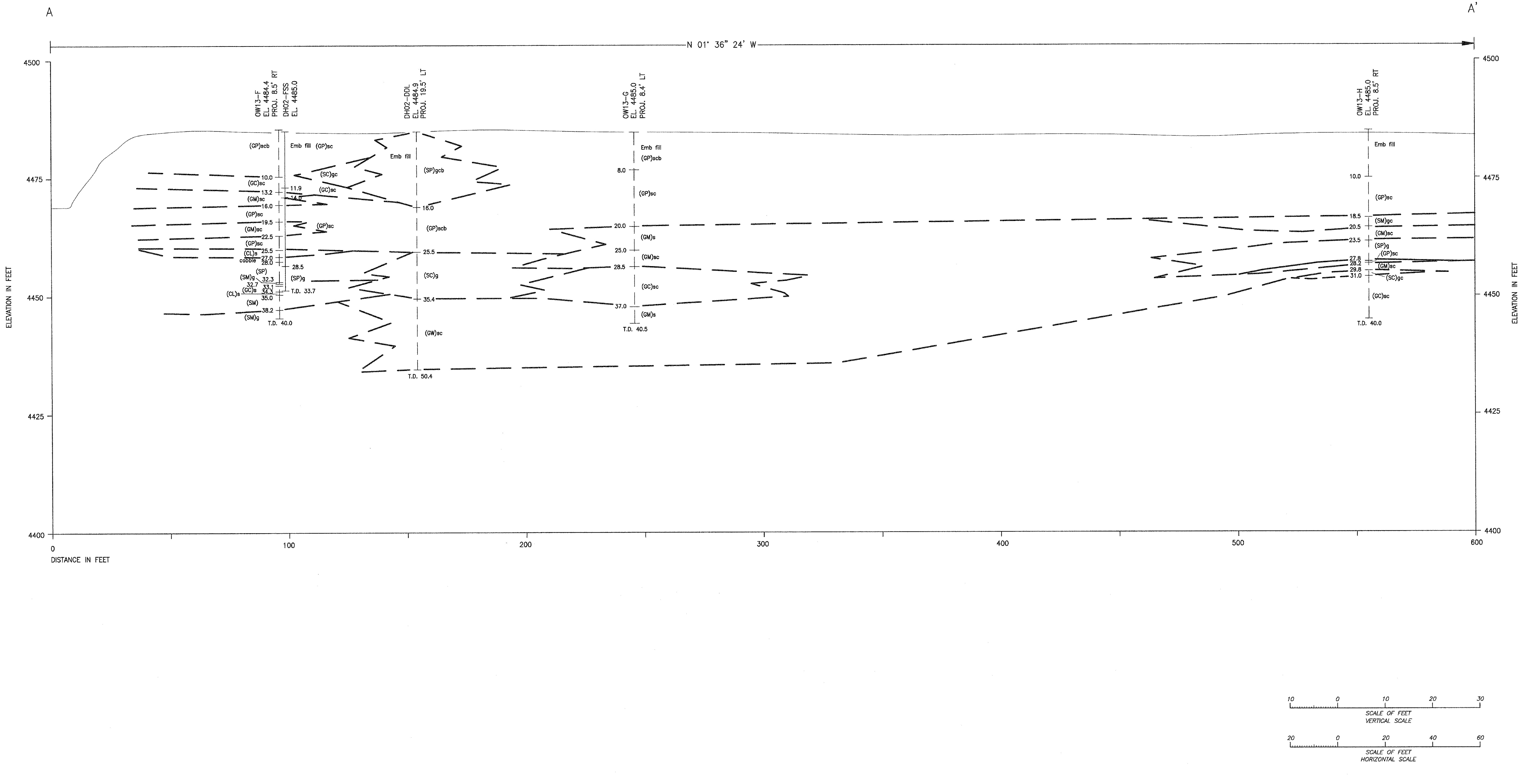
DENVER, COLORADO 2016-08-10

60% DESIGN REVISIONS

Geologic Investigations

Figure 1

RECLAMATION
Managing Water in the West



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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MILK RIVER PROJECT – MONTANA
MILK RIVER STORAGE DIVERSION

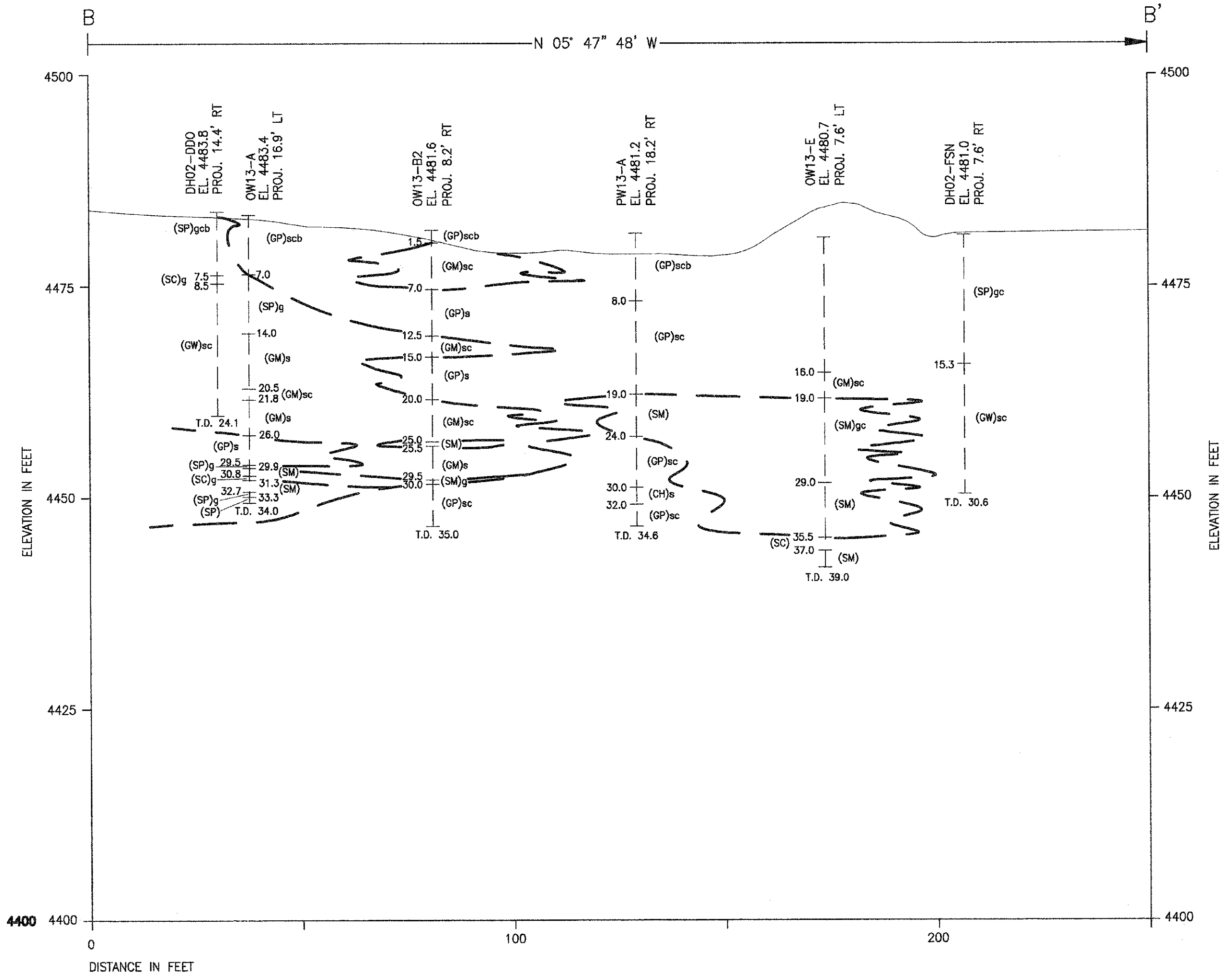
ST MARY DIVERSION DAM REPLACEMENT

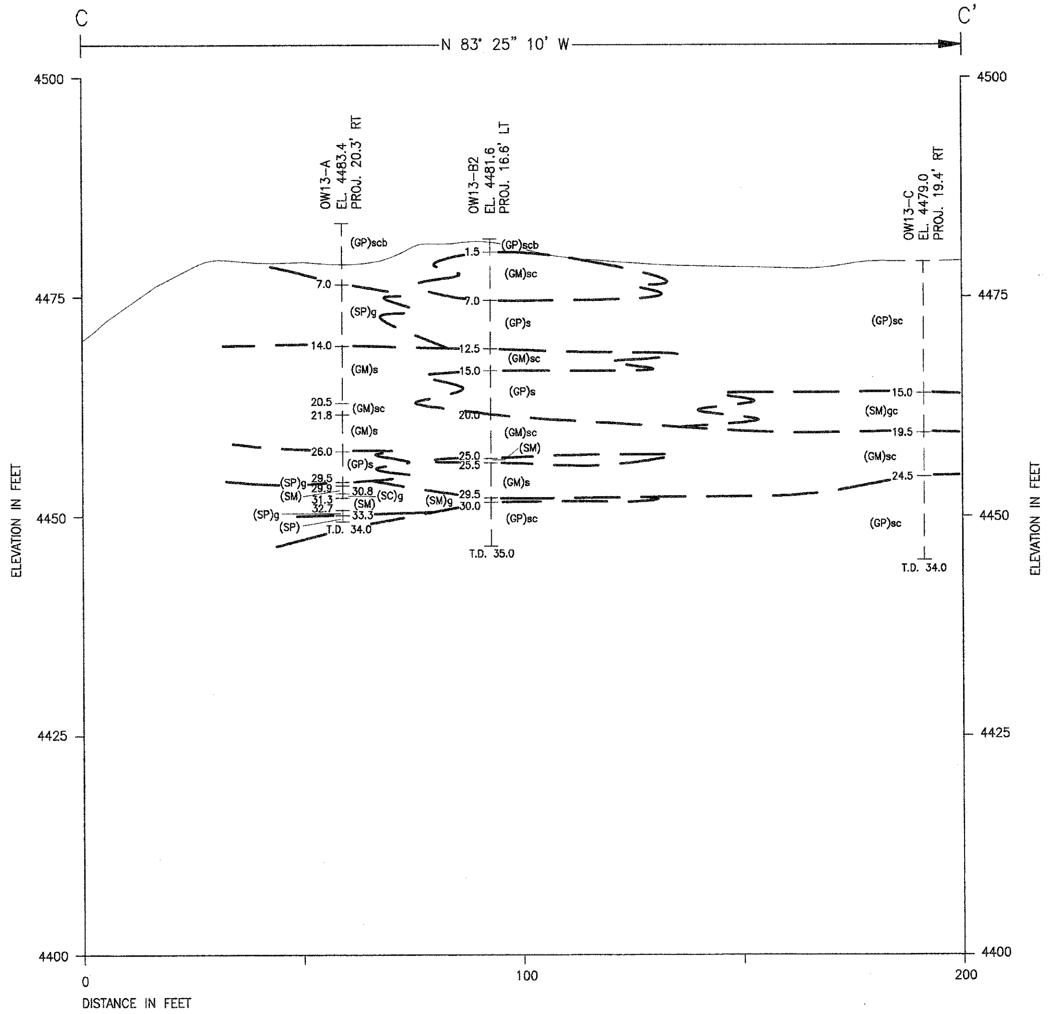
GEOLOGIC SECTION A–A'

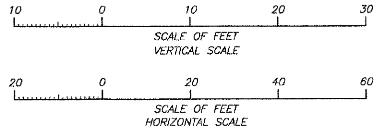
X
DESIGNED
X
DRAWN
X TITLE
CHECKED
X
TECH. APPR. NAME, PROF. ABBR.
X
ADMIN. APPROVAL
NAME
TITLE

DENVER, COLORADO

Figure 2







RECLAMATION
Managing Water in the West

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MILK RIVER PROJECT – MONTANA
MILK RIVER STORAGE DIVERSION

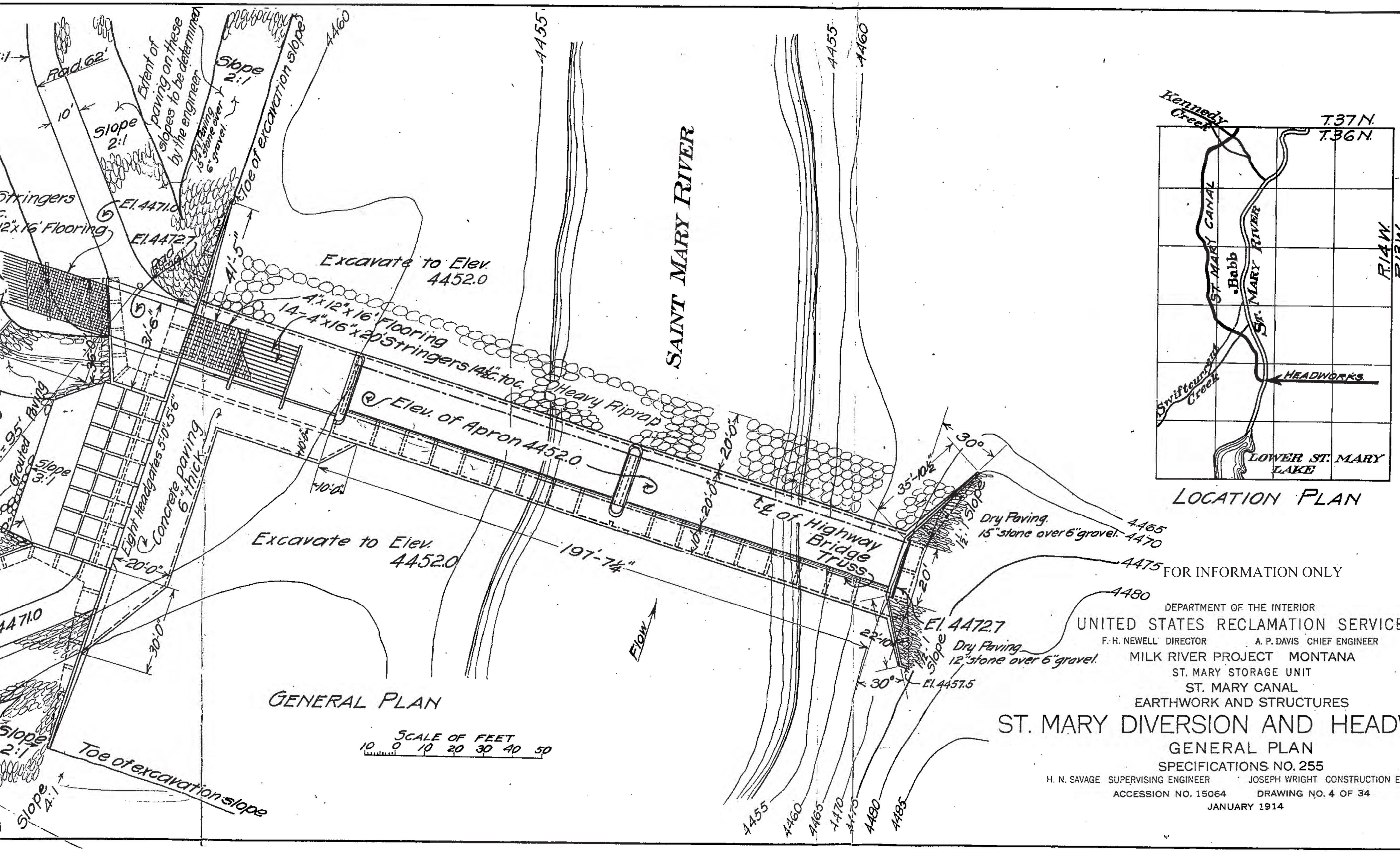
ST MARY DIVERSION DAM REPLACEMENT

GEOLOGIC SECTIONS B–B' AND C–C'

X
DESIGNED
X
DRAWN TITLE
X
CHECKED
X
TECH. APPR. NAME, PROF. ABBR.
X
ADMIN. APPROVAL
NAME
TITLE

DENVER, COLORADO

Figure 3



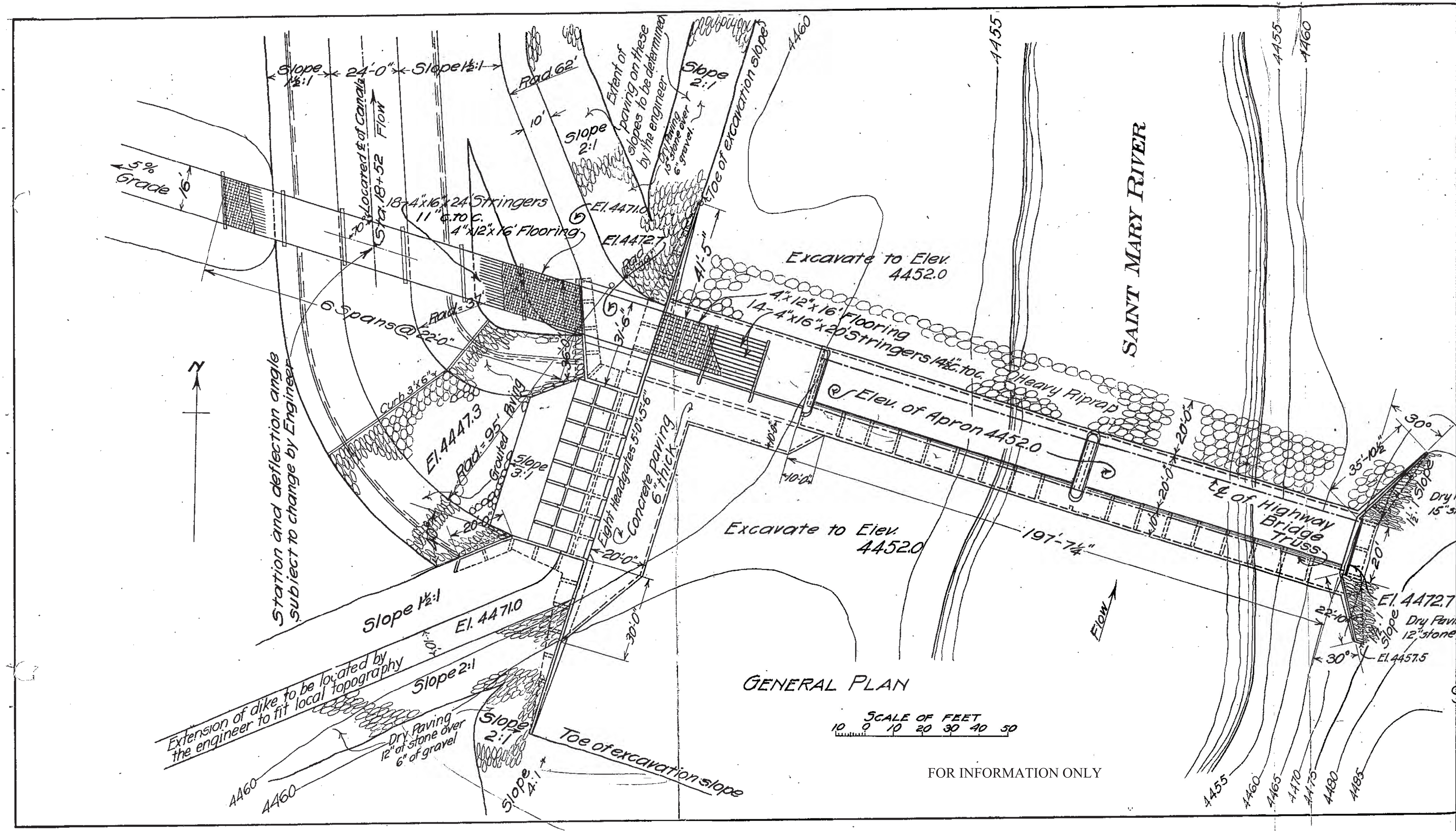
GENERAL PLAN

LOCATION PLAN

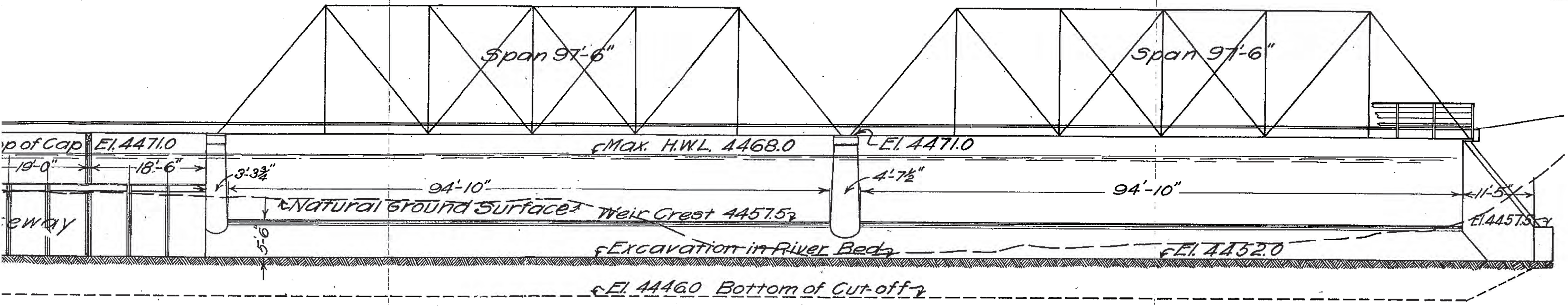
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
F. H. NEWELL DIRECTOR A. P. DAVIS CHIEF ENGINEER
MILK RIVER PROJECT MONTANA
ST. MARY STORAGE UNIT
ST. MARY CANAL
EARTHWORK AND STRUCTURES

ST. MARY DIVERSION AND HEADWORKS

GENERAL PLAN
SPECIFICATIONS NO. 255
H. N. SAVAGE SUPERVISING ENGINEER JOSEPH WRIGHT CONSTRUCTION ENGINEER
ACCESSION NO. 15064 DRAWING NO. 4 OF 34
JANUARY 1914



GENERAL PLAN



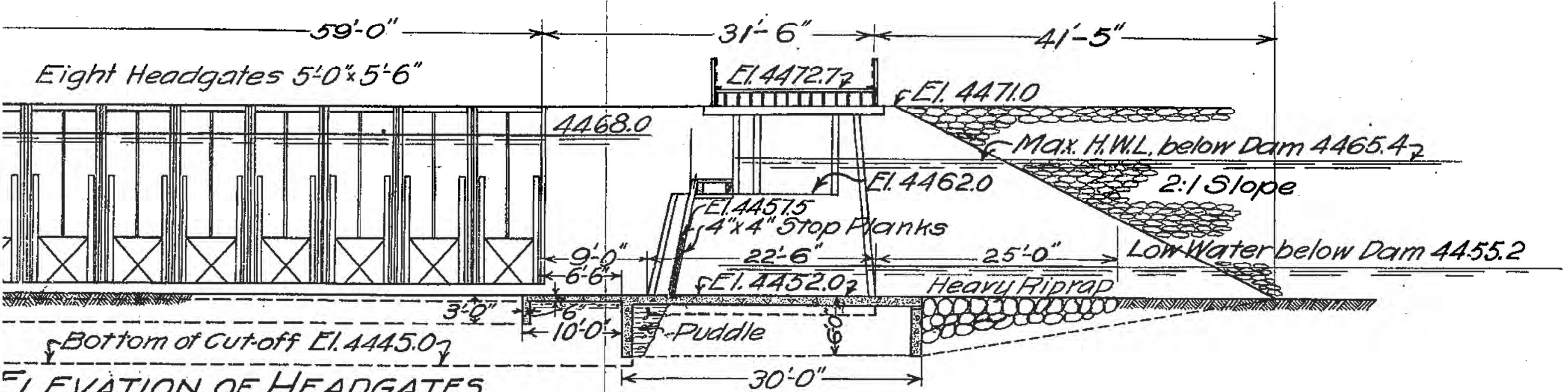
UPSTREAM ELEVATION OF DIVERSION DAM

SCALE OF FEET
10 0 10 20

NOTE:-Steel bridge superstructure not included in this contract.

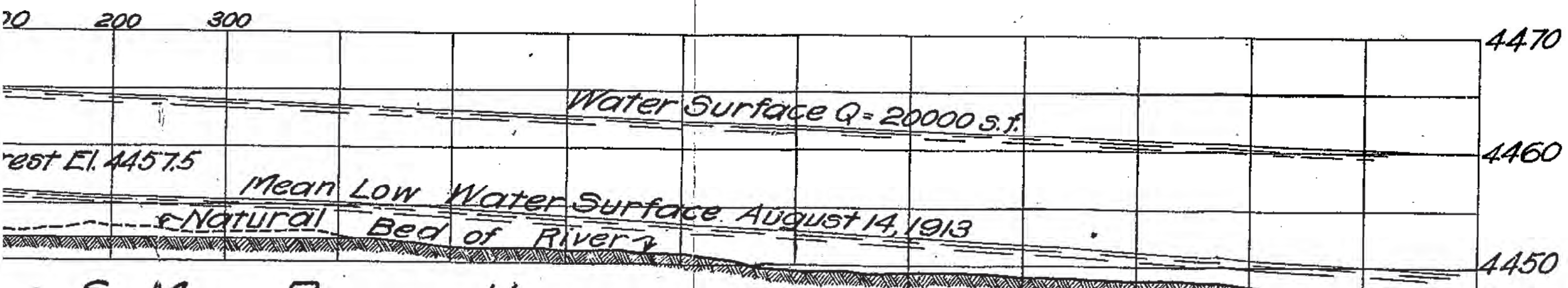
QUANTITIES

Excavation	26000 cu.yds.
Concrete	1055 cu.yds.
Reinforcing Steel	83500 lbs.
Structural Steel	40000 lbs.
Lumber	70000 ft. B.M.
Paving	2850 sq.yds.
Riprap	600 cu. yds.



ELEVATION OF HEADGATES

SCALE OF FEET.
10 0 10 20



OF ST. MARY RIVER AT HEADWORKS

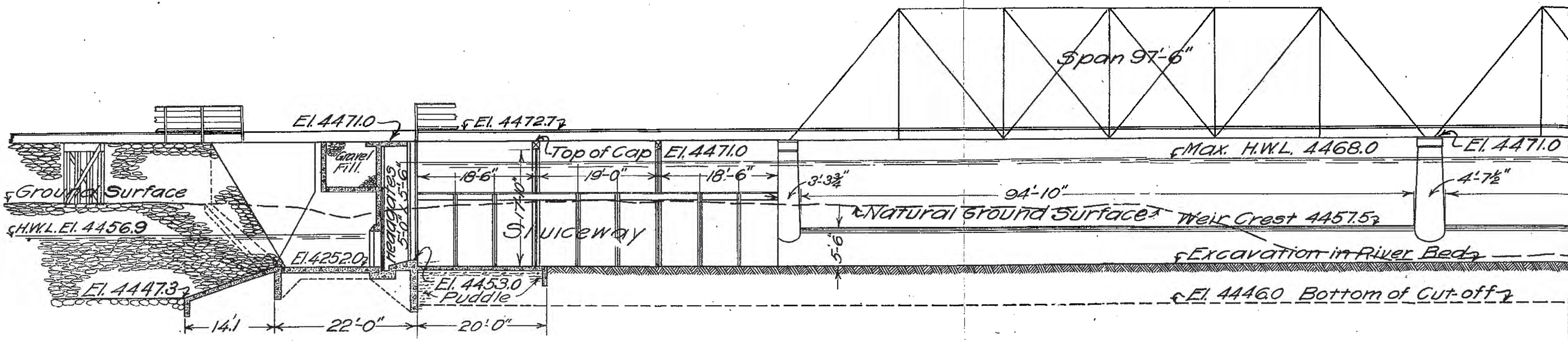
FOR INFORMATION ONLY

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
F. H. NEWELL DIRECTOR A. P. DAVIS CHIEF ENGINEER
MILK RIVER PROJECT MONTANA
ST. MARY STORAGE UNIT
ST. MARY CANAL
EARTHWORK AND STRUCTURES

ST. MARY DIVERSION AND HEADWORKS

PROFILE AND ELEVATIONS

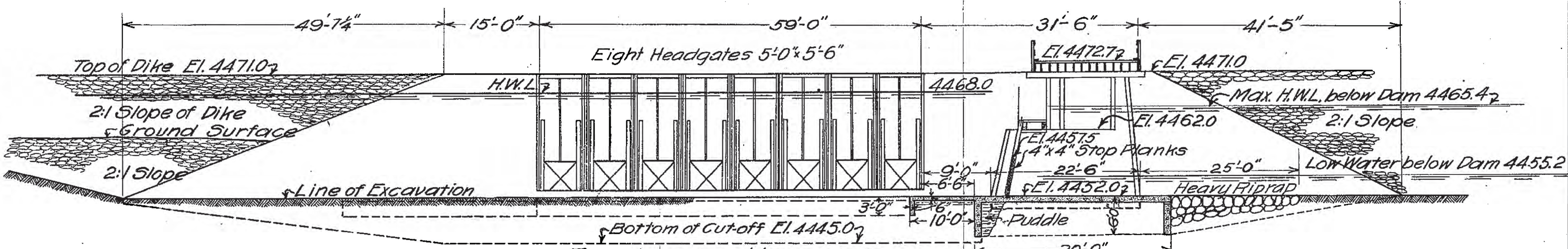
SPECIFICATIONS NO. 255
H. N. SAVAGE SUPERVISING ENGINEER JOSEPH WRIGHT CONSTRUCTION ENGINEER
ACCESSION NO. 15065 DRAWING NO. 5 OF 34
JANUARY 1914



UPSTREAM ELEVATION OF DIVERSION DAM

SCALE OF FEET
10 0 10 20

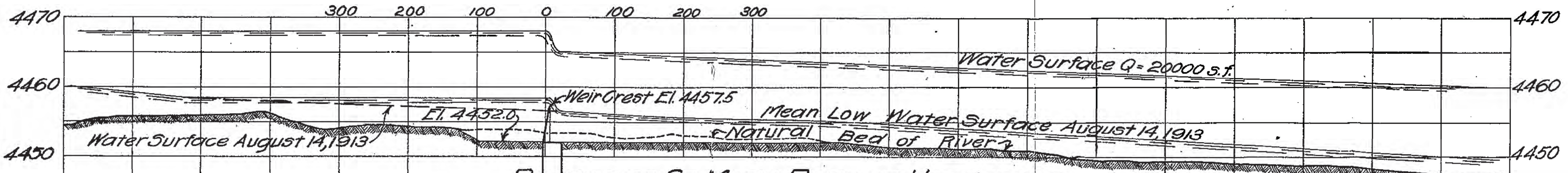
NOTE:-Steel bridge super
not included in this



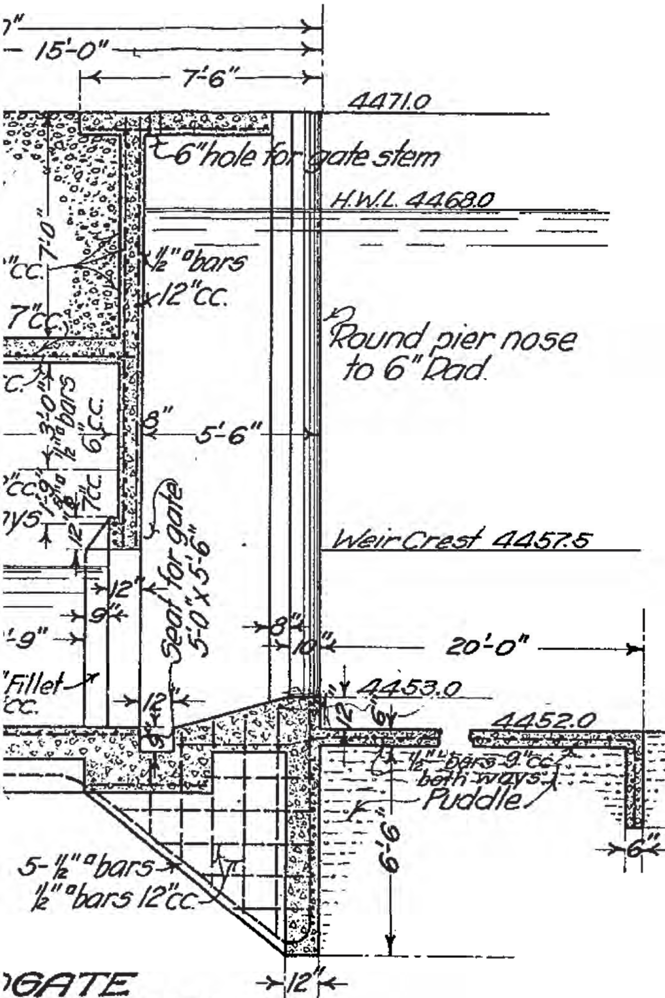
ELEVATION OF HEADGATES

SCALE OF FEET
10 0 10 20

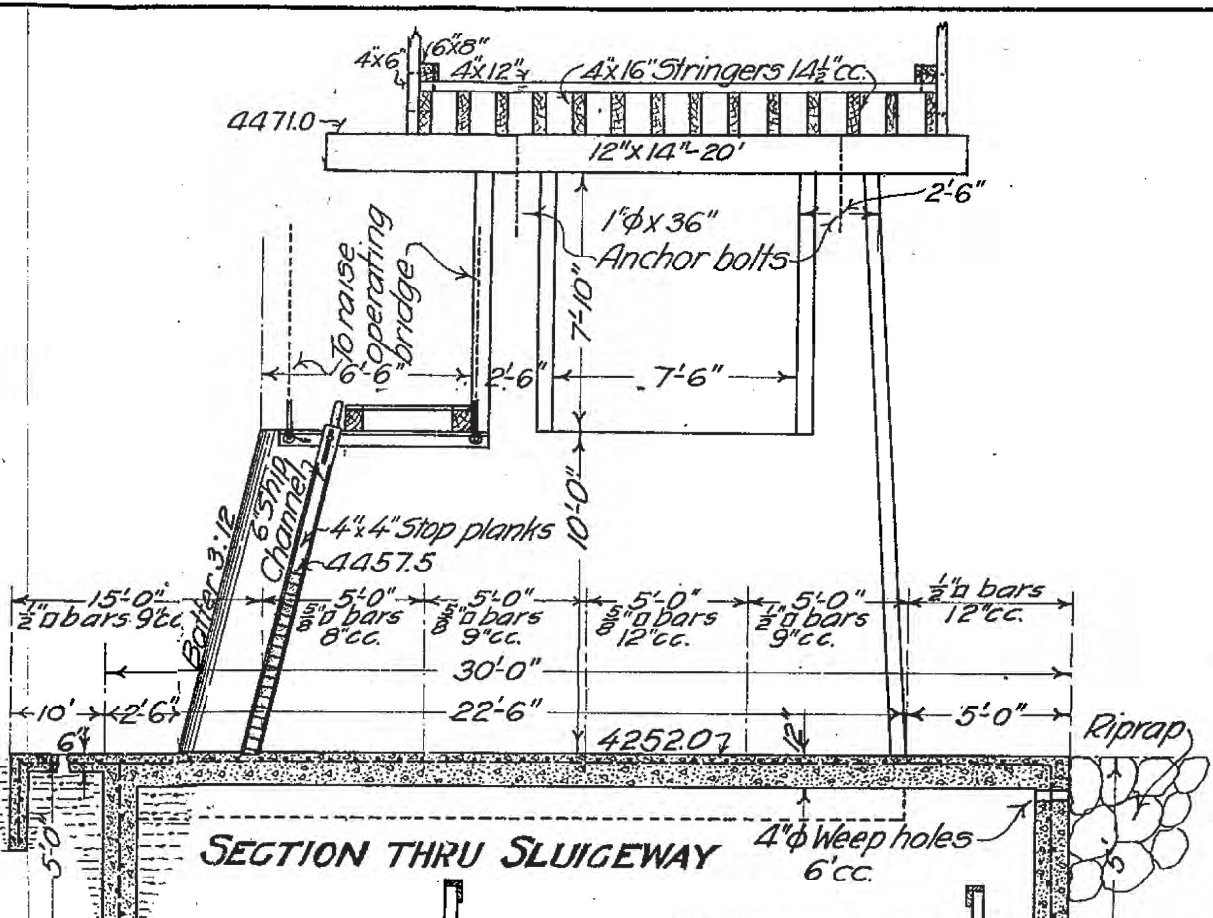
FOR INFORMATION ONLY



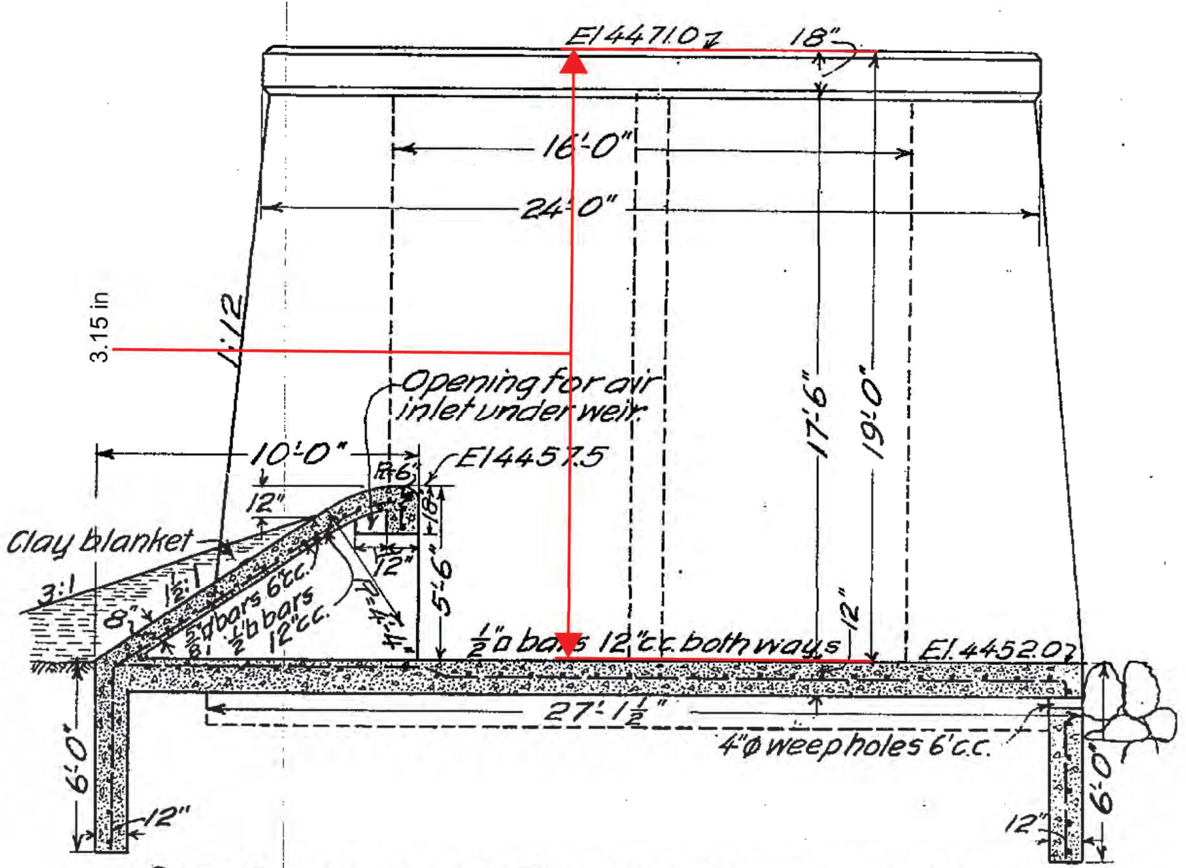
PROFILE OF ST. MARY RIVER AT HEADWORKS



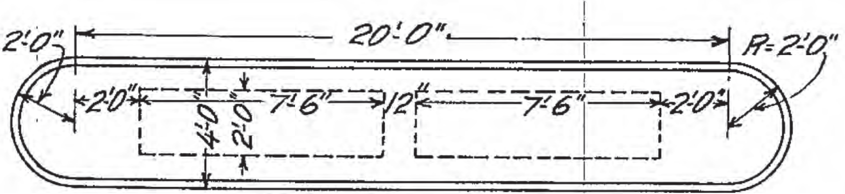
GATE



SECTION THRU SLUICEWAY

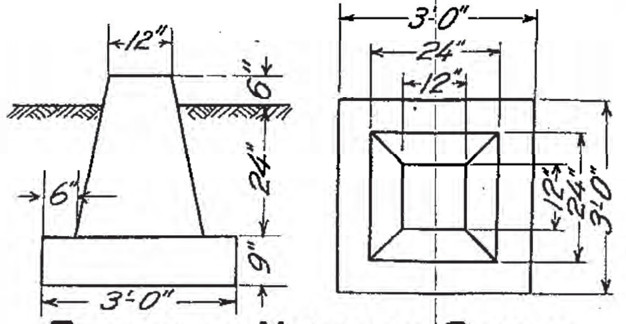


SIDE ELEVATION OF PIER WITH SECTION OF WEIR



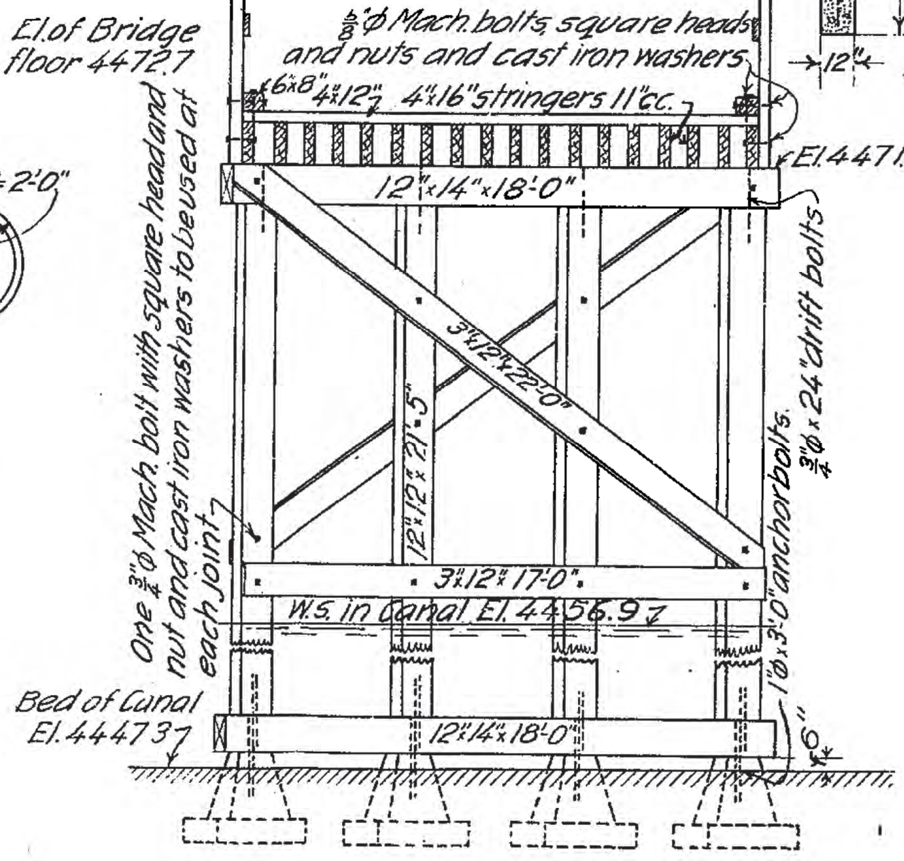
TOP VIEW OF PIER.

SECTIONAL
…ION OF PIER



PIER FOR HIGHWAY BRIDGE

SCALE OF FEET
1 0 1 2 3 4 5



ELEVATION OF HIGHWAY BRIDGE BENT

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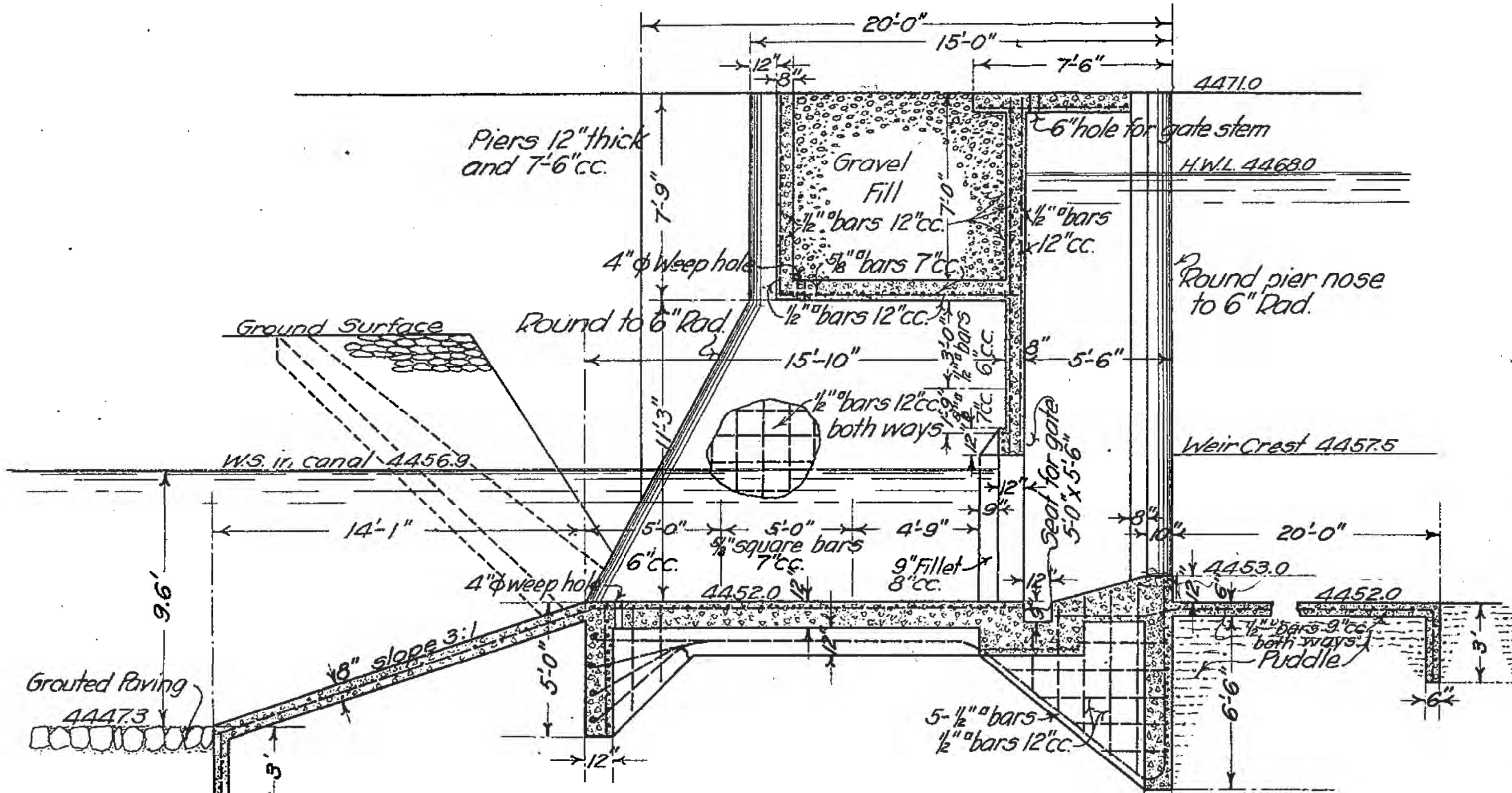
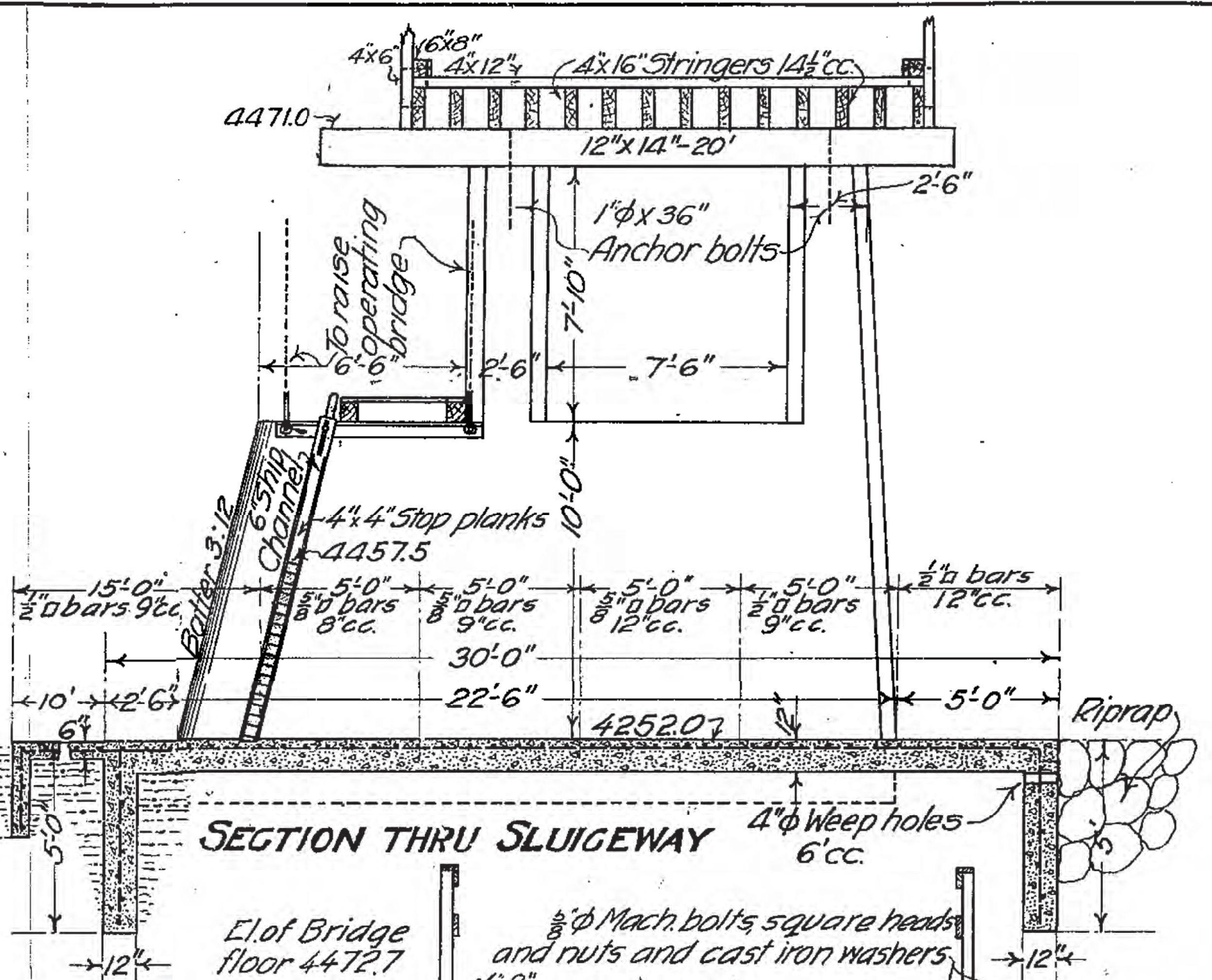
UNITED STATES RECLAMATION SERVICE
F. H. NEWELL DIRECTOR A. P. DAVIS, CHIEF ENGINEER
MILK RIVER PROJECT MONTANA
ST. MARY STORAGE UNIT
ST. MARY CANAL
EARTHWORK AND STRUCTURES

ST. MARY DIVERSION AND HEADWORKS

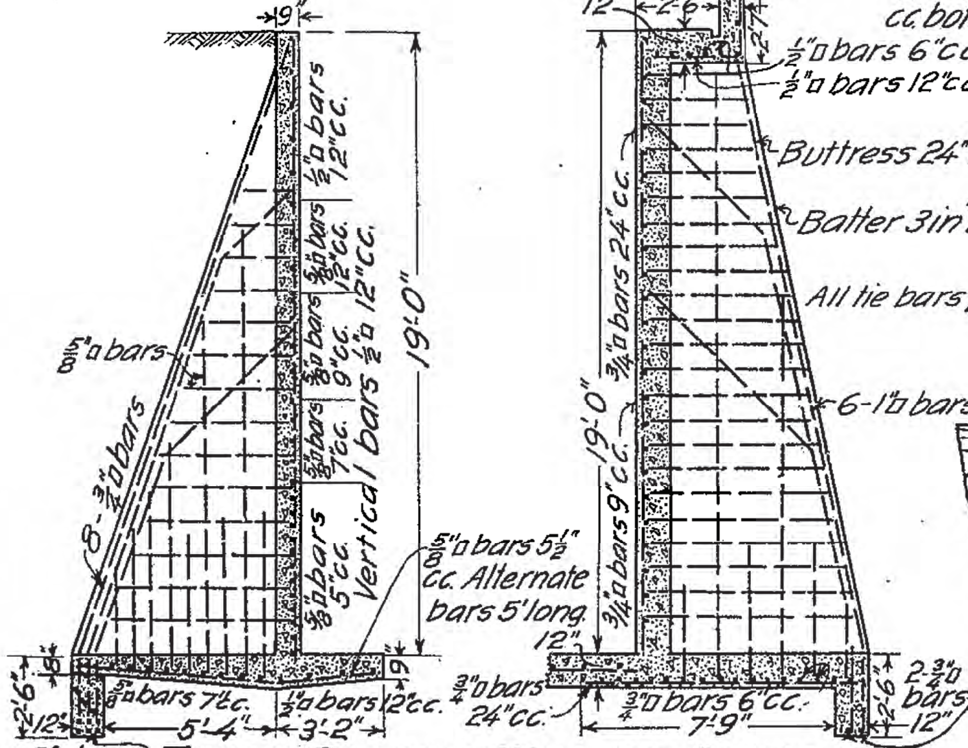
DETAIL SECTIONS
SPECIFICATIONS NO. 255
H. N. SAVAGE SUPERVISING ENGINEER JOSEPH WRIGHT CONSTRUCTION ENGINEER
ACCESSION NO. 15066 DRAWING NO. 6 OF 34
JANUARY 1914



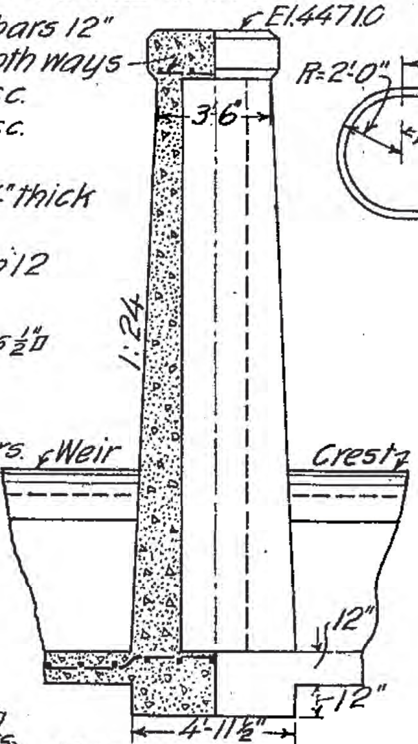
SECTION THROUGH HEADGATE



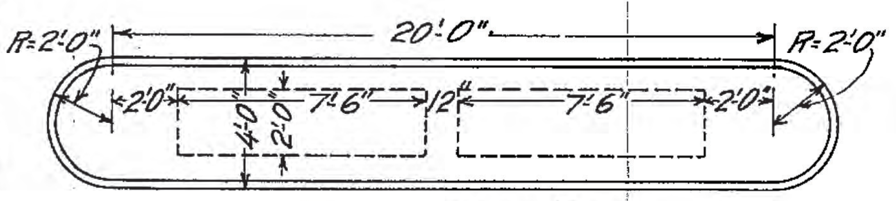
SECTION THRU SLUICEWAY



TYPICAL SECTIONS, WALL AND ABUTMENT

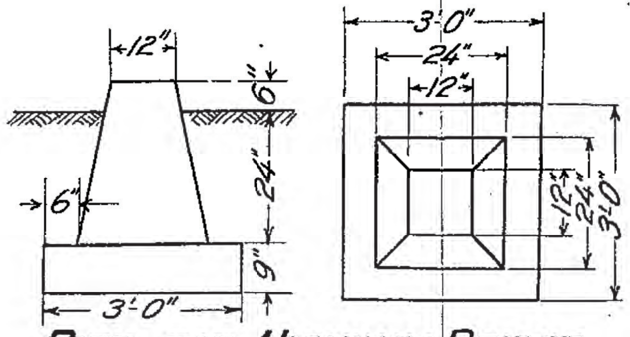


HALF SECTIONAL ELEVATION OF PIER



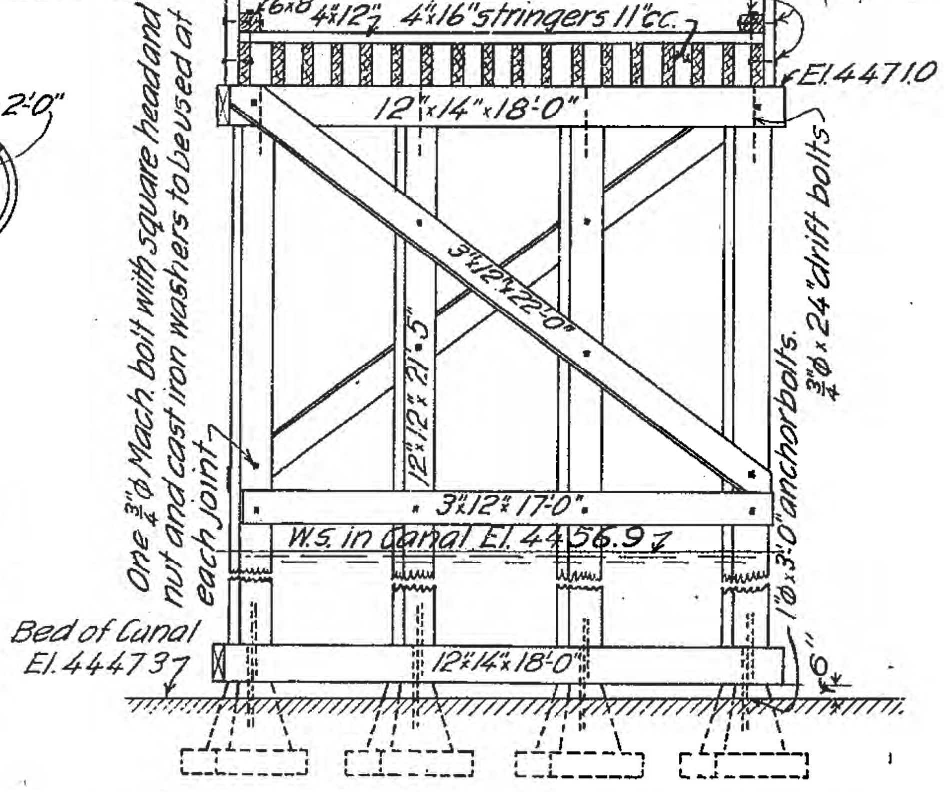
TOP VIEW OF PIER.

FOR INFORMATION ONLY

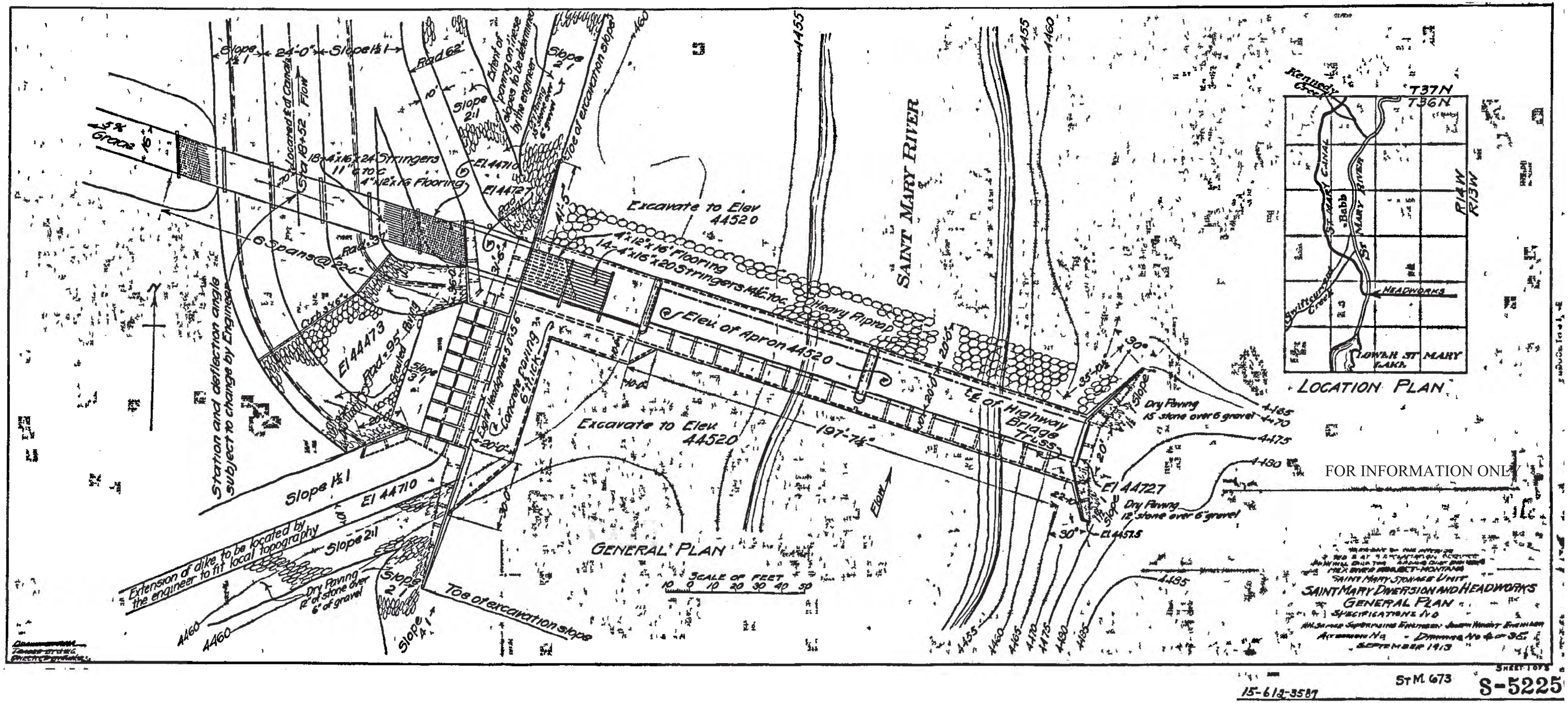


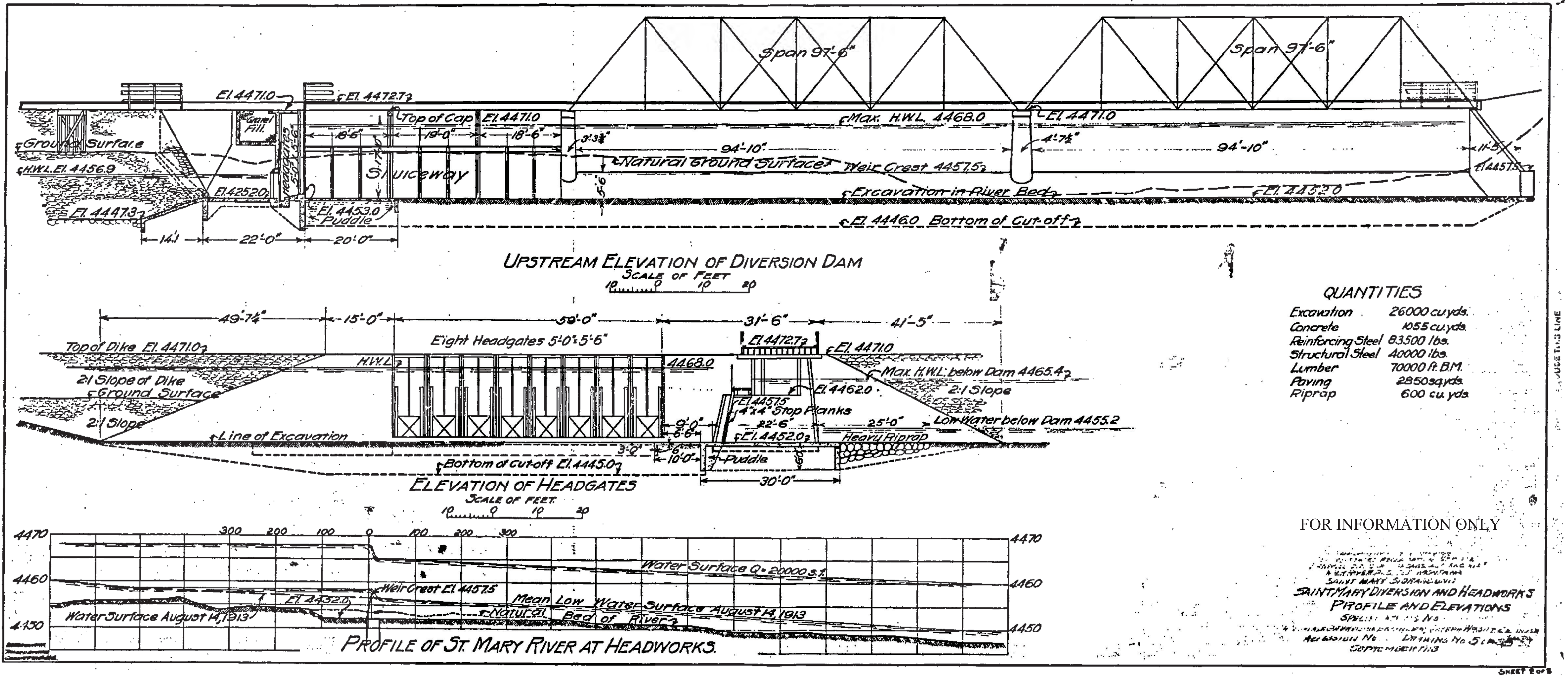
PIER FOR HIGHWAY BRIDGE

SCALE OF FEET
1 0 1 2 3 4 5



ELEVATION OF HIGHWAY BRIDGE BENT


Slope 1½:1
24'-0"
Slope 1½:1
Flow
Located ℄ of Canal Sta 18+52
Rad 62'
Extent of paving on these slopes to be determined by the engineer
Slope 2:1
Slope 2:1
Toe of excavation slope
4460
4455
4455
4460
3% Grade
18-4"x16"x24' Stringers 11" c to c
4"x12"x16' Flooring
El 44710
El 44727
Excavate to Elev 4452.0
4"x12"x16' Flooring
14-4"x16"x20' Stringers 14½" c to c
Heavy Riprap
SAINT MARY RIVER
6 Spans @ 22'-0"
N
Elev of Apron 4452.0
Station and deflection angle subject to change by Engineer
El 44473
Rad 95'
Grouted Paving
Slope 3:1
Eight Headgates 5'0"x5'6"
Concrete paving 6" thick
Excavate to Elev 4452.0
197'-7¼"
℄ of Highway Bridge Truss
Dry Paving 15 stone over 6 gravel
4465
4470
4475
4480
El 44727
Dry Paving 12" stone over 6" gravel
El 4457.5
30°
Slope 1½:1
El 44710
Extension of dike to be located by the engineer to fit local topography
Slope 2:1
Dry Paving 12" of stone over 6" of gravel
Slope 2:1
Slope 4:1
Toe of excavation slope
Flow
GENERAL PLAN
SCALE OF FEET
10 0 10 20 30 40 50
4485
4455
4460
4465
4470
4475
4480
4485
Kennedy Creek
T37N
T36N
St Mary Canal
Babb
St Mary River
R14W
R13W
Swiftcurrent Creek
HEADWORKS
LOWER ST MARY LAKE
LOCATION PLAN
MILK RIVER PROJECT-MONTANA
SAINT MARY STORAGE UNIT
SAINT MARY DIVERSION AND HEADWORKS
GENERAL PLAN
SPECIFICATIONS NO
SEPTEMBER 1913
SHEET 1 OF 3
ST M 673
15-612-3587
S-5225



QUANTITIES

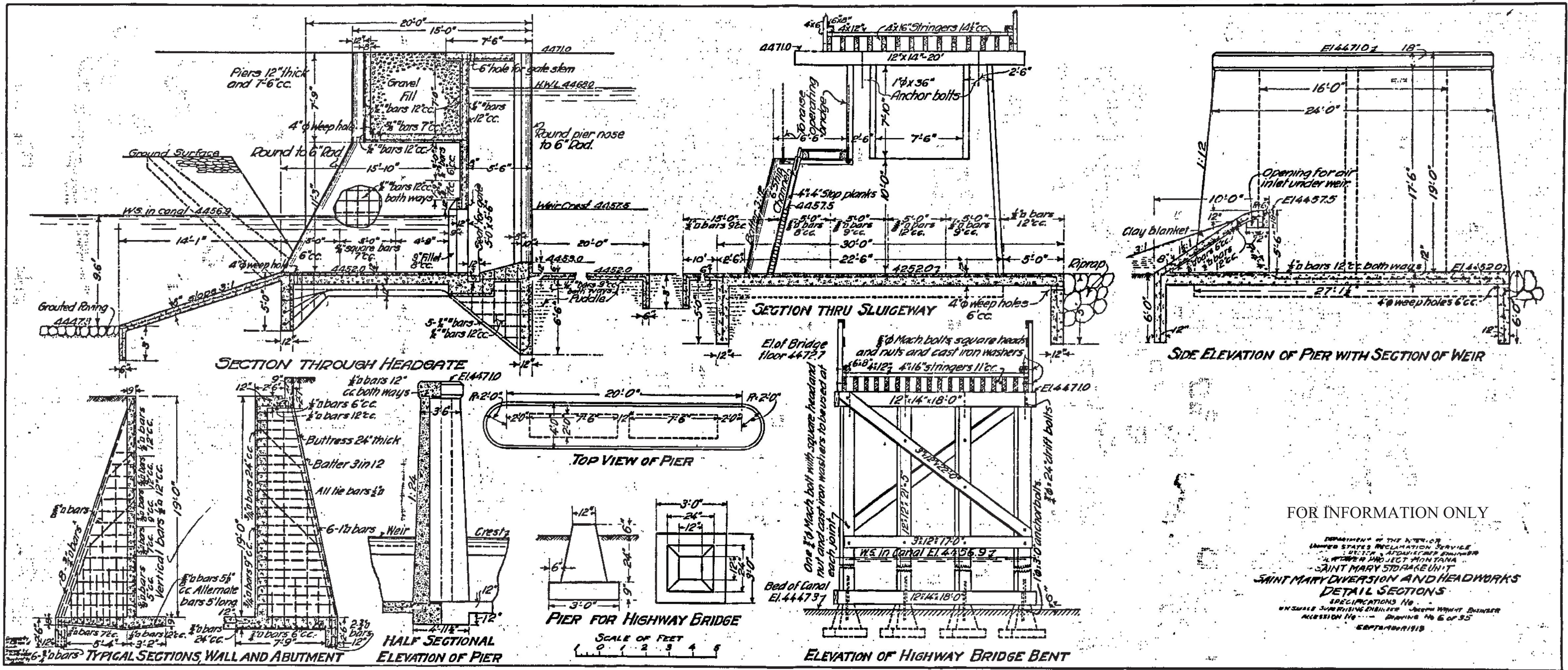
Excavation	26000 cu. yds.
Concrete	1055 cu. yds.
Reinforcing Steel	83500 lbs.
Structural Steel	40000 lbs.
Lumber	70000 ft. B.M.
Paving	2850 sq. yds.
Riprap	600 cu. yds.

FOR INFORMATION ONLY

15-612-5587

St. M. 673

S-5225



FOR INFORMATION ONLY

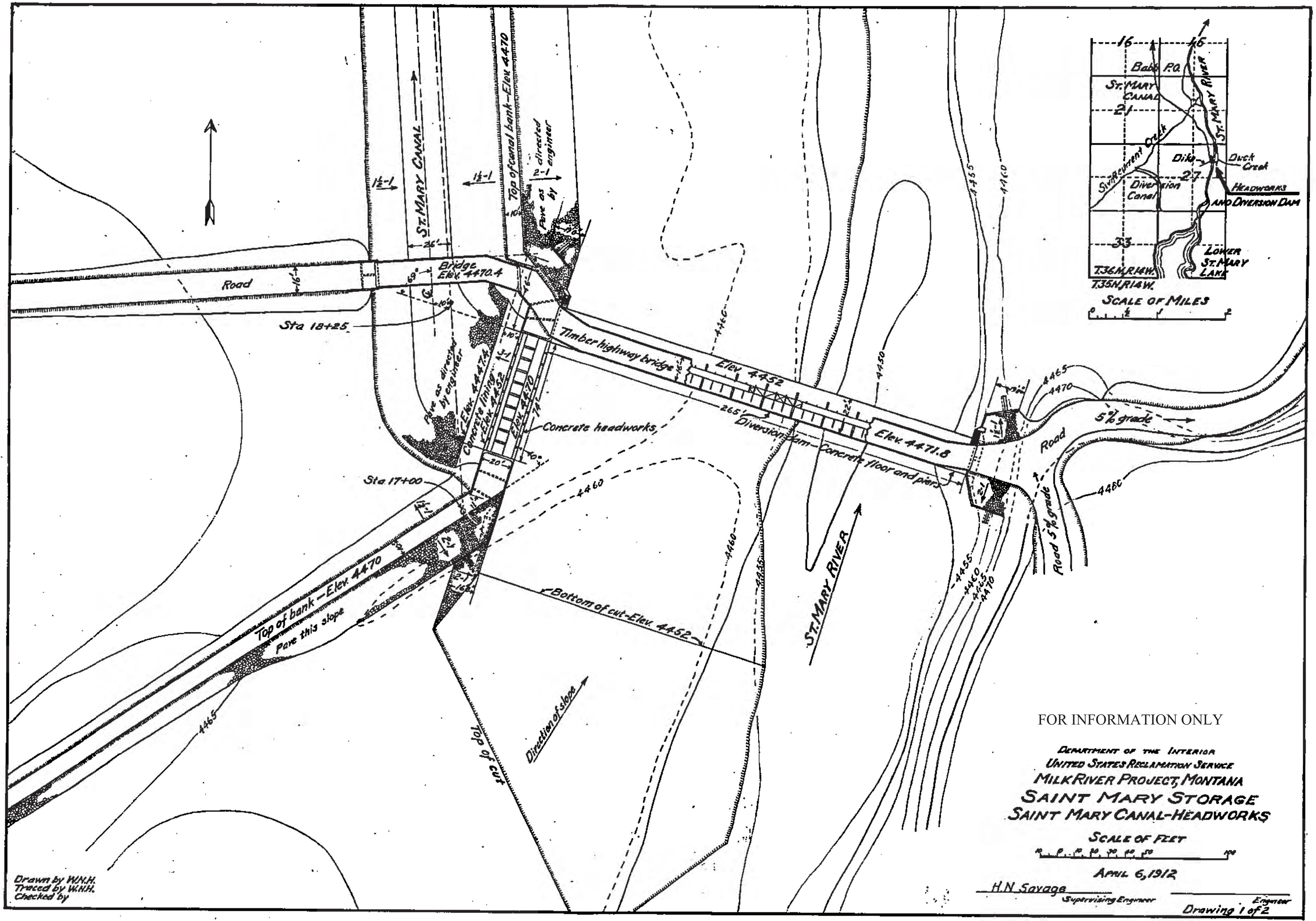
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
DIRECTOR, A.P. DAVIS CHIEF ENGINEER
MILK RIVER PROJECT MONTANA
SAINT MARY STORAGE UNIT
SAINT MARY DIVERSION AND HEADWORKS
DETAIL SECTIONS
SPECIFICATIONS No.
H.N. SAVAGE SUPERVISING ENGINEER JOSEPH WRIGHT ENGINEER
ACCESSION No. — DRAWING No 6 of 35
SEPTEMBER 1913

SHEET 3 OF

15-612-3587

St. M. 673

S-5225



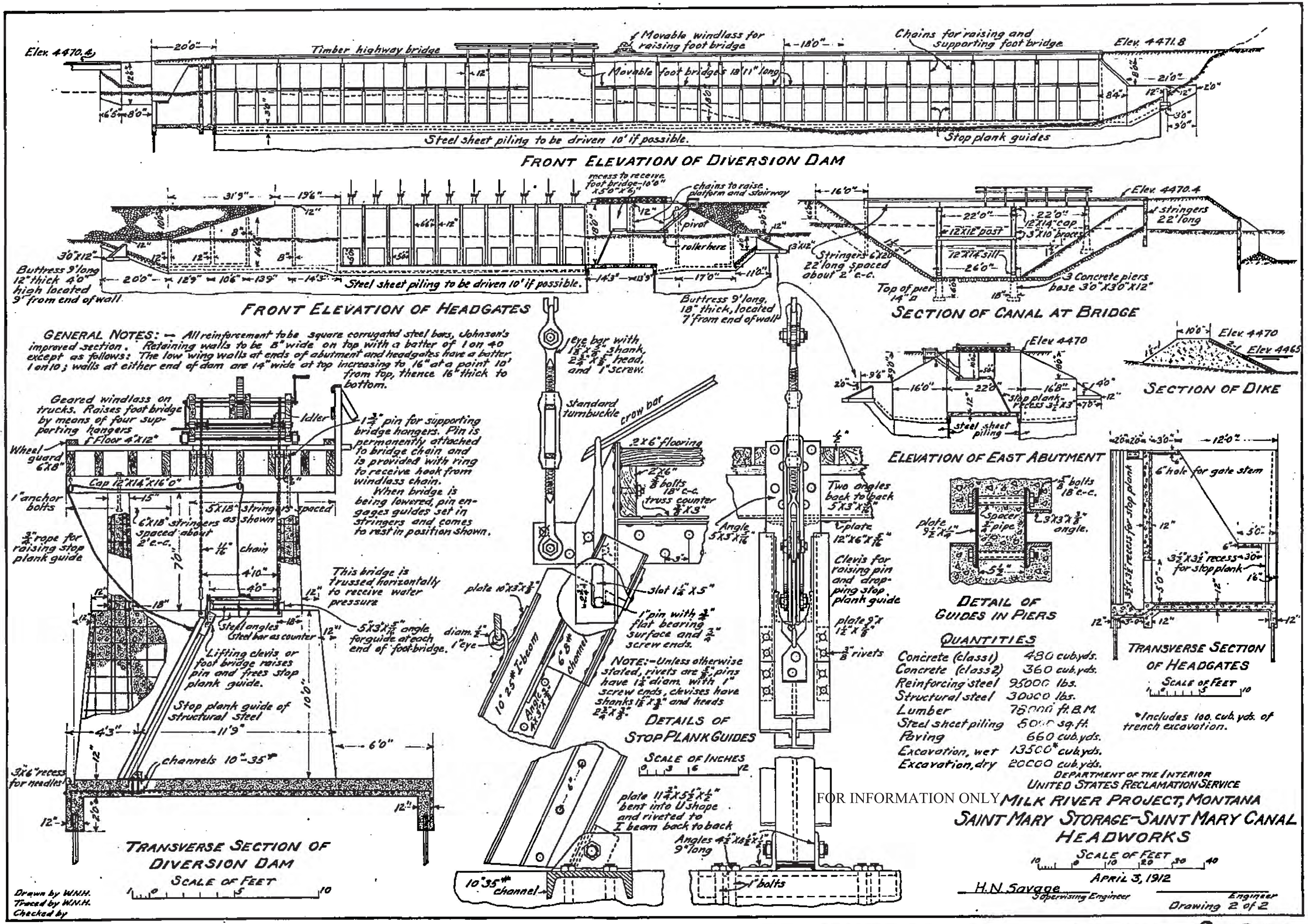
FOR INFORMATION ONLY

Department of the Interior
United States Reclamation Service
Milk River Project, Montana
Saint Mary Storage
Saint Mary Canal-Headworks
Scale of Feet
10 0 10 20 30 40 50 100
April 6, 1912
H.N. Savage
Supervising Engineer
Engineer
Drawing 1 of 2

15-612-3488
Sheet 1

ST.M-493

S-3986



GENERAL NOTES: — All reinforcement to be square corrugated steel bars, Johnson's improved section. Retaining walls to be 8" wide on top with a batter of 1 on 40 except as follows: The low wing walls at ends of abutment and headgates have a batter 1 on 10; walls at either end of dam are 14" wide at top increasing to 16" at a point 10' from top, thence 16" thick to bottom.

NOTE:— Unless otherwise stated, rivets are ⅝", pins have 1¼" diam. with 1" screw ends, clevises have shanks 1⅝"x⅜" and heads 2¾"x⅜".

QUANTITIES

Concrete (class 1)	480 cub.yds.
Concrete (class 2)	360 cub.yds.
Reinforcing steel	95000 lbs.
Structural steel	30000 lbs.
Lumber	78000 ft. B.M.
Steel sheet piling	6000 sq.ft.
Paving	660 cub.yds.
Excavation, wet	13500* cub.yds.
Excavation, dry	20000 cub.yds.

*Includes 100. cub. yds. of trench excavation.

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
MILK RIVER PROJECT, MONTANA
SAINT MARY STORAGE—SAINT MARY CANAL
HEADWORKS
SCALE OF FEET
APRIL 3, 1912
H. N. Savage
Supervising Engineer
Engineer
Drawing 2 of 2

Drawn by W.N.H.
Traced by W.N.H.
Checked by

15-612-3488 Sheet 2 ST.M-493 S-3986

Appendix D – Geologic Logs

GEOLOGIC LOG OF DRILL HOLE NO. DH-22-02

SHEET 1 OF 4

FEATURE: St. Mary's Diversion Dam
LOCATION: St. Mary's River
BEGUN: 5/1/22 FINISHED: 5/13/22
DEPTH AND ELEVATION OF WATER
LEVEL AND DATE MEASURED: 17.1 ft. (4467.1) 5/13/2022

PROJECT: Milk River
COORDINATES: N 52,607.5 E 26,237.0
TOTAL DEPTH: 85.4
DEPTH TO BEDROCK: N/A

STATE: Montana
GROUND ELEVATION: 4484.2 ft.
ANGLE FROM HORIZONTAL: 90
HOLE LOGGED BY: E.Hammers
REVIEWED BY: C.Clark

NOTES

LOCATION:
Peninsula between St. Mary River and St. Mary Canal, approximately 600 ft. north from the NW corner of the diversion structure.

PURPOSE OF HOLE:
To collect geotechnical and hydrologic data regarding the proposed diversion dam replacement.

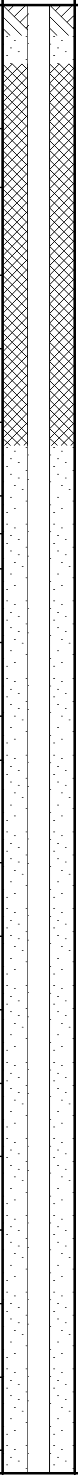
DRILLING EQUIPMENT:
Truck mounted CME-85 drill (Blue).
6.25" ID, 9.625" OD Hollow Stem Augers (HSA) with 10.50" OD carbide bullet bit.
5.38" ID, 6" OD split spoon core barrel, 5.13" ID, 6" OD core barrel shoe on hex rods.
6.25" OD Pilot Bit (PB) on hex rods.
CME automatic hammer with 2' long by 1.5" ID, 2" OD SPT barrel with 1.375" ID SPT shoe on NWJ rods.

DRILLER:
Cody Kelly (USBR)

DRILLING METHODS:
0.0 to 6.2 ft. - Advanced borehole with 6.25" ID HSA with a split sample barrel and hex rods per ASTM D6151.
6.2 to 9.2 ft. - Advanced borehole with 6.25" ID HSA with a pilot bit and hex rods per ASTM D6151.
9.2 to 18.0 ft. - Advanced borehole with 6.25" ID HSA with a split sample barrel and hex rods per ASTM D6151.
18.0 to 19.2 ft. - Advanced borehole with 6.25" ID HSA with a pilot bit and hex rods per ASTM D6151.
19.2 to 65.7 ft. - Advanced borehole with 6.25" ID HSA with a split sample barrel and hex rods per ASTM D6151.
65.7 to 67.2 ft. - Advanced borehole with 6.25" ID HSA with a pilot bit and hex rods per ASTM D6151.
67.2 to 69.6 ft. - Advanced borehole with 6.25" ID HSA with a split sample barrel and hex rods per ASTM D6151.
69.6 to 72.5 ft. - Advanced borehole with 6.25" ID HSA with a pilot bit and hex rods per ASTM D6151.
72.5 to 76.1 ft. - Advanced borehole with 6.25" ID HSA with a split sample barrel and hex rods per ASTM D6151.
76.1 to 83.9 ft. - Advanced borehole with 6.25" ID HSA with a pilot bit and hex rods per ASTM D6151.
82.4 to 83.9 ft. - 2" OD SPT barrel on NWJ rods was driven to gather samples.

DEPTH	GEOL. UNIT SYM.	USCS VISUAL CLASSIFICATION	% CORE RECOVERY
	fill	(GM)sc	60
5			25
			0
10	Qal	(GP-GM)sc	100
			80
15			100
			92
			0
20			68
			52
25			67
			29
30		(SP)gc	92
			72
35		(GM)sc	100
			76
		SM	
40		(GC)sc	100
			80
		CL	
45		(GP-GC)sc	88
		SC	
		(GP-GC)sc	92
		(GP)s	100

HOLE COMPLETION



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 9.2 ft.
Fill (fill):

0.0 to 9.2 ft. Silty Gravel with Sand and Cobbles (GM)sc: Approximately 55% fine to coarse, angular to subrounded, soft to hard gravel; approximately 25% fine to coarse, angular to subrounded sand; approximately 20% nonplastic to medium plasticity fines, with medium dry strength, slow dilatancy, medium toughness; firm; brown; moist; max size 4" recovered; 5% hard, subrounded cobbles by volume; Hit cobble/boulder at 6.2 ft., pilot bit to 9.2 ft..

0.0 to 6.2 ft. Lab Test Data: 10% fines, 27% sand, 63% gravel, LL=25.5, PI=6.4, Total MC=4.4%, Lab Classification = Well-graded Gravel with Clay and Sand (GW-GC)s.

0.0 to 85.4 ft.
Quaternary Alluvium (Qal):

9.2 to 29.2 ft. Poorly-graded Gravel with Silt, Sand, and Cobbles (GP-GM)sc: Approximately 45% to 50% fine to coarse, angular to subrounded, hard gravel; approximately 40% to 45% fine to coarse, subangular to subrounded sand; approximately 10% nonplastic fines, with low dry strength, rapid dilatancy, and low toughness; firm to loose; brown; moist, wet at 21.2 ft., saturated to 29.2 ft.; max size 4" recovered; trace to 30%, 3-5" subrounded, moderately soft to hard, cobbles by volume; hit cobble/boulder at 18.0 ft., pilot bit to 19.3 ft..

11.7 to 16.7 ft. Lab Test Data: 7% fines, 31% sand, 62% gravel, LL=NP, PI=NP, Total MC=1.2%, Lab Classification = Poorly-graded Gravel with Silt and Sand (GP-GM)s.

21.2 to 29.2 ft. Lab Test Data: 7% fines, 37% sand, 56% gravel, LL=NP, PI=NP, Total MC=7.9%, Lab Classification = Poorly-graded Gravel with Silt and Sand (GP-GM)s.

29.2 to 33.8 ft. Poorly-graded Sand with Gravel and Cobbles (SP)gc: Approximately 80% fine to coarse, angular to subangular, hard sand; approximately 20% fine to medium, subangular to subrounded, hard gravel; trace of nonplastic fines; brown, wet, ranges from firm and compact to soft and loose; Max size 3" recovered; approximately 10% 3-5" subrounded, hard cobbles by volume.

29.2 to 30.2 ft. Lab Test Data: 12% fines, 77% sand, 13% gravel, LL=NP, PI=NP, Total MC=19.7%, Lab Classification = Silty Sand (SM).

33.8 to 39.2 ft. Silty Gravel with Sand and Cobbles (GM)sc: Approximately 45% nonplastic to medium plasticity fines with low dry strength, rapid dilatancy, and low toughness; approximately 40% fine to coarse, hard to soft, angular to subrounded gravel; approximately 35% fine to coarse sand; brown; heterogenous mix of hard to soft, with high percentage of decomposed gravels of variable composition with a clayey and sandy matrix; wet; max size 4" recovered; approximately 5% 3-5", hard subrounded cobbles by volume.

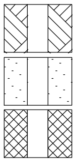
33.8 to 36.7 ft. Lab Test Data: 19% fines, 27% sand, 36% gravel, 18% cobbles, LL=19.4, PI=3.3, Total MC=8.6%, Lab Classification = Silty Gravel with Sand (GM)s.

39.2 to 40.1 ft. Silty Sand (SM): Approximately 80% fine to medium sand; approximately 20% non-plastic fines with low dry strength, rapid dilatancy, and low toughness; trace of medium hard, subrounded gravel; very soft; brown; wet; max size 2" recovered; trace of 3-5" hard, subrounded cobbles.

39.2 to 40.1 ft. Lab Test Data: 36% fines, 50% sand, 14% gravel, LL=NP, PI=NP, Total MC=18.9%, Lab Classification = Silty Sand (SM).

COMMENTS:

All depths and water levels are in feet below ground surface unless otherwise noted.
Heading water level measurement is after well development according to ASTM D5521.
Finished date is the day of well development.
ID = inner diameter LL = Liquid Limit
OD = outer diameter PL = Plastic Limit
NR = no recovery MC = Moisture Content
Coordinates are LOCAL (GROUND) (U.S. SURVEY FEET), Elevation is NAVD 88 (U.S. SURVEY FEET).



Cement Seal: 1 pipe group, 1 pipe
Filter Pack: 1 pipe group, 1 pipe
Bentonite seal with 1 pipe

GEOLOGIC LOG OF DRILL HOLE NO. DH-22-02

FEATURE: St. Mary's Diversion Dam
LOCATION: St. Mary's River
BEGUN: 5/1/22 FINISHED: 5/13/22
DEPTH AND ELEVATION OF WATER
LEVEL AND DATE MEASURED: 17.1 ft. (4467.1) 5/13/2022

PROJECT: Milk River
COORDINATES: N 52,607.5 E 26,237.0
TOTAL DEPTH: 85.4
DEPTH TO BEDROCK: N/A

STATE: Montana
GROUND ELEVATION: 4484.2 ft.
ANGLE FROM HORIZONTAL: 90
HOLE LOGGED BY: E.Hammers
REVIEWED BY: C.Clark

NOTES

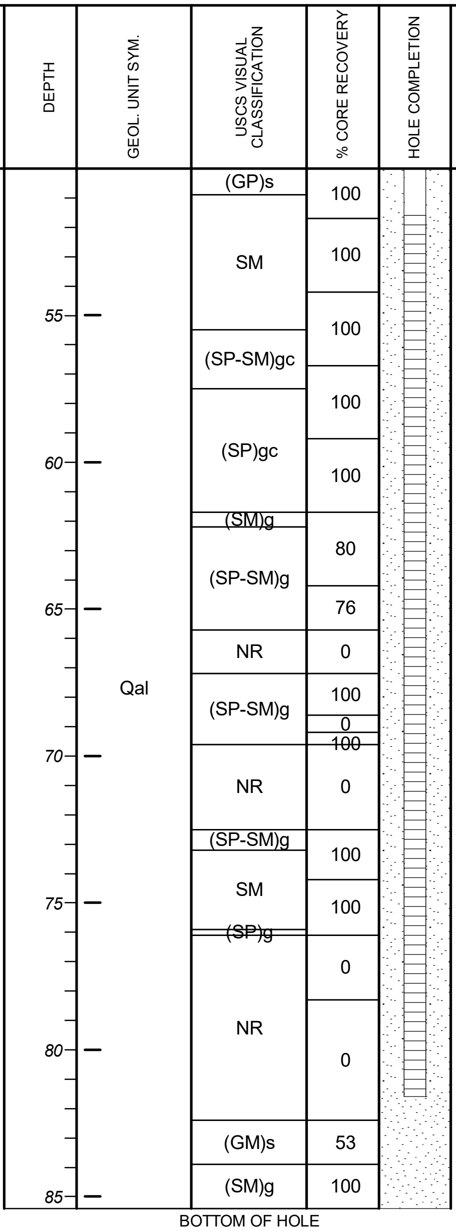
83.9 to 85.4 ft. - 2" OD SPT barrel on NWJ rods was driven to gather samples.

DRILLING FLUID:
0.0 to 85.4 ft. - no water added

HOLE COMPLETION:
85.4 to 15.0 ft. - Placed 40, 50lb sacks 8x12 filter sand.
81.6 to 51.6 ft. - Placed 30' long by 2" ID, schedule 40 PVC 0.030 screen.
51.6 to 3.0 ft. above ground - Placed 2" ID schedule 40 PVC riser pipe.
15.0 to 2.0 ft. - placed 18 - 50lb sacks of 3/8" bentonite chips.
2.0 to 0.0 ft. - Backfilled with 8X12 sand and cobbles for standpipe drainage.
1.0 to 3.0 ft. above ground- concreted in place a 6" x 48" protective steel casing with locking cap.

WELL DEVELOPMENT:
5/13/2020 - Water level before development = 17.1' below ground surface.
Dual line airlift until turbitity measured less than 15 NTU.

DRILLING CONDITIONS AND DRILLERS COMMENTS:
5/12/2022 - Hole advancement halted due to drill bit wearing out.



CLASSIFICATION AND PHYSICAL CONDITION

40.1 to 44.2 ft. Clayey Gravel with Sand and Cobbles (GC)sc: Approximately 65% fine to coarse, soft, angular to subrounded gravel; approximately 20% fine to coarse, predominantly angular sand; approximately 15% medium plasticity fines with medium dry strength; slow dilatancy, and medium toughness; brown; hard to soft; wet; max size 3.5" recovered; approximately 5% hard subangular to angular cobbles by volume.

42.0 to 44.0 ft. Lab Test Data: 14% fines, 27% sand, 59% gravel, LL=NP, PI=NP, Total MC=7.3%, Lab Classification = Silty Gravel with Sand (GM)s.

44.2 to 45.2 ft. Lean Clay (CL): Approximately 95% fines medium plasticity, medium toughness, medium dry strength, and no dilatancy; approximately 5% fine-med sand, subangular to subrounded, sand; light brown, very soft, wet, weak reaction with HCl.

44.2 to 45.2 ft. Lab Test Data: 94% fines, 6% sand, 0% gravel, LL=22.7, PI=2.1, Total MC=41.2%, Lab Classification = Silt (ML).

45.2 to 46.7 ft. Poorly-graded Gravel with Clay, Silt, Sand , and Cobles (GP-GC)sc: Approximately 70% fine to coarse, hard, subangular to subrounded, predominantly flat gravel; approximately 20% fine to coarse, subangular to subrounded, hard sand; approximately 10% medium plasticity fines with medium toughness, medium dry strength, and no dilatancy; light brown, red, green, cream/yellow; wet; weak reaction with HCL; max size 5" recovered; trace subangular to subrounded, hard cobbles by volume.

46.7 to 47.2 ft. Clayey Sand (SC): Approximately 85% fine to medium, subangular to subrounded sand; approximately 15% medium plasticity fines, with medium toughness, medium dry strength, and no dilatancy; light brown; very soft; wet; weak reaction with HCl.

47.2 to 49.2 ft. Poorly-graded Gravel with Clay, Silt, Sand , and Cobles (GP-GC)sc: Approximately 70% fine to coarse, hard, subangular to subrounded, predominantly flat gravel; approximately 20% fine to coarse, subangular to subrounded, hard sand; approximately 10% medium plasticity fines with medium toughness, medium dry strength, and no dilatancy; light brown, red, green, cream/yellow; wet; weak reaction with HCL; max size 5" recovered; trace subangular to subrounded, hard cobbles by volume.

46.7 to 49.7 ft. Lab Test Data: 14% fines, 34% sand, 38% gravel,14% cobbles LL=NP, PI=NP, Total MC=8.6%, Lab Classification = Silty Gravel with Sand (GM)s.

49.2 to 50.9 ft. Poorly-graded Gravel with Sand (GP)s: Approximately 50% fine to coarse, hard, subangular to subrounded, predominantly flat gravel; approximately 45% fine to coarse, subangular to subrounded, hard sand; approximately 5% low plasticity fines with low toughness, low dry strength, and slow dilatancy; light brown, wet; weak reaction with HCl; max size 3" recovered.

50.9 to 55.5 ft. Silty Sand (SM): Approximately 85% fine to medium, predominantly fine, subangular to subrounded, hard sand; approximately 15% nonplastic fines, with low toughness, low dry strength, medium dilatancy; light brown; wet; weak reaction with HCl.

50.9 to 51.7 ft. Lab Test Data: 27% fines, 73% sand, trace gravel, LL=NP, PI=NP, Total MC=19.0%, Lab Classification = Silty Sand (SM).

55.5 to 57.5 ft. Poorly-graded Sand with Silt, Gravel, and Cobbles (SP-SM)gc: Approximately 60% fine to coarse, predominantly fine, subangular to subrounded, hard sand; approximately 30% fine to coarse, subangular to subrounded, hard gravel; approximately 10% nonplastic fines, with low toughness, low dry strength, and rapid dilatancy; light brown; wet; weak reaction with HCl; max size 5" recovered; approximately 5% subangular to subrounded, hard cobbles by volume.

55.5 to 46.7 ft. Lab Test Data: 18% fines, 28% sand, 31% gravel, 23% cobbles, LL=NP, PI=NP, Total MC=9.3%, Lab Classification = Silty Sand with Gravel (SM)g.

GEOLOGIC LOG OF DRILL HOLE NO. DH-22-02

SHEET 3 OF 4

FEATURE: St. Mary's Diversion Dam
LOCATION: St. Mary's River
BEGUN: 5/1/22 FINISHED: 5/13/22
DEPTH AND ELEVATION OF WATER
LEVEL AND DATE MEASURED: 17.1 ft. (4467.1) 5/13/2022

PROJECT: Milk River
COORDINATES: N 52,607.5 E 26,237.0
TOTAL DEPTH: 85.4
DEPTH TO BEDROCK: N/A

STATE: Montana
GROUND ELEVATION: 4484.2 ft.
ANGLE FROM HORIZONTAL: 90
HOLE LOGGED BY: E.Hammers
REVIEWED BY: C.Clark

NOTES	DEPTH	GEOL. UNIT SYM.	USCS VISUAL CLASSIFICATION	% CORE RECOVERY	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION

57.5 to 61.7 ft. **Poorly-graded Sand with Gravel and Cobbles (SP)gc:** Approximately 55% fine to coarse, predominantly medium, subangular to subrounded, hard sand; approximately 40% fine to coarse, subangular to subrounded, hard gravel; approximately 5% nonplastic fines, with low toughness, low dry strength, and rapid dilatancy; light brown; wet; weak reaction with HCl; max size 5.5" recovered; approximately 15% subangular to subrounded, hard cobbles by volume.

61.7 to 62.2 ft. **Silty Sand with Gravel (SM)g:** Approximately 70% fine to coarse, predominantly coarse, subangular to subrounded, hard sand; approximately 15% subangular to subrounded, hard gravel, approximately 15% nonplastic fines, with low toughness, low dry strength, and rapid dilatancy; light brown; wet; weak reaction with HCl; max size 2" recovered.

61.7 to 62.2 ft. **Lab Test Data:** 13% fines, 40% sand, 47% gravel, LL=NP, PI=NP, Total MC=10.6%, Lab Classification = Silty Gravel with Sand (GM)s.

62.2 to 65.7 ft. **Poorly-graded Sand with Silt and Gravel (SP-SM)g:** Approximately 70% fine to coarse, predominantly medium, subangular to subrounded, hard sand; approximately 20% subangular to subrounded, hard gravel; approximately 10% nonplastic fines, with low toughness, low dry strength, and slow dilatancy; light brown to grayish brown; wet; weak reaction with HCl; max size 6" recovered; approximately trace subangular to subrounded hard cobbles by volume.

62.2 to 64.2 ft. **Lab Test Data:** 19% fines, 64% sand, 45% gravel, LL=NP, PI=NP, Total MC=9.5%, Lab Classification = Silty Sand with Gravel (SM)g.

65.7 to 67.2 ft. **pilot bit:** No recovery.

67.2 to 69.6 ft. **Poorly-graded Sand with Silt and Gravel (SP-SM)g:** Approximately 70% fine to coarse, predominantly medium, subangular to subrounded, hard sand; approximately 20% subangular to subrounded, hard gravel; approximately 10% nonplastic fines, with low toughness, low dry strength, and slow dilatancy; light brown to grayish brown; wet; weak reaction with HCl; max size 3" recovered.

69.6 to 72.5 ft. **pilot bit:** No recovery.

72.5 to 73.2 ft. **Poorly-graded Sand with Silt and Gravel (SP-SM)g:** Approximately 70% fine to coarse, predominantly medium, subangular to subrounded, hard sand; approximately 20% subangular to subrounded, hard gravel; approximately 10% nonplastic fines, with low toughness, low dry strength, and slow dilatancy; light brown to grayish brown; wet; weak reaction with HCl; max size 3" recovered.

73.2 to 75.9 ft. **Silty Sand (SM):** Approximately 80% fine to coarse, predominantly fine, subangular to subrounded, hard sand; 15% nonplastic fines, with low toughness, low dry strength, and rapid dilatancy; approximately 5% subangular to subrounded, hard gravel; gray-brown; lenses containing green sand giving mottled appearance; moist; weak reaction with HCl; max size 3" recovered.

73.2 to 74.2 ft. **Lab Test Data:** 29% fines, 56% sand, 15% gravel, LL=NP, PI=NP, Total MC=13.8%, Lab Classification = Silty Sand with Gravel (SM)g.

75.9 to 76.1 ft. **Poorly-graded Sand with Gravel (SP)g:**Approximately 50% fine to coarse, predominantly medium, subangular to subrounded, hard sand; approximately 45% fine to coarse, subangular to subrounded, hard gravel; approximately 5% nonplastic fines, with low toughness, low dry strength, and rapid dilatancy, gray-brown; moist; weak reaction with HCl; max size 3" recovered.

76.1 to 82.4 ft. **pilot bit:** No recovery.

82.4 to 83.9 ft. **Silty Gravel with Sand (GM)s:** Approximately 40% subangular to subrounded, hard gravel; approximately 20% fine to coarse, predominantly medium, subangular to subrounded, hard sand; approximately 20% nonplastic fines, with low toughness, low dry strength, and slow dilatancy; gray-brown; moist; weak reaction with HCl; max size ½" recovered.

GEOLOGIC LOG OF DRILL HOLE NO. DH-22-02

FEATURE: St. Mary's Diversion Dam
LOCATION: St. Mary's River
BEGUN: 5/1/22 FINISHED: 5/13/22
DEPTH AND ELEVATION OF WATER
LEVEL AND DATE MEASURED: 17.1 ft. (4467.1) 5/13/2022

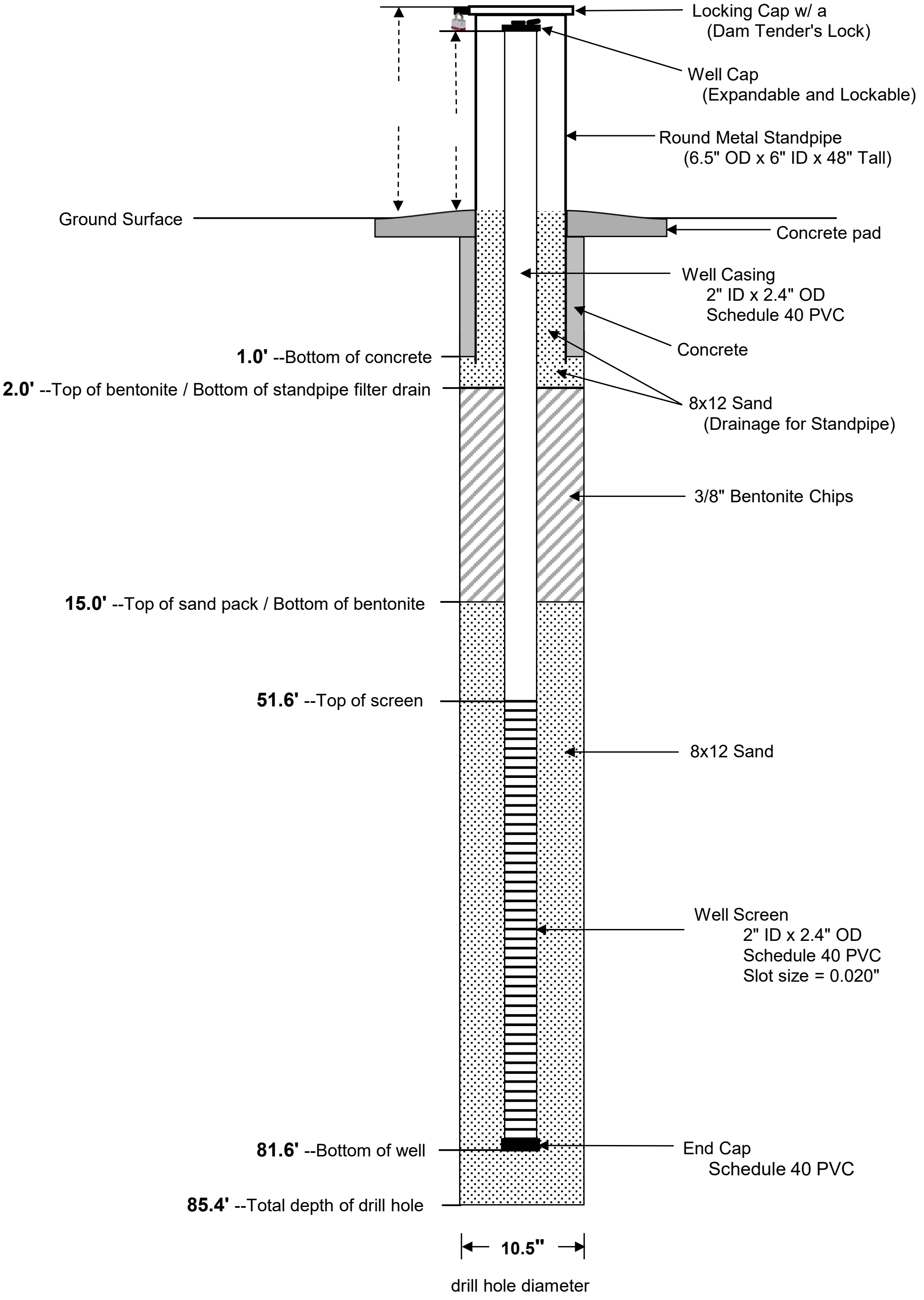
PROJECT: Milk River
COORDINATES: N 52,607.5 E 26,237.0
TOTAL DEPTH: 85.4
DEPTH TO BEDROCK: N/A

STATE: Montana
GROUND ELEVATION: 4484.2 ft.
ANGLE FROM HORIZONTAL: 90
HOLE LOGGED BY: E.Hammers
REVIEWED BY: C.Clark

NOTES	DEPTH	GEOL. UNIT SYM.	USCS VISUAL CLASSIFICATION	% CORE RECOVERY	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
						83.9 to 85.4 ft. Silty Sand with Gravel (SM)g: Approximately 50% fine to coarse; predominantly medium, subangular to subrounded, hard sand; approximately 30% subangular to subrounded, hard gravel; approximately 20% nonplastic fines, with low toughness, low dry strength, and rapid dilatancy; gray-brown; moist; weak reaction with HCl, max size 1.5" recovered.

PIEZOMETER COMPLETION DIAGRAM

DRILL HOLE: DH-22-02	GEOLOGIST: Cody Clark and Eric Hammers
DATE COMPLETED: 05/13/2022	DRILLER: Cody Kelly
LOCATION: St. Mary's Diversion Dam, MT	HELPERS: Pete Shawver and Ryan Dedeker
T.O.C. ELEVATION:	
G.S. ELEVATION:	



***NOT TO SCALE**

NOTES:

T.O.C. = Top of (PVC) well casing	ID = inside diameter
G.S. = Ground surface	OD = outside diameter

GEOLOGIC LOG OF DRILL HOLE NO. PW-22-1

FEATURE: St. Mary's Diversion Dam
LOCATION: St. Mary's River
BEGUN: 3/31/22 FINISHED: 4/5/22
DEPTH AND ELEVATION OF WATER
LEVEL AND DATE MEASURED: 13.1 ft. (4465.5) 5/3/2022

PROJECT: Milk River
COORDINATES: N 51,924.6 E 26,078.0
TOTAL DEPTH: 84.5
DEPTH TO BEDROCK: N/A

STATE: Montana
GROUND ELEVATION: 4478.6 ft.
ANGLE FROM HORIZONTAL: 90
HOLE LOGGED BY: S.Joramo
REVIEWED BY: C.Clark

NOTES

LOCATION:
Approximately 105 ft. southwest of the SW corner of the diversion structure on the south side of the access road.

PURPOSE OF HOLE:
To collect geotechnical and hydrologic data regarding the proposed diversion dam replacement.

DRILLING EQUIPMENT:
Truck mounted Atlas Copco T2W-III rotary drill.
12.0" ODEX Down the Hole Hammer.
12.75" OD Schedule 40 Weld Down Casing.

DRILLER:
Cody Kelly (USBR)

DRILLING METHODS:
0.0 to 84.5 ft. - Advanced borehole with 12.0" ODEX Down the Hole Hammer 12.75" OD Schedule 40 Weld Down Casing.

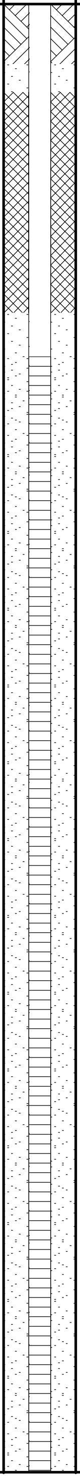
DRILLING FLUID:
0.0 to 84.5 ft. - no water added, drilled with air.

HOLE COMPLETION:
84.5 to 67.0 ft. - Placed 5 - 50lb buckets of 3/8" Pel Plug bentonite pellets and 22, 50lb sacks of 3/8" bentonite chips.
67.0 to 10.5 ft. - Placed 17, 50lb sacks 8x12 filter sand.
64.3 to 12.0 ft. - Placed 52.3' long by 10" ID, 304 Wire Wrapped Stainless Steel 0.020 weld together screen with bottom cap.
12.0 to 3.0 ft. above ground - Placed 10" ID schedule 40 flush thread PVC riser pipe.
10.5 to 3.0 ft. - placed 3 - 50lb sacks of 3/8" bentonite chips.
3.0 to 2.0 ft. - Placed 2 - 50lb sack of 8x12 filter sand for standpipe drainage.
2.0 to 3.0 ft. above ground- concreted in place with 3 - 50lb sacks a 12" schedule 40 steel standpipe with locking cap.

WELL DEVELOPMENT:
4/05/2020 - Water level before development = 12.3' below ground surface.
Dual line airlift until turbitity measured less than 15 NTU.

DRILLING CONDITIONS AND DRILLERS COMMENTS:
None

DEPTH	GEOL. UNIT SYM.	USCS VISUAL CLASSIFICATION	% CORE RECOVERY	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
					0.0 to 84.5 ft. **Quaternary Alluvium (Qal):** **0.0 to 84.5 ft.** **<u>ODEX Down the Hole Hammer:</u>** No Recovery
5					
10					
15					
20					
25	Qal	NR	0		
30					
35					
40					
45					



COMMENTS:

All depths and water levels are in feet below ground surface unless otherwise noted.
Heading water level measurement is after well development according to ASTM D5521.
Finished date is the day of well development.
ID = inner diameter LL = Liquid Limit
OD = outer diameter PL = Plastic Limit
NR = no recovery MC = Moisture Content
Coordinates are LOCAL (GROUND) (U.S. SURVEY FEET), Elevation is NAVD 88 (U.S. SURVEY FEET).

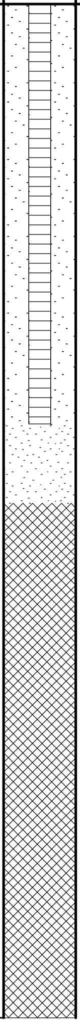
▧ Cement Seal: 1 pipe group, 1 pipe
⁚ Filter Pack: 1 pipe group, 1 pipe
▩ Bentonite seal with 1 pipe

GEOLOGIC LOG OF DRILL HOLE NO. PW-22-1

FEATURE: St. Mary's Diversion Dam
LOCATION: St. Mary's River
BEGUN: 3/31/22 FINISHED: 4/5/22
DEPTH AND ELEVATION OF WATER
LEVEL AND DATE MEASURED: 13.1 ft. (4465.5) 5/3/2022

PROJECT: Milk River
COORDINATES: N 51,924.6 E 26,078.0
TOTAL DEPTH: 84.5
DEPTH TO BEDROCK: N/A

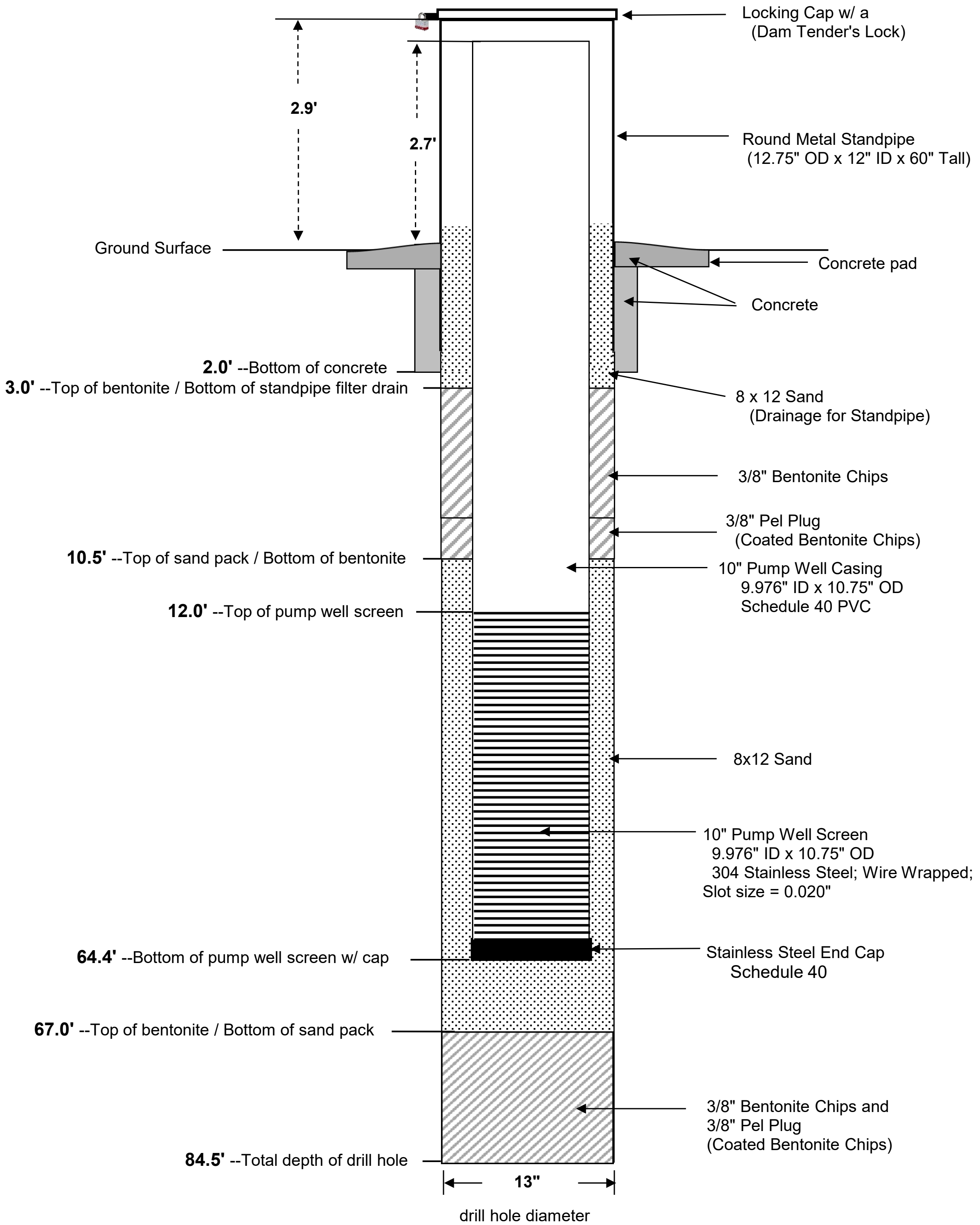
STATE: Montana
GROUND ELEVATION: 4478.6 ft.
ANGLE FROM HORIZONTAL: 90
HOLE LOGGED BY: S.Joramo
REVIEWED BY: C.Clark

NOTES	DEPTH	GEOL. UNIT SYM.	USCS VISUAL CLASSIFICATION	% CORE RECOVERY	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
	55 60 65 70 75 80	Qal	NR	0		

BOTTOM OF HOLE

PUMP WELL COMPLETION DIAGRAM

DRILL HOLE: PW-22-01	GEOLOGIST: Seth Joramo
DATE COMPLETED: 04/06/2022	DRILLER: Cody Kelly
LOCATION: St. Mary's Diversion Dam, MT	HELPERS: Pete Shawver, Ryan Dedecker
T.O.C. ELEVATION:	
G.S. ELEVATION:	



***NOT TO SCALE**

NOTES:

T.O.C. = Top of (PVC) well casing
G.S. = Ground surface
ID = inside diameter
OD = outside diameter

GEOLOGIC LOG OF DRILL HOLE NO. PW-22-1A

FEATURE: St. Mary's Diversion Dam
LOCATION: St. Mary's River
BEGUN: 4/15/22 FINISHED: 4/18/22
DEPTH AND ELEVATION OF WATER
LEVEL AND DATE MEASURED: 12.0 ft. (4466.6) 5/3/2022

PROJECT: Milk River
COORDINATES: N 51,933.4 E 26,075.3
TOTAL DEPTH: 80.0
DEPTH TO BEDROCK: N/A

STATE: Montana
GROUND ELEVATION: 4478.6 ft.
ANGLE FROM HORIZONTAL: 90
HOLE LOGGED BY: A.Brusak
REVIEWED BY: C.Clark

NOTES

LOCATION:
Approximately 10 feet northeast of pump well PW-22-1

PURPOSE OF HOLE:
To collect geotechnical and hydrologic data regarding the proposed diversion dam replacement.

DRILLING EQUIPMENT:
Gus Pech GP-3000 CHR drill rig equipped with a Sonic Core drill head.
7.0" ID Sonic Core Barrel.
8.0" ID Casing and a Carbide Rockbit.

DRILLER:
Braden Samuels (USBR)

DRILLING METHODS:
0.0 to 80.0 ft. - Advanced borehole with 7.0" ID Sonic core barrel, 8.0" ID casing and a carbide bit.

DRILLING FLUID:
0.0 to 80.0 ft. - no water added

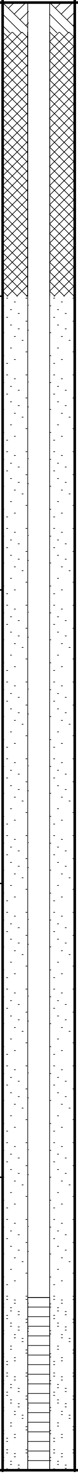
HOLE COMPLETION:
80.0 to 58.0 ft. - 50lb sacks of 3/8" bentonite chips.
58.0 to 10.0 ft. - Placed 31, 50lb sacks #8 filter sand.
54.1 to 44.1 ft. - Placed 10' long by 2" ID, schedule 40 PVC 0.020 screen.
44.1 to 2.8 ft. above ground - Placed 2" ID schedule 40 PVC riser pipe.
10.0 to 1.0 ft. - 50lb sacks of 3/8" bentonite chips.
1.0 to 3.0 ft. above ground- concreted in place with 2-50lb sacks of concrete, a square protective steel casing with locking cap.

WELL DEVELOPMENT:
4/15/2020 - Water level before development = 12.9' below ground surface.
Dual line airlift until turbitity measured less than 15 NTU.

DRILLING CONDITIONS AND DRILLERS COMMENTS:
59.0 ft. - 18.0 ft. of sand heave.

DEPTH	GEOL. UNIT SYM.	USCS VISUAL CLASSIFICATION	% CORE RECOVERY
5		(GP)s	71
10			
15			60
20		(GP-GC)s	
25	Qal		80
30			
		CL	
35		(SP)g	80
		s(CL)g	
40			
		(GC)s	
45			90
		(SC)g	

HOLE COMPLETION



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 84.5 ft.
Quaternary Alluvium (Qal):

0.0 to 9.0 ft. <u>Poorly-Graded Gravel with Sand (GP)s:</u> Approximately 50% to 60% fine to medium, subrounded, hard gravel; approximately 30% to 35% fine to coarse, subrounded sand; Approximately 5% medium plasticity fines with low dry strength, rapid dilatancy, and low toughness; approximately 5% to 10% hard cobbles; light brown; moist; no reaction to HCl.

3.5 to 6.5 ft. <u>Lab Test Data:</u> 6% fines, 19% sand, 75% gravel, LL=20.9, PI=17.2, Total MC=1.8%, Lab Classification = Well-graded Gravel with Clay and Sand (GW-GC)s.

9.0 to 29.7 ft. <u>Poorly-Graded Gravel with Clay and Sand (GP-GC)s:</u> Approximately 50% fine to medium, subrounded, hard gravel; approximately 40% fine to coarse, subrounded sand; Approximately 10% high plasticity fines with medium to high dry strength, slow dilatancy, and high toughness; light brown; wet; no reaction to HCl.

11.5 to 19.0 ft. <u>Lab Test Data:</u> 9% fines, 37% sand, 54% gravel, LL=NP, PI=NP, Total MC=2.1%, Lab Classification = Well-graded Gravel with Silt and Sand (GW-GM)s.

26.0 to 29.0 ft. <u>Lab Test Data:</u> 9% fines, 37% sand, 54% gravel, LL=23.4, PI=7.8, Total MC=7.3%, Lab Classification = Well-graded Gravel with Clay and Sand (GW-GC)s.

29.7 to 33.3 ft. <u>Lean Clay (CL):</u> Approximately 100% medium plasticity fines with high dry strength, no dilatancy, and medium toughness; gray; wet; no reaction to HCl.

30.5 to 33.3 ft. <u>Lab Test Data:</u> 89% fines, 11% sand, trace gravel, LL=26.0, PI=17.0, Total MC=25.8%, Lab Classification = Lean Clay (CL).

33.3 to 37.7 ft. <u>Poorly-Graded Sand with Gravel (SP)g:</u> approximately 70% fine to coarse, subrounded sand; Approximately 30% medium to coarse, subrounded, hard gravel; light brown; wet; no reaction to HCl

37.2 to 37.4 ft. Interbed of Lean Clay (CL): Approximately 100% medium plasticity fines with high dry strength, no dilatancy, and medium toughness; gray; wet; no reaction to HCl.

33.5 to 37.4 ft. <u>Lab Test Data:</u> 16% fines, 70% sand, 14% gravel, LL=NP, PI=NP, Total MC=12.0%, Lab Classification = Silty Sand (SM).

37.7 to 39.0 ft. <u>Sandy Lean Clay with Gravel s(CL)g:</u> Approximately 60% medium plasticity fines with medium dry strength, slow dilatancy, and medium toughness; approximately 40% coarse, subangular sand; Approximately 15% medium to coarse, subrounded, hard gravel; gray to light brown; wet; no reaction to HCl.

39.0 to 49.0 ft. <u>Clayey Gravel with Sand (GC)s:</u> Approximately 40% fine to medium, subrounded, hard gravel; Approximately 35% medium plasticity fines with medium dry strength, slow dilatancy, and medium toughness; approximately 25% fine, subrounded sand; light brown; wet; no reaction to HCl.

42.0 to 45.0 ft. <u>Lab Test Data:</u> 20% fines, 30% sand, 50% gravel, LL=19.4, PI=4.4, Total MC=6.8%, Lab Classification = Silty Clayey Gravel with Sand (GC-GM)s.

49.0 to 59.0 ft. <u>Clayey Sand with Gravel (SC)g:</u> Approximately 40% medium to fine, subrounded sand; approximately 30% fine to coarse, subrounded, hard gravel; approximately 30% medium plasticity fines with medium dry strength, slow dilatancy, and medium toughness; light brown; wet; no reaction to HCl.

COMMENTS:

All depths and water levels are in feet below ground surface unless otherwise noted.
Heading water level measurement is after well development according to ASTM D5521.
Finished date is the day of well development.
ID = inner diameter LL = Liquid Limit
OD = outer diameter PL = Plastic Limit
NR = no recovery MC = Moisture Content
Coordinates are LOCAL (GROUND) (U.S. SURVEY FEET), Elevation is NAVD 88 (U.S. SURVEY FEET).

▧	Cement Seal: 1 pipe group, 1 pipe
▩	Bentonite seal with 1 pipe
⁙	Filter Pack: 1 pipe group, 1 pipe

GEOLOGIC LOG OF DRILL HOLE NO. PW-22-1A

SHEET 2 OF 2

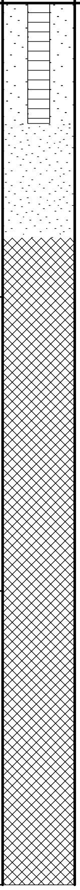
FEATURE: St. Mary's Diversion Dam
LOCATION: St. Mary's River
BEGUN: 4/15/22 FINISHED: 4/18/22
DEPTH AND ELEVATION OF WATER
LEVEL AND DATE MEASURED: 12.0 ft. (4466.6) 5/3/2022

PROJECT: Milk River
COORDINATES: N 51,933.4 E 26,075.3
TOTAL DEPTH: 80.0
DEPTH TO BEDROCK: N/A

STATE: Montana
GROUND ELEVATION: 4478.6 ft.
ANGLE FROM HORIZONTAL: 90
HOLE LOGGED BY: A.Brusak
REVIEWED BY: C.Clark

NOTES	DEPTH	GEOL. UNIT SYM.	USCS VISUAL CLASSIFICATION	% CORE RECOVERY	HOLE COMPLETION
	55		(SC)g	20	
	60				
	65	Qal	(ML)s	92	
	70				
	75		(SC)g	72	
			(GC)s		
			SM		
	80				

BOTTOM OF HOLE



CLASSIFICATION AND PHYSICAL CONDITION

51.0 to 51.2 ft. Lab Test Data: 19% fines, 50% sand, 31% gravel, LL=24.0, PI=8.1, Total MC=9.0%, Lab Classification = Clayey Sand with Gravel (SC)g.

54.0 to 59.0 ft. Lab Test Data: 80% fines, 20% sand, 0% gravel, LL=20.5, PI=2.2, Total MC=22.2%, Lab Classification = Silt with Sand (ML)s.

59.0 to 72.0 ft. Silt with Sand (ML)s: Approximately 85% nonplastic fines with low dry strength, medium dilatancy, and low toughness; Approximately 15% medium to fine, subrounded sand; gray; moist; no reaction to HCl.

62.0 to 65.0 ft. Lab Test Data: 91% fines, 9% sand, 0% gravel, LL=20.7, PI=1.8, Total MC=22.5%, Lab Classification = Silt (ML).

72.0 to 76.0 ft. Clayey Sand with Gravel (SC)g: Approximately 40% medium to fine, subrounded sand; approximately 40% fine to coarse, subrounded, hard gravel; approximately 20% medium plasticity fines with medium dry strength, slow dilatancy, and medium toughness; light brown; wet; no reaction to HCl.

72.0 to 76.0 ft. Lab Test Data: 25% fines, 49% sand, 26% gravel, LL=21.0, PI=6.4, Total MC=10%, Lab Classification = Silty Clayey Sand with Gravel (SC-SM)g.

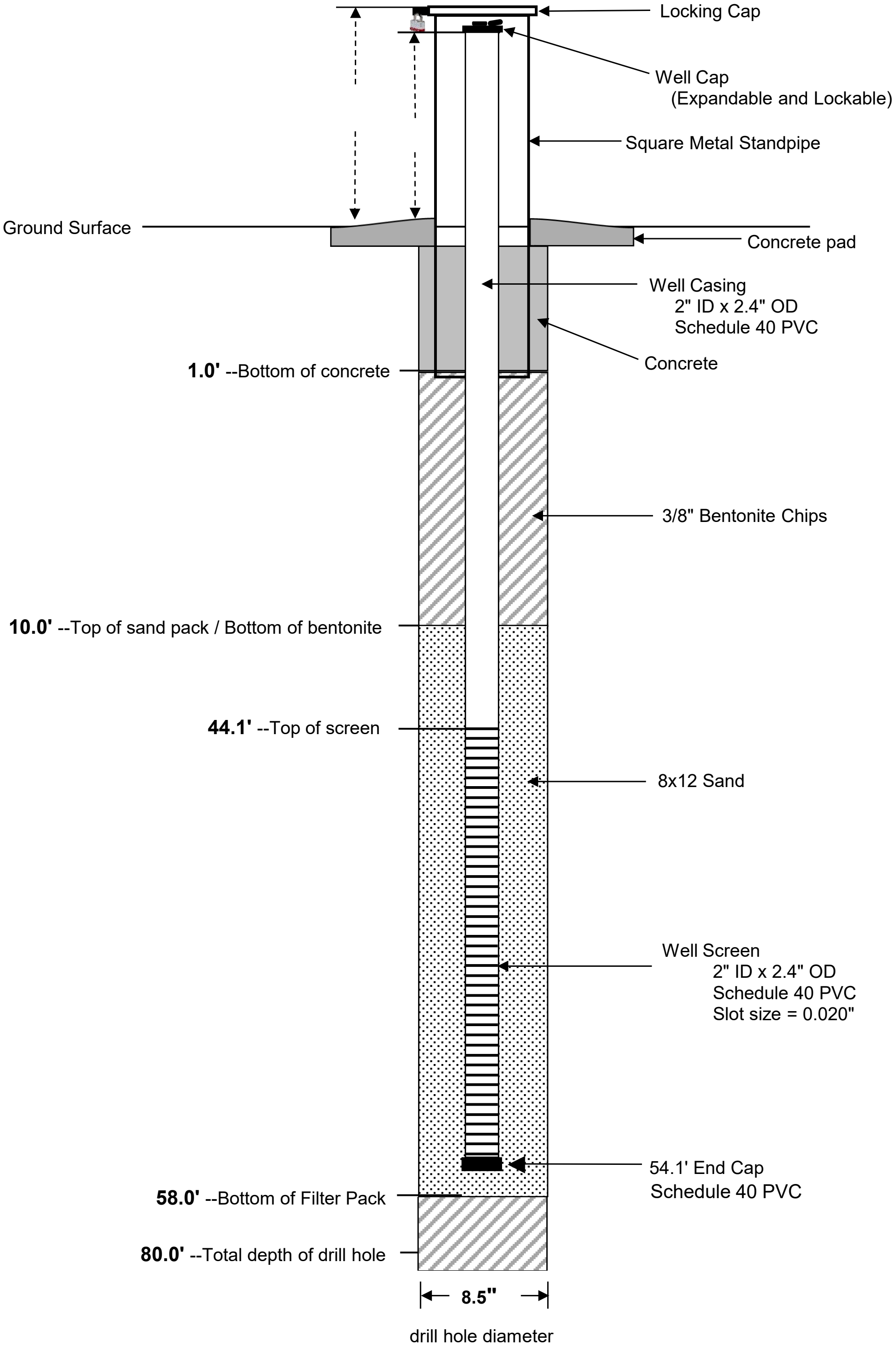
76.0 to 78.0 ft. Clayey Gravel with Sand (GC)s: Approximately 40% fine to medium, subrounded, hard gravel; Approximately 40% medium plasticity fines with medium dry strength, slow dilatancy, and medium toughness; approximately 20% fine, subrounded sand; light brown; wet; no reaction to HCl.

76.0 to 78.0 ft. Lab Test Data: 32% fines, 30% sand, 38% gravel, LL=18.1, PI=4.0, Total MC=7.1%, Lab Classification = Silty Clayey Gravel with Sand (GC-GM)s.

78.0 to 80.0 ft. Silty Sand (SM): Approximately 85% fine, subrounded sand; Approximately 15% nonplastic fines with low dry strength, rapid dilatancy, and low toughness; light brown; wet; no reaction to HCl.

PIEZOMETER COMPLETION DIAGRAM

DRILL HOLE: PW-22-1A	GEOLOGIST: Cody Clark and Eric Hammers
DATE COMPLETED: 04/18/2022	DRILLER: Braden Samuels
LOCATION: St. Mary's Diversion Dam, MT	
T.O.C. ELEVATION: 4481.43	
G.S. ELEVATION: 4478.6 ft.	



***NOT TO SCALE**

NOTES:

T.O.C. = Top of (PVC) well casing	ID = inside diameter
G.S. = Ground surface	OD = outside diameter

GEOLOGIC LOG OF DRILL HOLE NO. PW-15-1

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 8/13/15 FINISHED: 8/20/15
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 13.1 (4467.9) 09/22/2015

PROJECT: Milk River
COORDINATES: N 1,701,480.0 E 102,785.0
TOTAL DEPTH: 38.5
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.0 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: S. Rafferty
REVIEWED BY: C. Sullivan

NOTES

LOCATION:
Left bank of St. Mary River along the St. Mary Canal embankment, about 165 ft from the NW corner of the diversion structure

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Install a pump well to do testing on permeability of foundation materials

DRILLING EQUIPMENT:
Truck mounted Atlas-Copco T3W, with 12-inch-steel casing and 10-?-inch rock bit

DRILLING METHODS:
0.0 to 23.0 drive 12" steel casing and center rock bit.
23.0 to 33.0 drive 12" steel casing and center rock bit, and foam for cleanout.
33.0 to 48.0 drive 12" steel casing, cleanout with center bit to 36.5
48.0 to 38.0 pulled back casing to cleanout drill string.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper
B. Sammons, helper

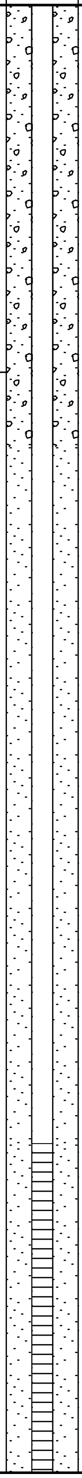
DRILLING COMMENTS:
Trouble starting rig, replaced o-rings and cleaned out foot petal.
Replaced discharge hose, replaced switch on air compressor

WATER LEVELS:
Date/ hole depth/ water level
08-17-15, 23.0, 15.2 (4465.8)
09-22-15, 38.0, 13.1 (4467.9)

HOLE COMPLETION:
38.0 - 35.5 filter sand below pump well screen
35.5 - 15.5 installed 90 wire-316 stainless steel-pump well screen - 20 ft long by 6-inch O.D.
15.5 to +2.4 above ground surface - 6-inch O.D. blank PVC riser pipe
35.5 - 6.0 filter sand around screen and blank PVC riser pipe
6.0 - 0.0 cement filled with 8-inch steel sandpipe for protection.

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.
	(GP)scb		emb fill
5			
	(GP)sc		
10		c bit	
			Qal
15			
	(GP)sc		
	(SM)c		

HOLE COMPLETION



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 5.0 ft. Embankment Fill:

0.0 to 8.0 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: about 65-70% coarse to fine, hard, angular to subrounded gravel; about 20-30% coarse to fine, hard, subrounded to rounded sand; about 5-10% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; dry, no cementation, overall light to medium brown with a large variety of colors in individual particles, no reaction with HCl.

Total sample (by volume): About 25-30% cobbles at 3-5 inches; 10-15% cobbles at 5-12 inches; 10% boulders; maximum size, 16 inches, determined by visual observations of surface exposure.

5.0 to 38.5 ft. Quaternary Alluvium:

5.0 to 14.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Gradations are estimated from auger cuttings in previous hole PW-13-A: about 65-70% coarse to fine, hard, angular to subrounded gravel; about 20-30% coarse to fine, hard, subangular to rounded sand, with some elongate shapes; about 5-10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 3 inches; dry, light to medium brown, no reaction with HCl.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; 10% cobbles at 5-12 inches; maximum size recovered, 6 inches, determined by visual observations of material returned outside the auger flights.

14.0 to 19.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Gradations are estimated from auger cuttings in previous hole PW-13-A: about 70% coarse to fine, hard, subangular to subrounded gravel with elongated and flat shapes present; about 25% coarse to fine, hard, angular to subangular sand, with some elongate shapes; about 5% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 2 inches; dry, light to medium brown, no reaction with HCl.

Total sample (by volume): About 5% cobbles at 3-5 inches; maximum size recovered, 5 inches.

19.0 to 20.0 ft. SILTY SAND WITH COBBLES (SM)c: Gradations are estimated from auger cuttings in previous hole PW-13-A: about 75% coarse to fine, hard, angular to subangular sand; about 5% fine, hard, subangular gravel; about 20% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 0.5 inch; wet, medium brown with a large variety of colors present in individual particles, no cementation, firm to hard consistency, no to weak reaction with HCl.

Total sample (by volume): About 5% cobbles at 3-5 inches; maximum size recovered, 5 inches.

20.0 to 24.0 ft. SILTY SAND (SM): Gradations are estimated from auger cuttings in previous hole PW-13-A: about 75% coarse to fine, hard, subangular to rounded sand; about 25% nonplastic fines with slow dilatancy; maximum size recovered, coarse sand; wet, light brown to gray, no cementation, firm consistency, heave occurred into sample barrel at this depth, no reaction with HCl.

24.0 to 25.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Gradations are estimated from auger cuttings in previous hole PW-13-A: about 50% coarse to fine, hard, subangular to subrounded gravel with elongated and flat shapes present; about 40% coarse to fine, hard, subangular to rounded sand; about 10% low

COMMENTS:

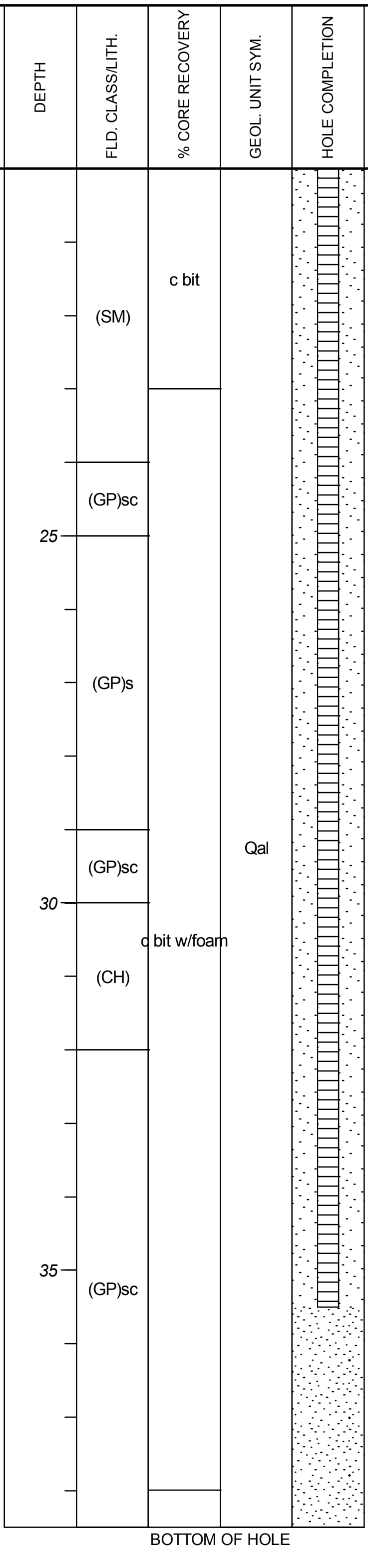
GEOLOGIC LOG OF DRILL HOLE NO. PW-15-1

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 8/13/15 FINISHED: 8/20/15
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 13.1 (4467.9) 09/22/2015

PROJECT: Milk River
COORDINATES: N 1,701,480.0 E 102,785.0
TOTAL DEPTH: 38.5
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.0 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: S. Rafferty
REVIEWED BY: C. Sullivan

NOTES



CLASSIFICATION AND PHYSICAL CONDITION

plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; wet, medium brown with a large variety of colors in individual particles; no to weak cementation; very soft to soft consistency; no to weak reaction with HCl.

Total sample (by volume): About 10% cobbles at 3-5 inches; maximum size, 5 inches, determined by rough drilling and visual observations of material returned outside the auger flights.

<u>25.0 to 29.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:</u> Gradations are estimated from auger cuttings in previous hole PW-13-A: about 50% coarse to fine, hard, subangular to subrounded gravel with elongate and flat shapes present; about 40% medium to fine, hard, angular to subangular sand; about 10% nonplastic fines; maximum size recovered, 2.5 inches; wet, dark gray to brown with a large variety of colors in individual particles; no to weak cementation; weak to strong reaction with HCl.

<u>29.0 to 30.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:</u> Gradations are estimated from auger cuttings in previous hole PW-13-A: about 60% coarse to fine, hard, subangular to subrounded gravel with elongated and flat shapes present; about 30% medium to fine, hard, angular to subangular sand; about 10% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; wet, medium brown with a large variety of colors in individual particles; no to weak cementation; weak reaction with HCl.

Total sample (by volume): About 5% cobbles at 3-5 inches; maximum size, 5 inches, determined by rough drilling and visual observations of material returned outside the auger flights.

<u>30.0 to 32.0 ft. FAT CLAY (CH):</u> Gradations are estimated from auger cuttings in previous hole PW-13-A: about 90% medium plasticity fines with medium to high dry strength, medium to high toughness, no dilatancy; about 10% predominately fine, hard, rounded sand; maximum size recovered, fine sand; wet, medium brown, firm consistency, weak reaction with HCl.

<u>32.0 to 38.5 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:</u> Gradations are estimated from auger cuttings in previous hole PW-13-A: about 55% medium to fine, hard, subangular to subrounded sand; about 20% coarse to fine, subangular to subrounded gravel; about 25% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 3 inches; wet, medium brown with a large variety of colors present in individual particles, weak to moderate cementation, weak reaction with HCl.

Total sample (by volume): About 5% cobbles at 3-5 inches; maximum size recovered, 3.5 inches.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

SHEET 1 OF 1
HOLE NO. TP13-1

FEATURE: St. Mary Diversion Dam
PROJECT: Milk River Project - Montana
LOCATION: Temporary bypass channel
GROUND ELEVATION: 4481.7
BOTTOM CENTER:
METHOD OF EXPLORATION: CAT 420E Backhoe
APPROXIMATE DIMENSIONS: 13.0' x 3.0' x 9.0' deep
HOLE LOGGED BY: C. Sullivan
TOTAL DEPTH: 9.0 ft.
DEPTH TO WATER: 9.0
DATE EXCAVATED: 9/12/2013 to 9/12/2013

CLASSIFICATION GROUP SYMBOL	CLASSIFICATION AND DESCRIPTION OF MATERIAL	% PLUS 3 INCH (BY VOLUME)		
		3-5 IN	5-12 IN	PLUS 12 IN
Cobbles and Bolders Visual GP-GC Visual 9.0 Ft.	0.0 to 9.0 ft. COBBLES AND BOULDERS WITH GRAVEL AND SAND: Total Sample (by volume) - Approximately 30% 3-to-5 inch, hard, subangular to subrounded cobbles; approximately 20% 5-to-12 inch, hard, subangular to subrounded cobbles; and approximately 10% plus 12-inch, hard subrounded boulders. Rock is approximately 80% sedimentary: (~55% limestone/dolomite; ~25% sandstone); approximately 15% metamorphic rock composed of predominately quartzite; and approximately 5% igneous rock composed of granite and gabbro; Quartzite, granite, and gabbro rock are moderately weathered (W5) - rock surfaces chipped when struck with heavy manual pressure by a rock hammer (H3). Quartzite is sugary textured and red and green in color while granite and gabbro are coarse-grained and varicolored. Limestone and dolomite rocks are fine-grained, light yellow to tan, moderately hard (H4), can be scratched with moderate pressure with a knife. Limestone had vigorous reaction with HCl; Dolomite hade vigorous reaction with HCl after being scratched. Sandstone is tan to yellow-brown, fine-grained, soft (H6), can be scratched with light moderate pressure with a fingernail. All rocks appeared to have a visual field durability index of D10. Minus 3-inch fraction (by mass): Approximately 70% fine to predominately coarse, hard, subrounded gravel; approximately 30% fine to coarse, hard, subangular to subrounded sand; composed predominately of quartzite; trace of nonplastic fines; maximum dimension recovered 3.0 inches; weak to strong reaction with HCl. IN-PLACE CONDITION: Relatively homogenous, light brown; dry to 9.0 ft., then saturated by groundwater. LAB TEST DATA: 50lb bag sample (0.0 to 12.5 ft.) +3 in. 95.2%; 3.3% Gravel; 1.2% Sand; 0.3% fines. +3 in. % scraped off: 69.1% Gravel; 23.7% Sand; 7.2% Fines; PL=20; PL=27; PI=7. REMARKS: Site is covered in boulders, cobbles and gravels composed predominately of quartzite. Few frocks on the ground surface exhibited fracturing of their faces; some open as much as ¼ in. with no tilting, subsurface materials outside of the selected test pit area may contain surface fracturing on rock faces. These rocks should be avoided. Grasses and some shrubs are common; shrubs were avoided. The test pit was terminated at 9.0 feet after equipment encountered (repeated) excessive caving due to loosely compacted, wet material. Excavation was slow and difficult as a consequence of oversize material. Encountered water at 9.0 ft.	30	20	10

REMARKS:

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

SHEET 1 OF 3
HOLE NO. TP13-2

FEATURE: St. Mary Diversion Dam
PROJECT: Milk River Project - Montana
LOCATION: Temporary bypass channel
GROUND ELEVATION: 4481.7
BOTTOM CENTER:
METHOD OF EXPLORATION: CAT 420E Backhoe
APPROXIMATE DIMENSIONS: 12.5' x 4.0' x 9.0' deep
HOLE LOGGED BY: C. Sullivan
TOTAL DEPTH: 9.0 ft.
DEPTH TO WATER: 9.0
DATE EXCAVATED: 9/12/2013 to 9/12/2013

CLASSIFICATION GROUP SYMBOL	CLASSIFICATION AND DESCRIPTION OF MATERIAL	% PLUS 3 INCH (BY VOLUME)		
		3-5 IN	5-12 IN	PLUS 12 IN
Cobblesand Boulders Visual GP-GC Lab Class 4.2 Ft.	0.0 to 4.2 ft. COBBLES AND BOULDERS WITH GRAVEL AND SAND: Total Sample (by volume) - Approximately 30% 3-to-5 inch, hard subangular to subrounded cobbles; approximately 20% 5-to-12 inch, hard, subangular to subrounded cobbles; and approximately 5% plus 12-inch, hard, subrounded boulders. Rock is approximately 80% sedimentary:(~55% limestone/dolomite; ~25% sandstone); approximately 15% metamorphic rock composed of predominately quartzite; and approximately 5% igneous rock composed of granite and gabbro; Quartzite, granite, and gabbro rocks are moderately weathered (W5) - rock surfaces chipped when struck with heavy manual pressure by a rock hammer (H3). Quartzite is sugary textured and red and green in color while granite and gabbro are coarse-grained and varicolored. Limestone and dolomite rock are fine-grained, light yellow to tan, moderately hard (H4), can be scratched with moderate pressure with a knife. Limestone had vigorous reaction with HCl; Dolomite had vigorous reaction with HCl after being scratched. Sandstone is yellow-brown, fine-grained, soft (H6), can be scratched with light moderate pressure with a fingernail. All rocks appeared to have a visual field durability index of D10. Minus 3-inch fraction (by mass): Approximately 70% fine to predominately coarse, hard subrounded sand; approximately 30% fine to coarse, hard, subangular to subrounded gravel, composed predominately of quartzite; maximum dimension recovered, 3.0 inches; weak to strong reaction with HCl. IN-PLACE CONDITION: Relatively homogenous, light brown; dry to 9.0 ft., then saturated by groundwater. LAB TEST DATA: 50lb bag sample (0.0 to 12.5 ft.) +3 in. 95.2%; 3.3% Gravel; 1.2% Sand; 0.3% fines. +3 in. % scrapped off; 69.1% Gravel; 23.7% Sand; 7.2% Fines. PL=20; PL=27; PI=7	30	20	5

REMARKS:

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

SHEET 2 OF 3
HOLE NO. TP13-2

FEATURE: St. Mary Diversion Dam
PROJECT: Milk River Project - Montana
LOCATION: Temporary bypass channel
GROUND ELEVATION: 4481.7
BOTTOM CENTER:
METHOD OF EXPLORATION: CAT 420E Backhoe
APPROXIMATE DIMENSIONS: 12.5' x 4.0' x 9.0' deep
HOLE LOGGED BY: C. Sullivan
TOTAL DEPTH: 9.0 ft.
DEPTH TO WATER: 9.0
DATE EXCAVATED: 9/12/2013 to 9/12/2013

CLASSIFICATION GROUP SYMBOL	CLASSIFICATION AND DESCRIPTION OF MATERIAL	% PLUS 3 INCH (BY VOLUME)		
		3-5 IN	5-12 IN	PLUS 12 IN
(GP)sc Visual	4.2 to 9.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Approximately 65% fine to coarse, hard, subangular to subrounded gravel; approximately 35% coarse to fine, hard subrounded to rounded sand; approximately 5% nonplastic fines. Total Sample (by volume) - Approximately 35% 3-to-5 inch, hard, subangular to subrounded cobbles; approximately 25% 5-to-12 inch, hard, subangular to subrounded cobbles; maximum size, 8 inches. Cobbles are composed of predominately of weathered limestone, dolomite, and sandstone with traces of quartzite, granite, and gabbro. IN-PLACE CONDITION: Relatively homogenous, light brown, dry above 9.0 feet then wet, loose to caving when wet, weak to strong reaction with HCl. LAB TEST DATA: 4 50lb bag samples (2.0 to 12.5 FT.): +3 in. 67.3%; 3.3% Gravel; 1.2% Sand; 0.3% fiens. +3 in % scalped off: 61.9% Gravel; 30.5% Sand; 7.6% Fines. PL=17; PL=21; PI=4. GEOLOGIC INTERPRETATION: Quaternary glacial/alluvium			
GP-GC Lab Class		35	25	-

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

SHEET 3 OF 3
HOLE NO. TP13-2

FEATURE: St. Mary Diversion Dam
PROJECT: Milk River Project - Montana
LOCATION: Temporary bypass channel
GROUND ELEVATION: 4481.7
BOTTOM CENTER:
METHOD OF EXPLORATION: CAT 420E Backhoe
APPROXIMATE DIMENSIONS: 12.5' x 4.0' x 9.0' deep
HOLE LOGGED BY: C. Sullivan
TOTAL DEPTH: 9.0 ft. DEPTH TO WATER: 9.0
DATE EXCAVATED: 9/12/2013 to 9/12/2013

CLASSIFICATION GROUP SYMBOL	CLASSIFICATION AND DESCRIPTION OF MATERIAL	% PLUS 3 INCH (BY VOLUME)		
		3-5 IN	5-12 IN	PLUS 12 IN
9.0 Ft.				

ST_MARY_TEST_PITS ST_MARY_TEST_PITS.GPJ ST_MARY_TEST_PITS.GDT 10/4/16 11:20:09 AM

GEOLOGIC LOG OF DRILL HOLE NO. SPT-13-A

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Right bank of St. Mary River
BEGUN: 7/19/13 FINISHED: 7/21/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 8.6 (4473.5) 07/22/13

PROJECT: Milk River
COORDINATES: N 1,701,512.0 E 1,026,331.0
TOTAL DEPTH: 23.5
DEPTH TO BEDROCK: 10.5

STATE: Montana
GROUND ELEVATION: 4482.1 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: J. Earle
REVIEWED BY: C. Sullivan

NOTES

LOCATION:
Right bank of St. Mary River about 140 ft from the NE corner of the bridge abutment

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HSA) with 5-foot long split sample barrel

DRILLING METHODS:
0.0 to 9.0 cored with 4-¼ " I.D. HSA and split barrel sampler.
9.0 to 10.0 cored with 4-¼ " I.D. HSA and center bit.
10.0 to 23.5 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper
S. Watt, helper

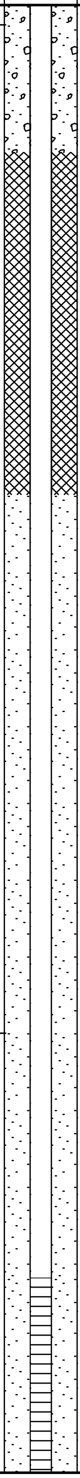
DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
07-20-13, 10.0, 10.0
07-22-13, 23.5, 8.6
07-29-14, 23.5, 7.8

HOLE COMPLETION:
23.5 - 23.0 filter sand # 8-12
23.0 - 13.0 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
13.0 - 5.0 filter sand for influence zone # 8-12
5.0 - 1.5 filled with bentonite chips
1.5 - 0.0 placed mortar cement and set steel stand pipe
Returned 08-14-13 to change out stand pipe with flush mount sewer cap

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.
	(SM)gc	20	topsoil
	(SM)		Qal
5	(GM)sc	16	
	cobble	c bit	
10	(SC)	60	
	bedrock		bedrock
		10	

HOLE COMPLETION



CLASSIFICATION AND PHYSICAL CONDITION

<u>0.0 to 0.2 ft. Topsoil (fill):</u>

<u>0.0 to 0.2 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:</u> About 60% coarse to fine, hard, subangular to rounded sand; about 15% coarse to fine, hard, angular to subrounded gravel; about 25% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 2 inches; dry; dark brown matrix with a large variety of colors present in individual particles; no cementation; firm consistency; roots present; organic smell; no reaction with HCl.

Total sample (by volume): About 20% cobbles at 3-5 inches; 5% cobbles at 5-12 inches; maximum size, 12 inches, determined by visual observations of surface exposure.

<u>0.2 to 10.5 ft. Quaternary Alluvium (Qal):</u>

<u>0.2 to 0.6 ft. SILTY SAND (SM):</u> About 80% predominately fine, hard, subrounded to rounded sand; about 20% nonplastic fines with slow dilatancy; maximum size recovered, fine sand; dry; light brown to buff; no cementation; no reaction with HCl.

<u>0.6 to 9.0 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:</u> About 50% coarse to fine, hard, angular to subrounded gravel with elongated shapes present; about 25% coarse to fine, hard, subangular to subrounded sand; about 25% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 2 inches; dry; no cementation; overall light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

Total sample (by volume): About 10% cobbles at 3-5 inches; 10% cobbles at 5-12 inches; maximum size, 6 inches, determined by visual observations of cuttings and drilling roughness.

<u>9.0 to 10.0 ft. LARGE COBBLE OR BOULDER:</u> Drilling conditions indicated a large rock that blocked the bottom of the augers so that no recovery was possible. This rock was finally broken through so that progress and further sampling could occur.

<u>10.0 to 10.5 ft. CLAYEY SAND (SC):</u> About 70% medium to predominately fine, hard, subrounded to rounded sand; about 30% medium plasticity fines, medium dry strength, low toughness, no dilatancy; maximum size recovered, medium sand; wet; medium to dark gray; firm consistency; no reaction with HCl.

<u>10.5 to 23.5 ft. Cretaceous Two Medicine Formation (Ktm):</u>

The Two Medicine Formation is composed of medium- to predominately fine-grained, moderately hard (H4) to hard (H3) sandstone; containing sedimentary clasts of quartz, feldspar, hornblende and nodular limestone; light to medium gray with dark gray to black mineral grains; massive; mostly moderately weathered (W5) with depth; moderately rough (R3); fracture surfaces are clean or containing very thin (< 1mm) infilling of calcium carbonate; strong reaction with HCl throughout.

<u>10.5 to 12.0 ft. Sandstone</u> is intensely weathered (W7); moderately soft (H5); moderately rough (R3); massive; openness (O1); infilling and staining (T1).

<u>12.0 to 18.0 ft. Sandstone</u> is slightly weathered (W3); hard (H3) to very hard (H2); moderately rough (R3); massive; slightly open (O1); very thin fracture filling (<1mm) of calcium carbonate, on some surfaces, others are clean, no staining or alteration.

<u>18.0 to 19.0 ft. Sandstone</u> is moderately weathered (W5): moderately

COMMENTS:

GEOLOGIC LOG OF DRILL HOLE NO. SPT-13-A

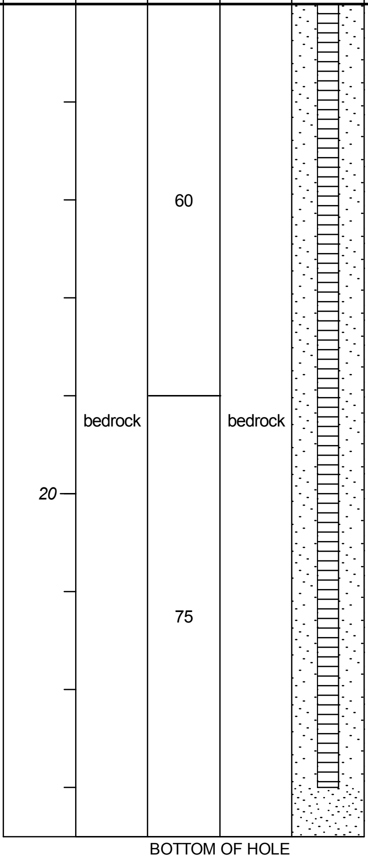
SHEET 2 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Right bank of St. Mary River
BEGUN: 7/19/13 FINISHED: 7/21/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 8.6 (4473.5) 07/22/13

PROJECT: Milk River
COORDINATES: N 1,701,512.0 E 1,026,331.0
TOTAL DEPTH: 23.5
DEPTH TO BEDROCK: 10.5

STATE: Montana
GROUND ELEVATION: 4482.1 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: J. Earle
REVIEWED BY: C. Sullivan

NOTES	DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION



soft (H5) to soft (H6); moderately rough (R3); massive; openness (O1); infilling and staining (T1).

19.0 to 23.5 ft. Sandstone is moderately to intensely weathered (W6); moderately soft (H5) to soft (H6); moderately rough (R3); massive; openness (O1); infilling and staining (T1)

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-A

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 7/6/13 FINISHED: 7/8/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 13.5 (4469.9) 7/6/13

PROJECT: Milk River
COORDINATES: N 1,701,391.0 E 1,025,857.0
TOTAL DEPTH: 34.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4483.4 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES

LOCATION:
Left bank of St. Mary River along the St. Mary Canal embankment, about 90 ft from the SW corner of the diversion structure

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HAS) with 5-foot long split sample barrel

DRILLING METHODS:
0.0 to 16.0 cored with 4-¼ " I.D. HSA and center bit.
16.0 to 21.8 cored with 4-¼ " I.D. HSA and split barrel sampler.
21.8 to 24.0 cored with 4-¼ " I.D. HSA and center bit.
24.0 to 26.0 cored with 4-¼ " I.D. HSA and split barrel sampler.
26.0 to 26.8 cored with 4-¼ " I.D. HSA and center bit.
26.8 to 34.0 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper
S. Watt, helper

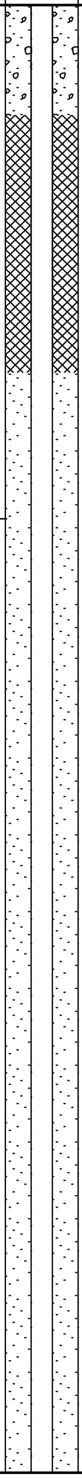
DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
07-06-13, 16.0, 13.5
07-07-13, 19.0, 15.8
07-08-13, 34.0, 8.9
08-19-13, 34.0, 13.5

HOLE COMPLETION:
34.0 - 33.0 used 8-12 filter sand
33.0 - 23.0 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
23.0 - 5.0 used 8-12 filter sand for influence zone
5.0 - 1.5 filled with bentonite chips
1.5 - 0.0 placed mortar cement and set steel stand pipe
3.05 = stickup of PVC (elev= 4486.45)

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.
	(GP)scb		Fill
5			
		c bit	
10			
	(SP)gc		
			Qal
	cobble		
15			
	(GM)s	70	
		100	

HOLE COMPLETION



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 7.0 ft. Road Fill:

0.0 to 7.0 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: about 70-75% coarse to fine, hard, angular to subrounded gravel; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5-10% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; dry, no cementation, overall light to medium brown with a large variety of colors in individual particles, no reaction with HCl.

Total sample (by volume): About 30-35% cobbles at 3-5 inches; 20-25% cobbles at 5-12 inches; maximum size, 12 inches, determined by visual observations of surface exposure.

7.0 to 34.0 ft. Quaternary Alluvium:

7.0 to 14.0 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc: Gradations are estimated from auger cuttings and drilling conditions: About 50-60% coarse to fine, hard, subangular to rounded sand, with some elongate shapes; about 30-40% coarse to fine, hard, angular to subrounded gravel; about 10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 2.5 inches; dry, light to medium brown, no reaction with HCl.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; 10% cobbles at 5-12 inches; maximum size, 5 inches, determined by visual observations of material returned outside the auger flights.

14.0 to 15.0 LARGE COBBLE OR BOULDER: Drilling conditions indicated a large rock that blocked the bottom of the augers so that no recovery was possible. This rock was finally broken through so that progress and further sampling could occur.

15.0 to 20.5 ft. SILTY GRAVEL WITH SAND (GM)s: A sampling barrel was used to retrieve foundation material from this interval: About 45% coarse to fine, hard, subangular to subrounded gravel; about 35% coarse to fine, hard, subangular to rounded sand; about 20% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 2.75 inches; wet, medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

20.5 to 21.8 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc: A sampling barrel was used to retrieve foundation material from this interval: About 50% coarse to fine, hard, subangular to subrounded gravel; about 30% coarse to fine, hard, subangular to rounded sand; about 20% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size, 3 inches; wet, medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

Total sample (by volume): About 10% cobbles at 3-5 inches; 5% cobbles at 5-12 inches; maximum size, 6.5 inches; determined by visual observations of material returned outside the auger flights.

21.8 to 23.0 ft. LARGE COBBLE OR BOULDER: Drilling conditions indicated a large rock that blocked the bottom of the augers so that no recovery was possible. This rock was finally broken through so that progress and further sampling could occur.

23.0 to 26.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: A sampling barrel was used to retrieve foundation material from this interval: About 60% coarse to fine, hard, subangular to subrounded gravel; about 30% coarse to fine, hard, subangular to rounded sand;

COMMENTS:

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-A

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 7/6/13 FINISHED: 7/8/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 13.5 (4469.9) 7/6/13

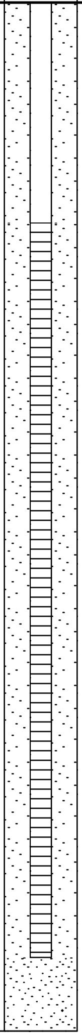
PROJECT: Milk River
COORDINATES: N 1,701,391.0 E 1,025,857.0
TOTAL DEPTH: 34.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4483.4 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.
	(GM)s	100	Qal
	(GM)sc		
	cobble	c bit	
25	(GM)s	75	
	cobble	c bit	
	(GP)s		
	(SP)g	100	
30	(SM)		
	(SC)g		
	(SM)		
	(SP)g		
	(SP)		

HOLE COMPLETION



BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

about 10% nonplastic fines; maximum size recovered, 2.25 inches; wet, medium brown with a large variety of colors in individual particles; no cementation; firm consistency; no reaction with HCl.

26.0 to 26.8 ft. LARGE COBBLE OR BOULDER: Drilling conditions indicated a large rock that blocked the bottom of the augers so that no recovery was possible. This rock was finally broken through so that progress and further sampling could occur.

26.8 to 29.5 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: Gradations are estimated from material remaining on the center bit as it was extracted from drill hole: About 60% coarse to fine, hard, angular to subrounded gravel; about 40% fine, hard, sub angular to subrounded sand: with a trace of nonplastic fines; maximum size recovered, 1.5 inches; wet; a large variety of colors are present in individual particles; uncemented; no reaction with HCl.

29.5 to 29.9 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 75% coarse to fine, hard, subangular to rounded sand; about 20% coarse to fine, hard, angular to subrounded gravel; about 5% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 1.5 inches; wet; a large variety of colors are present in individual particles; no reaction with HCl.

29.9 to 30.8 ft. SILTY SAND (SM): About 80% coarse to fine, hard, subangular to rounded sand; about 20% nonplastic fines with slow dilatancy; trace of fine subangular gravel: maximum size recovered, 0.75 inch; wet, a large variety of colors are present in individual particles, no cementation, firm consistency, no reaction with HCl.

30.8 to 31.3 ft. CLAYEY SAND WITH GRAVEL (SC)g: About 50% coarse to fine, hard, subangular to rounded sand; about 35% coarse to fine, hard, subangular gravel: and about 15% fines with low plasticity, medium dry strength, low toughness, no dilatancy; maximum size recovered, 3 inch; wet, a large variety of colors are present in individual particles, no cementation, very soft consistency, no reaction with HCl.

31.3 to 32.7 ft. SILTY SAND (SM): About 80% coarse to fine, hard, subangular to rounded sand; about 5% fine, hard, subangular gravel; about 15% nonplastic fines with slow dilatancy; maximum size recovered, 0.75 inch; wet; a large variety of colors are present in individual particles, no cementation, firm consistency, no reaction with HCl.

32.7 to 33.3 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 70% coarse to fine, hard, subangular to rounded sand; about 25% coarse to fine, hard, angular to subrounded gravel; about 5% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 2.75 inches; wet; a large variety of colors are present in individual particles; firm consistency; no reaction with HCl.

33.3 to 34.0 ft. POORLY GRADED SAND (SP): About 90% coarse to fine, hard, subangular to rounded sand; about 5% fine, hard, subrounded gravel; about 5% nonplastic fines; maximum size recovered, 0.75 inch; wet; a large variety of colors are present in individual particles; firm consistency; no reaction with HCl.

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-B

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 7/9/13 FINISHED: 7/10/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 11.7 (4469.9) 07/09/13

PROJECT: Milk River
COORDINATES: N 1,701,429.0 E 1,025,826.0
TOTAL DEPTH: 22.8
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.6 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES

LOCATION:
Left bank of St. Mary River along the St. Mary Canal embankment, about 115 ft from the SW corner of the diversion structure and 53 ft NNW from OW-13-A

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HSA) with 5-foot long split sample barrel

DRILLING METHODS:
0.0 to 15.5 cored with 4-¼ " I.D. HSA and center bit.
15.5 to 22.8 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper
S. Watt, helper

DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
07-09-13, 14.2, 11.7
07-10-13, 20.2, 11.7

HOLE COMPLETION:
22.8 - 0.0 abandoned hole and refilled with mix of bentonite chips and drill cuttings

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION
	(GP)scb	c bit	road fill	
	(GM)sc		emb fill	
	(GP)sc			
5	(GM)s			
10	(GP)s		Qal	
	cobble			
	(GP)sc			
	(GM)s			

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 1.5 ft. Road Fill:

0.0 to 1.5 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: about 70-75% coarse to fine, hard, angular to subrounded gravel; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5% low plasticity fines with low dry strength, low toughness, slow dilatancy; dry; no cementation; overall light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

Total sample (by volume): About 30% cobbles at 3-5 inches; 25% cobbles at 5-12 inches; 5% boulders at plus 12 inches; maximum size, 2 x 1.8 x 1 foot, determined by visual observations of surface exposure.

1.5 to 7.0 ft. Embankment Fill:

1.5 to 3.0 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:
Gradations are estimated from auger cuttings and drilling conditions: About 45% coarse to fine, hard, subangular to subrounded gravel; about 40% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size, 4.5 inches; dry; light to medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

3.0 to 4.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Gradations are estimated from auger cuttings and drilling conditions: About 60-65% coarse to fine, hard, angular to subrounded gravel; about 30-35% coarse to fine, hard, angular to subrounded sand; about 5% nonplastic fines; maximum size, 5 inches, estimated by what is seen coming up on the augers; dry; light to medium brown; no reaction with HCl.

4.5 to 7.0 ft. SILTY GRAVEL WITH SAND (GM)s: Gradations are estimated from auger cuttings and drilling conditions: About 45-50% coarse to fine, hard, subangular to subrounded gravel; about 30-35% coarse to fine, hard, subangular to rounded sand; about 20% nonplastic fines; maximum size, 3 inches, estimated by what is seen coming up on the augers; dry; light to medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

7.0 to 22.8 ft. Quaternary Alluvium:

7.0 to 11.5 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:
Gradations are estimated from auger cuttings and drilling conditions: About 50-55% coarse to fine, hard, angular to subrounded gravel; about 40-45% coarse to fine, hard, angular to subrounded sand; about 5% nonplastic fines; maximum size, 5 inches, estimated by what is seen coming up on the augers; dry; light to medium brown; no reaction with HCl.

11.5 to 12.0 LARGE COBBLE OR BOULDER: Drilling conditions indicated a large rock that blocked the bottom of the augers so that no recovery was possible. Stopped drilling and checked the center bit teeth for wear, noted water on rods at 11.7 feet. This rock was finally broken through so that progress and further sampling could occur.

12.0 to 14.2 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Gradations are estimated from auger cuttings and drilling conditions: About 70-75% coarse to fine, hard, angular to subrounded gravel; about 20-25% coarse to fine, hard, angular to subrounded sand; about 5% nonplastic fines; maximum size, 6 inches, estimated by what is seen coming up on the augers and a

COMMENTS:

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-B

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 7/9/13 FINISHED: 7/10/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 11.7 (4469.9) 07/09/13

PROJECT: Milk River
COORDINATES: N 1,701,429.0 E 1,025,826.0
TOTAL DEPTH: 22.8
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.6 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES	DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
		cobble	c bit	Qal		
		(GP)s	57			
	20	cobble	0			
		(GP)sc				
			0			

BOTTOM OF HOLE

blockage at 13.5 ft.; dry; light to medium brown; no reaction with HCl.

<u>14.2 to 15.0 ft. SILTY GRAVEL WITH SAND (GM)s:</u> Gradations are estimated from auger cuttings and drilling conditions: About 50-55% coarse to fine, hard, subangular to subrounded gravel; about 25-35% coarse to fine, hard, subangular to rounded sand; about 15-20% nonplastic fines; maximum size, 3 inches, estimated by what is seen coming up on the augers; moist to wet; medium brown with a large variety of colors in individual particles; no reaction with HCl.

<u>15.0 to 15.5 ft. LARGE COBBLE OR BOULDER:</u> Drilling conditions indicated a large rock that blocked the bottom of the augers so that no recovery was possible. This rock was finally broken through so that progress and further sampling could occur.

<u>15.5 to 19.5 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:</u> A sampling barrel was used to retrieve foundation material from the interval between 16.0 to 19.5 feet, and drill cuttings were observed from the interval below the cobble to the depth of 16.0 feet: About 55% coarse to fine, hard, angular to subrounded gravel; about 40% coarse to fine, hard, subangular to rounded sand; about 5% nonplastic fines; maximum size, 3 inches, estimated by what is seen coming up on the augers; wet; light brown with a large variety of colors in individual particles; no reaction with HCl.

<u>19.5 to 20.2 ft. LARGE COBBLE OR BOULDER:</u> Drilling conditions indicated a large rock that blocked the bottom of the augers so that no recovery was possible. This rock was finally broken through so that progress and further sampling could occur.

<u>20.2 to 22.8 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:</u> Gradations are estimated from auger cuttings and drilling conditions below large blockage: About 70-75% coarse to fine, hard, angular to subrounded gravel; about 20-25% coarse to fine, hard, angular to subrounded sand; about 5% nonplastic fines; maximum size, 6 inches, estimated by what is seen coming up on the augers; wet; light to medium brown; no reaction with HCl.

<u>22.8 ft. LARGE COBBLE OR BOULDER:</u> Drilling conditions indicated a large rock that blocked the bottom of the augers and was impossible to proceed past. The hole had to be abandoned due to no downward progress.

Abandoned hole, pulled 10 feet of the augers and measured the bottom of the hole with caving material to 16.5 feet. Added bentonite chips as augers were removed to 2.0 feet of depth. Filled the remaining hole with auger cuttings to the existing ground surface.

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-B2

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 7/10/13 FINISHED: 7/18/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 11.8 (4469.8) 07/18/13

PROJECT: Milk River
COORDINATES: N 1,701,392.0 E 1,025,828.0
TOTAL DEPTH: 35.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.6 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan / J. Earle
REVIEWED BY: J. Earle

NOTES

LOCATION:
Left bank of St. Mary River along the St. Mary Canal embankment, about 115 ft from the SW corner of the diversion structure and 50 ft NNW from OW-13-A

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HSA) with 5-foot long split sample barrel

DRILLING METHODS:
0.0 to 20.0 cored with 4-¼ " I.D. HSA and center bit.
20.0 to 35.0 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper
S. Watt, helper

DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
07-10-13, 15.0, 9.2
07-17-13, 25.0, 11.6
07-18-13, 35.0, 11.8

HOLE COMPLETION:
35.0 - 34.0 filter sand #10-20
34.0 - 24.0 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
24.0 - 14.0 filter sand #10-20
14.0 - 1.5 filled with bentonite chips
1.5 - 0.0 placed mortar cement and set steel stand pipe
2.76 ft = stickup of PVC (elev= 4484.36)

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION
	(GP)scb		road fill	
	(GM)sc		emb fill	
5	cobble			
	(GM)sc			
10	(GP)s	c bit		
	(GM)sc		Qal	
15	(GP)s			

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 1.5 ft. Road Fill:

0.0 to 1.5 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: about 70-75% coarse to fine, hard, angular to subrounded gravel; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5% low plasticity fines with low dry strength, low toughness, slow dilatancy; dry; no cementation; overall light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

Total sample (by volume): About 30% cobbles at 3-5 inches; 25% cobbles at 5-12 inches; 5% boulders at plus 12 inches; maximum size, 1.7 x 1.2 x 1.0 foot, determined by visual observations of surface exposure.

1.5 to 7.0 ft. Embankment Fill:

1.5 to 4.5 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:
Gradations are estimated from auger cuttings and drilling conditions: About 45% coarse to fine, hard, subangular to subrounded gravel; about 40% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size, 4.5 inches; dry; light to medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

4.5 to 5.2 LARGE COBBLE OR BOULDER: Drilling conditions indicated a large rock that blocked the bottom of the augers so that no recovery was possible. This rock was finally broken through so that progress and further sampling could occur.

5.2 to 7.0 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:
Gradations are estimated from auger cuttings and drilling conditions: About 45-50% coarse to fine, hard, subangular to subrounded gravel; about 30-35% coarse to fine, hard, subangular to rounded sand; about 20% nonplastic fines; maximum size, 3 inches, estimated by what is seen coming up on the augers; dry; light to medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

Total sample (by volume): Estimated by drilling conditions and material carried to the surface on the outside of the auger flights: About 10% cobbles at 3-5 inches; 5% cobbles at 5-12 inches; maximum size, 7 inches.

7.0 to 35.0 ft. Quaternary Alluvium:

7.0 to 12.5 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:
Gradations are estimated from auger cuttings and drilling conditions: About 50-55% coarse to fine, hard, angular to subrounded gravel; about 40-45% coarse to fine, hard, angular to subrounded sand; about 5% nonplastic fines; maximum size, 5 inches, estimated by what is seen coming up on the augers; dry, light to medium brown; no reaction with HCl.

12.5 to 15.0 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:
Gradations are estimated from auger cuttings and drilling conditions: About 40-45% coarse to fine, hard, angular to subrounded gravel; about 40-45% coarse to fine, hard, subangular to rounded sand; about 15% nonplastic fines; maximum size, 3 inches, estimated by what is seen coming up on the augers; dry; light to medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

15.0 to 20.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:

COMMENTS:

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-B2

SHEET 2 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 7/10/13 FINISHED: 7/18/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 11.8 (4469.8) 07/18/13

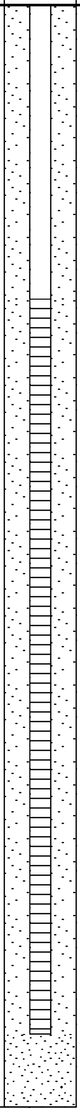
PROJECT: Milk River
COORDINATES: N 1,701,392.0 E 1,025,828.0
TOTAL DEPTH: 35.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.6 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan / J. Earle
REVIEWED BY: J. Earle

NOTES	DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.
		(GM)sc	84	
	25	(SM)	100	
		(GM)s	100	Qal
		(SM)g	100	
	30	(GP)sc	50	
	35			

BOTTOM OF HOLE

HOLE COMPLETION



CLASSIFICATION AND PHYSICAL CONDITION

Gradations are estimated from auger cuttings and drilling conditions: About 50-55% coarse to fine, hard, angular to subrounded gravel; about 45-50% coarse to fine, hard, subangular to rounded sand; about a trace of nonplastic fines; maximum size, 6 inches, estimated by what is seen coming up on the augers; moist to wet; light to medium brown; no reaction with HCl.

20.0 to 25.0 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc: A sampling barrel was used to retrieve foundation material from the interval between 20.0 to 25.0 feet: About 45% coarse to fine, hard, angular to subrounded gravel; about 35% coarse to fine, hard, subangular to rounded sand; about 20% low plasticity fines, with low dry strength, low toughness, slow dilatancy; maximum size, 4 inches, but limited by the interior diameter of the augers; wet; light to medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

Total sample (by volume): Estimated by drilling conditions and material sampled inside the auger flights: About 10% cobbles at 3-5 inches (sampled); 5% cobbles at 5-12 inches in foundation.

25.0 to 25.5 ft. SILTY SAND (SM): About 80% predominately fine, hard, rounded sand; about 5% coarse to fine, hard, angular to subrounded gravel; about 15% low plasticity fines with no to low dry strength, no to low toughness, slow dilatancy; maximum size recovered, fine sand; wet, light to medium brown with a large variety of colors in individual particles; no cementation; weak reaction with HCl.

25.5 to 29.5 ft. SILTY GRAVEL WITH SAND (GM)s: About 55% coarse to fine, hard, subangular to subrounded gravel with elongate shapes present; about 30% predominately fine, hard, rounded sand; about 15% low plasticity fines, with no dry strength, low toughness, no dilatancy; maximum size recovered, 2 inches; wet; light to medium brown with a large variety of colors in individual particles; no to weak cementation; no reaction with HCl.

29.5 to 30.0 ft. SILTY SAND WITH GRAVEL (SM)g: About 55% predominately fine, hard, rounded sand; about 30% coarse to fine, hard, subrounded to rounded gravel with elongate shapes present; about 15% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 1 inch; wet; light to medium brown with a large variety of colors in individual particles; weak cementation; soft consistency; weak reaction with HCl.

30.0 to 35.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 60% coarse to fine, hard, subangular to subrounded gravel; about 35% coarse to fine, hard, subangular to rounded sand; about 5% nonplastic fines; maximum size, 3 inches, estimated by what is seen coming up on the augers; dry; light to medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

Total sample (by volume): Estimated by drilling conditions and material carried to the surface on the outside of the auger flights: About 5% cobbles at 3-5 inches; maximum size recovered, 4.5 inches.

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-C

SHEET 1 OF 1

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 8/1/13 FINISHED: 8/3/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 12.4 (4468.8) 08/03/13

PROJECT: Milk River
COORDINATES: N 1,701,408.0 E 1,025,725.0
TOTAL DEPTH: 34.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.2 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: J. Earle
REVIEWED BY: C. Sullivan

NOTES

LOCATION:
225 ft west of the left bank of St. Mary River along the access road, about 130 ft WSW of the pump well

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HSA) with 5-foot long split sample barrel

DRILLING METHODS:
0.0 to 15.0 cored with 4-¼ " I.D. HSA and center bit.
15.0 to 34.0 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper
S. Watt, helper

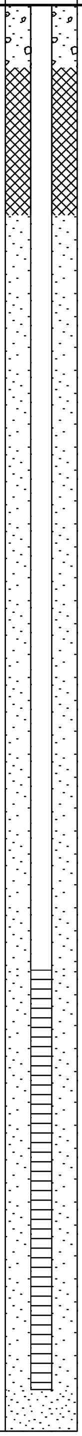
DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
08-03-13, 34.0, 12.4

HOLE COMPLETION:
34.0 - 33.0 filter sand #8-12
33.0 - 23.0 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
23.0 - 5.0 filter sand for influence zone #8-12
5.0 - 1.5 filled with bentonite chips
1.5 - 0.0 placed mortar cement and set steel stand pipe
Stickup = 2.72 on PVC riser

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.
5 10	(GP)scb	c bit	Qal
15	(SM)gc	22	
20	(GM)sc	20	
25	(GP)s	0	
30	(GP)sc	50	

HOLE COMPLETION



BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 34.0 ft. Quaternary Alluvium:

0.0 to 15.0 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: about 70-75% coarse to fine, hard, angular to subrounded gravel with elongated shapes present; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5-10% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; dry; no cementation; overall light to medium brown with a large variety of colors in individual particles; weak reaction with HCl.

Total sample (by volume): About 30-35% cobbles at 3-5 inches; 20-25% cobbles at 5-12 inches; maximum size, 12 inches, determined by visual observations of surface exposure.

15.0 to 19.5 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc: A sampling barrel was used to retrieve foundation material from this interval: About 45% medium to fine, hard, subrounded to rounded sand; about 35% coarse to fine, hard, subrounded gravel with elongated shapes present; about 20% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; moist; reddish brown with a large variety of colors in individual particles; weak cementation; no reaction with HCl.

Total sample (by volume): About 5% cobbles at 3-5 inches; maximum size recovered, 5 inches.

19.5 to 24.5 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:
About 45% coarse to fine, hard, subrounded gravel with elongated shapes present; about 25% medium to fine, hard, subrounded to rounded sand; about 30% low plasticity fines with low dry strength, low toughness, no dilatancy; maximum size recovered, 2.5 inches: wet; brown with a large variety of colors in individual particles; weak cementation; no reaction with HCl.

Total sample (by volume): About 5% cobbles at 3-5 inches; maximum size recovered, 6 inches.

24.5 to 29.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:
About 55% coarse to fine, hard, angular to subrounded gravel with elongated shapes present; about 25% predominately fine, hard, subrounded to rounded sand; about 20% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; wet; medium brown with a large variety of colors in individual particles; weak cementation; weak reaction with HCl.

29.0 to 34.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 60% coarse to fine, hard, angular to subangular gravel with elongated shapes present; about 30% coarse to fine, hard, subangular to subrounded sand; about 10% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; wet; weak cementation; overall light to medium brown with a large variety of colors in individual particles; weak reaction with HCl.

Total sample (by volume): About 10% cobbles at 3-5 inches; maximum size recovered, 5 inches.

COMMENTS:

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-D

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 7/22/13 FINISHED: 7/23/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 9.0 (4472.2) 07/23/13

PROJECT: Milk River
COORDINATES: N 1,701,515.0 E 1,025,775.0
TOTAL DEPTH: 39.5
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.2 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: J. Earle
REVIEWED BY: C. Sullivan

NOTES

LOCATION:
Along the left side of the St. Mary Canal embankment, about 280 ft from the SW corner of the diversion structure and 125 ft from the pump well

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HSA) with 5-foot long split sample barrel

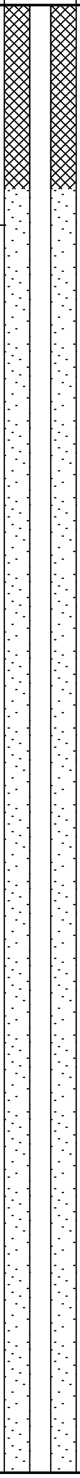
DRILLING METHODS:
0.0 to 15.0 cored with 4-¼ " I.D. HSA and center bit.
15.0 to 39.5 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper
S. Watt, helper

DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
07-23-13, 39.5, 9.0

HOLE COMPLETION:
39.5 - 35.0 filter sand # 10-20
35.0 - 25.0 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
25.0 - 2.5 filter sand # 10-20 for influence zone
2.5 - 0.0 filled with bentonite chips and set steel stand pipe
Stickup = 3.02 on PVC riser

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION
	(GP)scb	c bit	fill	
5 10	(SP)gc		Qal	
15	(GP)sc	50		
	(GP)sc	45		

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 3.0 ft. Road Fill:

0.0 to 3.0 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: About 70-75% coarse to fine, hard, angular to subrounded gravel with elongated shapes present; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5-10% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 2 inches; dry; no cementation; overall light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

Total sample (by volume): About 30-35% cobbles at 3-5 inches; 20-25% cobbles at 5-12 inches; maximum size, 12 inches, determined by visual observations of surface exposure.

3.0 to 39.5 ft. Quaternary Alluvium:

3.0 to 15.0 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc: Gradations are estimated from auger cuttings and drilling conditions: About 50-60% coarse to fine, hard, subangular to rounded sand, with some elongated shapes; about 30-40% coarse to fine, hard, angular to subrounded gravel; about 10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 2 inches; dry to 9.0 then wet; light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; 10% cobbles at 5-12 inches; maximum size, 7 inches, determined by visual observations of material returned outside the auger flights.

15.0 to 19.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: A sampling barrel was used to retrieve foundation material from this interval: About 50% coarse to fine, hard, angular to subangular gravel with elongated shapes present; about 40% coarse to fine, hard, subangular to rounded sand; about 10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 2 inches; wet; gray to brown with a large variety of colors in individual particles; no to weak cementation; no reaction with HCl.

Total sample (by volume): About 25% cobbles at 3-5 inches; maximum size recovered, 4 inches.

19.0 to 24.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 50% coarse to fine, hard, angular to subangular gravel with elongated shapes present; about 40% coarse to fine, hard, subangular to rounded sand; about 10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 3 inches; wet; gray to reddish brown with a large variety of colors in individual particles; weak cementation; weak reaction with HCl.

Total sample (by volume): About 20% cobbles at 3-5 inches; maximum size recovered, 6 inches.

24.5 to 29.5 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc: About 50% coarse to fine, hard, subangular to rounded sand; about 30% fine, hard, angular to subangular gravel with some elongated shapes present; about 20% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 1 inch; wet; tri-color, red, green, brown with a large variety of colors in individual particles; weak cementation; weak reaction with HCl.

Total sample (by volume): About 15% cobbles at 3-5 inches; maximum size recovered, 6 inches.

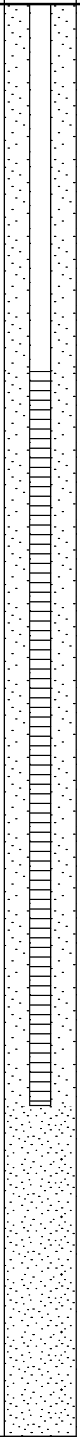
COMMENTS:

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-D

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of St. Mary River
BEGUN: 7/22/13 FINISHED: 7/23/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 9.0 (4472.2) 07/23/13

PROJECT: Milk River
COORDINATES: N 1,701,515.0 E 1,025,775.0
TOTAL DEPTH: 39.5
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4481.2 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: J. Earle
REVIEWED BY: C. Sullivan

NOTES	DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
		(GP)sc	45	Qal		<u>29.5 to 34.5 ft. CLAYEY SAND WITH GRAVEL (SC)g:</u> About 50% medium to fine, hard, subrounded to rounded sand; about 25% coarse to fine, hard, angular to subangular gravel with some elongated shapes present; about 25% medium plasticity fines, medium dry strength, medium toughness, slow dilatancy; maximum size recovered, 2.5 inches; wet; black to brown with a large variety of colors in individual particles; weak cementation; no reaction with HCl. <u>34.5 to 39.5 ft. CLAYEY SAND (SC):</u> About 60% medium to fine, hard, subrounded to rounded sand; about 40% medium plasticity fines, medium dry strength, medium toughness, slow dilatancy; maximum size recovered, 2.5 inches; wet; black to brown with a large variety of colors in individual particles; weak cementation; no reaction with HCl.
	25	(SM)gc	20			
	30	(SC)g	20			
	35	(SC)	55			

BOTTOM OF HOLE

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-E

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of diversion canal
BEGUN: 8/4/13 FINISHED: 8/7/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 9.5 (4471.2) 08/07/13

PROJECT: Milk River
COORDINATES: N 1,701,526.0 E 1,025,799.0
TOTAL DEPTH: 39.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4480.7 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: J. Earle
REVIEWED BY: C. Sullivan

NOTES

LOCATION:
Along the left side of the St. Mary Canal embankment, about 180 ft from the SW corner of the diversion structure and 80 ft from the pump well

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HAS) with 5-foot long split sample barrel

DRILLING METHODS:
0.0 to 15.0 cored with 4-¼ " I.D. HSA and center bit.
15.0 to 39.5 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper
S. Watt, helper

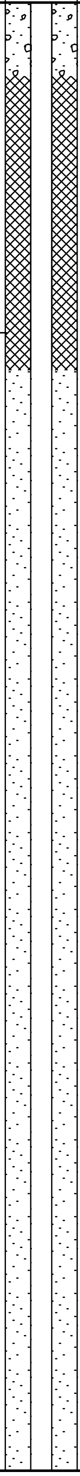
DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
08-07-13, 39.0, 9.5

HOLE COMPLETION:
39.0- 38.0 filter sand # 10-20
38.0 - 28.0 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
28.0 - 5.0 filter sand # 10-20 for influence zone
5.0 - 1.0 filled with bentonite chips and set steel stand pipe
1.0 - 0.0 concrete pad
Stickup = 2.2 on PVC riser = 4482.92
Steel protective pipe to 3.0 above ground

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.
0–4.5	(GP)scb	c bit	Fill
4.5–15	(SP)gc		Qal
15–19	(GP)sc	50	
19–		85	

HOLE COMPLETION



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 4.5 ft. Road Fill:

0.0 to 4.5 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb: Gradations are estimated from auger cuttings and drilling conditions: about 70-75% coarse to fine, hard, angular to subrounded gravel with elongate shapes present; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5-10% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 2 inches; dry, no cementation, overall light to medium brown with a large variety of colors in individual particles, no reaction with HCl.

Total sample (by volume): About 30-35% cobbles at 3-5 inches; 20-25% cobbles at 5-12 inches; maximum size, 12 inches, determined by visual observations of surface exposure.

4.5 to 39.0 ft. Quaternary Alluvium:

4.5 to 15.0 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc: Gradations are estimated from auger cuttings and drilling conditions: About 50-60% coarse to fine, hard, subangular to rounded sand, with some elongate shapes; about 30-40% coarse to fine, hard, angular to subrounded gravel; about 10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 7.0 inches; dry to 9.5 then wet, light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; 10% cobbles at 5-12 inches; maximum size, 7 inches, determined by visual observations of material returned outside the auger flights.

15.0 to 19.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: A sampling barrel was used to retrieve foundation material from this interval: About 50% coarse to fine, hard, angular to subangular gravel with elongate shapes present; about 40% coarse to fine, hard, subangular to rounded sand; about 10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 2 inches; wet, gray to brown with a large variety of colors in individual particles; no to weak cementation; no reaction with HCl.

Total sample (by volume): About 25% cobbles at 3-5 inches; maximum size recovered, 4 inches.

19.0 to 24.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 55% coarse to fine, hard, angular to subangular gravel with elongate shapes present; about 35% coarse to fine, hard, subangular to rounded sand; about 10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 3 inches; wet, gray to reddish brown with a large variety of colors in individual particles; weak cementation; weak reaction with HCl.

Total sample (by volume): About 20% cobbles at 3-5 inches; maximum size recovered, 6 inches.

24.0 to 29.0 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc: About 50% coarse to fine, hard, subangular to rounded sand; about 30% fine, hard, angular to subangular gravel with some elongated shapes present; about 20% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 1 inch; wet, tri-color, red, green, brown with a large variety of colors in individual particles, weak cementation, weak reaction with HCl.

Total sample (by volume): About 15% cobbles at 3-5 inches; maximum size recovered, 6 inches.

COMMENTS:

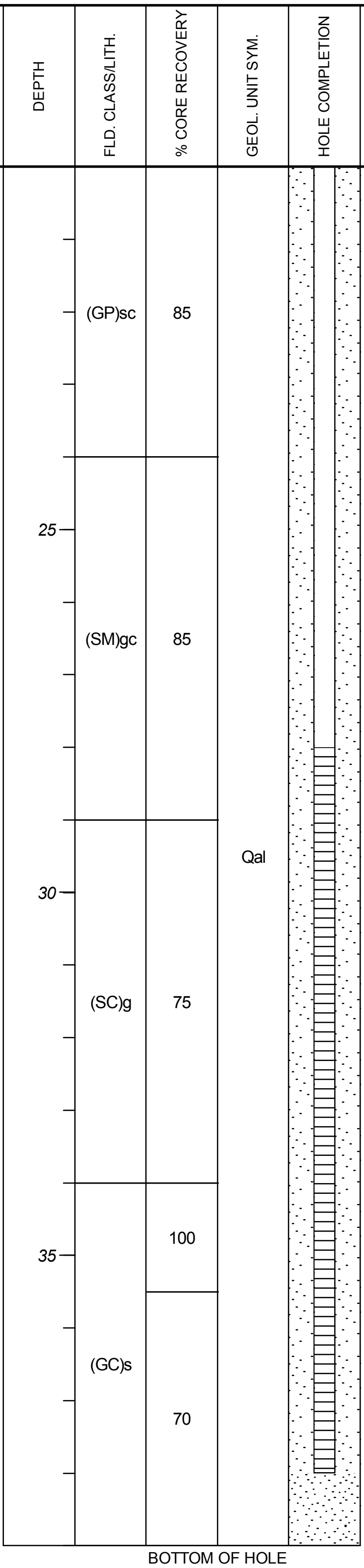
GEOLOGIC LOG OF DRILL HOLE NO. OW-13-E

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Left bank of diversion canal
BEGUN: 8/4/13 FINISHED: 8/7/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 9.5 (4471.2) 08/07/13

PROJECT: Milk River
COORDINATES: N 1,701,526.0 E 1,025,799.0
TOTAL DEPTH: 39.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4480.7 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: J. Earle
REVIEWED BY: C. Sullivan

NOTES



CLASSIFICATION AND PHYSICAL CONDITION

<u>29.0 to 34.0 ft. CLAYEY SAND WITH GRAVEL (SC)g:</u> About 50% medium to fine, hard, subrounded to rounded sand; about 25% coarse to fine, hard, angular to subangular gravel with some elongate shapes present; about 25% medium plasticity fines, medium dry strength, medium toughness, slow dilatancy; maximum size recovered, 2.5 inches; wet, black to brown with a large variety of colors in individual particles, weak cementation, no reaction with HCl.

<u>34.0 to 39.0 ft. CLAYEY GRAVEL WITH SAND (GC)s:</u> About 60% coarse to fine, hard, subrounded to rounded gravel; about 20% medium to fine, hard, subrounded to rounded sand; about 20% medium plasticity fines, medium dry strength, medium toughness, slow dilatancy; maximum size recovered, 2.5 inches; wet, black to brown with a large variety of colors in individual particles, weak cementation, no reaction with HCl.

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-F

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Peninsula closest to St. Mary Diversion Dam
BEGUN: 8/15/13 FINISHED: 8/17/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 14.5 (4470.9) 08/16/13

PROJECT: Milk River
COORDINATES: N 1,701,560.0 E 1,025,951.0
TOTAL DEPTH: 40.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4485.4 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES

LOCATION:
Peninsula between St. Mary River and St. Mary Canal, about 85 ft from NW corner of the diversion structure

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HSA) with 5-foot long split sample barrel

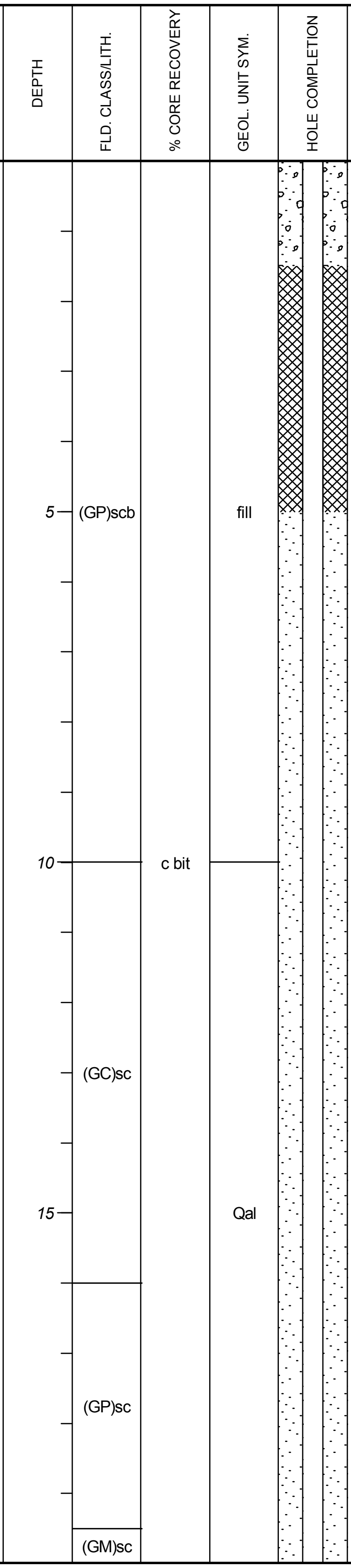
DRILLING METHODS:
0.0 to 20.0 cored with 4-¼ " I.D. HSA and center bit.
20.0 to 40.0 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper

DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
08-15-13, 13.0, ---
08-16-13, 25.0, 14.5
08-17-13, 40.0, 14.5

HOLE COMPLETION:
40.0 - 38.0 filter sand #10-20
38.0 - 28.0 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
28.0 - 5.0 filter sand #10-20 for influence zone
5.0 - 1.5 filled with bentonite chips
1.5 - 0.0 placed mortar cement and set steel stand pipe
1.74 = stickup on PVC (elev= 4487.14)



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 10.0 ft. Embankment Fill:

0.0 to 10.0 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: About 70-75% coarse to fine, hard, angular to subrounded gravel with flat and elongated shapes present; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5-10% low plasticity fines with low dry strength, low toughness, slow dilatancy; dry; overall light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

Total sample (by volume): About 25-30% cobbles at 3-5 inches; 10-15% cobbles at 5-12 inches; 5-10% boulders; maximum size observed, 15 inches, determined by visual observations of surface exposure.

10.0 to 40.0 ft. Quaternary Alluvium:

10.0 to 16.0 ft. CLAYEY GRAVEL WITH SAND AND COBBLES (GC)sc: Gradations are estimated from auger cuttings and drilling conditions: About 50% coarse to fine, hard, subangular to subrounded gravel; about 35% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines with low to medium dry strength, low toughness, no dilatancy; dry to 14.5 ft. then wet; medium brown with a large variety of colors in individual particles; no cementation; weak reaction with HCl.

Total sample (by volume): About 15-20% cobbles at 3-5 inches; 5% cobbles at 5-12 inches; maximum size recovered, 6.5 inches, determined by visual observations of material returned outside the auger flights.

16.0 to 19.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Gradations are estimated from material remaining on the center bit as it was extracted from drill hole: About 55% coarse to fine, hard, angular to subrounded gravel; about 40% coarse to fine, hard, subangular to subrounded sand: about 5% nonplastic fines; wet; dark gray to brown with a large variety of colors are present in individual particles; uncemented; no reaction with HCl.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; 5% cobbles at 5-12 inches; maximum size recovered, 6.5 inches, determined by visual observations of material returned outside the auger flights.

19.5 to 22.5 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:
A sampling barrel was used to retrieve foundation material from this interval: About 45% coarse to fine, hard, subangular to subrounded gravel; about 40% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines with low dry strength, no toughness, slow dilatancy; wet; medium gray to brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; 5% cobbles at 5-12 inches; maximum size recovered, 6 inches, determined by visual observations of material returned outside the auger flights.

22.5 to 25.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 60% coarse to fine, hard, subangular to subrounded gravel; about 30% coarse to fine, hard, subangular to rounded sand; about 10% nonplastic fines; wet; medium brown with a large variety of colors in individual particles; no cementation; firm consistency; no reaction with HCl.

25.5 to 27.0 ft. LEAN CLAY WITH SAND (CL)s: About 75% low

COMMENTS:

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-F

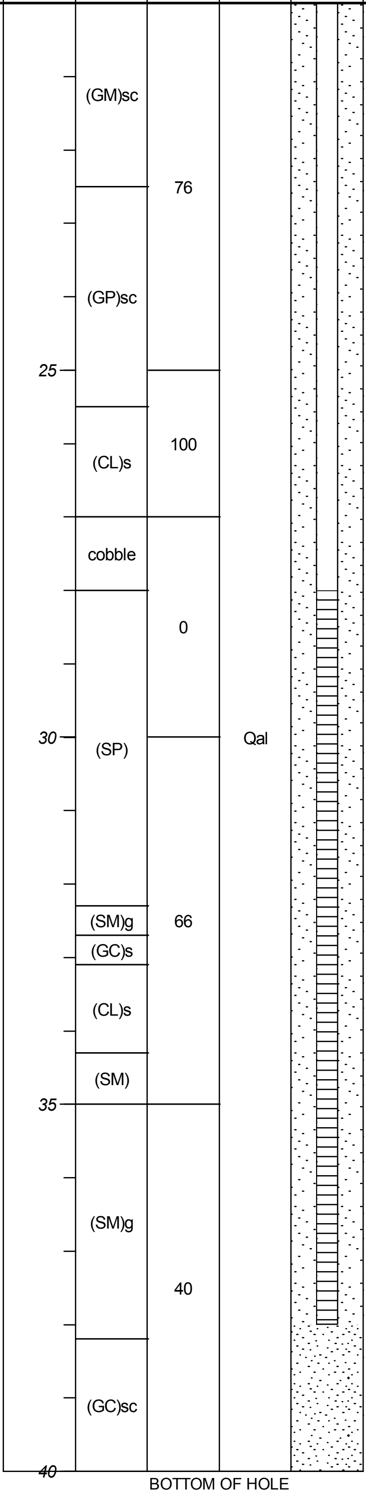
SHEET 2 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Peninsula closest to St. Mary Diversion Dam
BEGUN: 8/15/13 FINISHED: 8/17/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 14.5 (4470.9) 08/16/13

PROJECT: Milk River
COORDINATES: N 1,701,560.0 E 1,025,951.0
TOTAL DEPTH: 40.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4485.4 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES	DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION



plasticity fines, medium dry strength, low to medium toughness, no dilatancy: about 20% medium to predominately fine, hard, subrounded to rounded sand: about 5% fine, hard, subrounded gravel: maximum size recovered, 3/8 inches; wet; very soft to soft consistency; no reaction with HCl.

When the sample barrel was returned to the hole, 1.5 ft. of fine-grained foundation material had heaved into the hole. The hole was filled with water and heaved material was removed.

<u>27.0 to 28.0 ft. LARGE COBBLE:</u> A large sandstone cobble blocked the bottom of the sample barrel so no recovery was possible. This rock was pushed through the softer material to the end of the run and removed from the barrel so sampling could resume. Most likely the foundation materials are reflected in the interval above and below this blockage.

<u>28.0 to 32.3 ft. POORLY GRADED SAND (SP):</u> About 95% coarse to predominately fine, hard, subrounded to rounded sand, with some elongated shapes; about 5% nonplastic fines with rapid dilatancy; maximum size recovered, coarse sand; wet; dark gray to medium brown; no cementation; soft consistency; no reaction with HCl.

<u>32.3 to 32.7 ft. SILTY SAND WITH GRAVEL (SM)g:</u> About 70% coarse to fine, hard, subrounded to rounded sand; about 15% fine, hard, subrounded gravel; about 15% nonplastic fines with slow dilatancy; maximum size recovered, 0.5 inch; wet; medium brown with stringers of light gray; no cementation; firm consistency; no reaction with HCl.

<u>32.7 to 33.1 ft. CLAYEY GRAVEL WITH SAND (GC)s:</u> About 50% coarse to fine, hard, subangular to subrounded gravel; about 30% coarse to fine, hard, subangular to rounded sand; about 20% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 1.5 inches; wet; medium brown with a large variety of colors present in individual particles; no reaction with HCl.

<u>33.1 to 34.3 ft. LEAN CLAY WITH SAND (CL)s:</u> About 65% low plasticity fines, medium dry strength, low to medium toughness, no dilatancy: about 35% medium to predominately fine, hard, subrounded to rounded sand; maximum size recovered, medium sand; wet; light gray to orangish light brown with small blebs of medium sand and some light colored lamina; soft to moderately firm consistency; no reaction with HCl.

<u>34.3 to 35.0 ft. SILTY SAND (SM):</u> About 75% coarse to fine, hard, subrounded to rounded sand; about 15% nonplastic fines with rapid dilatancy; about 10% fine, hard, subrounded gravel; maximum size recovered, 0.5 inch; wet; medium gray with a large variety of colors present in individual particles; no cementation; soft consistency; no reaction with HCl.

<u>35.0 to 38.2 ft. SILTY SAND WITH GRAVEL (SM)g:</u> About 65% coarse to fine, hard, subangular to subrounded sand; about 20% coarse to fine, hard, subangular to subrounded gravel; about 15% nonplastic fines with rapid dilatancy; maximum size recovered, 0.875 inch; wet; medium brown with stringers of light gray; no cementation; firm consistency; no reaction with HCl.

<u>38.2 to 40.0 ft. CLAYEY GRAVEL WITH SAND AND COBBLES (GC)sc:</u> About 50% coarse to fine, hard, subangular to subrounded gravel with some elongated and flat shapes present; about 30% coarse to fine, hard, subangular to rounded sand; about 20% low plasticity fines, low dry strength, slow dilatancy, low toughness; wet; medium brown with a large variety of colors present in individual particles; no reaction with HCl.

Total sample (by volume): About 15-20% cobbles at 3-5 inches; maximum size recovered, 4 inches.

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-G

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Peninsula along left bank of St. Mary River
BEGUN: 9/13/13 FINISHED: 9/14/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 8.7 (4476.3) 09/14/13

PROJECT: Milk River
COORDINATES: N 1,701,710.0 E 1,025,963.0
TOTAL DEPTH: 40.5
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4485.0 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES

LOCATION:
Peninsula between St. Mary River and St. Mary Canal, about 245 ft from NW corner of the diversion structure

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HSA) with 5-foot long split sample barrel

DRILLING METHODS:
0.0 to 25.0 cored with 4-¼ " I.D. HSA and center bit.
25.0 to 40.5 cored with 4-¼ " I.D. HSA and split barrel sampler.

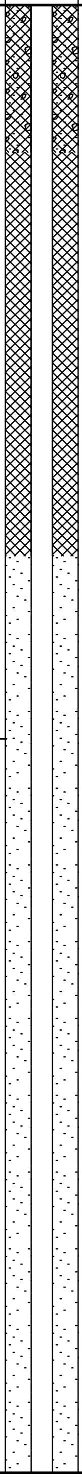
DRILLER:
S. Rafferty (USBR)
R. Perez, helper

DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
09-13-13, 25.0, 16.2
09-14-13, 40.5, 18.7
10-22-13, 40.5, 20.9

HOLE COMPLETION:
40.5 - 39.5 filter sand #10-20
39.5 - 29.5 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
29.5 - 7.5 filter sand #10-20 for influence zone
7.5 - 2.0 filled with bentonite chips
2.0 - 0.0 placed mortar cement and set steel stand pipe
3.66 ft = stickup on PVC (elev= 4488.66)

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION
5	(GP)scb		fill	
10		c bit		
15	(GP)sc		Qal	



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 10.0 Road Fill:

0.0 to 10.0 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: About 70-75% coarse to fine, hard, angular to subrounded gravel with flat and elongated shapes present; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5-10% low plasticity fines with low dry strength, low toughness, slow dilatancy; dry; overall light to medium brown with a large variety of colors in individual particles; no to weak reaction with HCl.

Total sample (by volume): About 25-30% cobbles at 3-5 inches; 10-15% cobbles at 5-12 inches; 5-10% boulders; maximum size observed, 15 inches, determined by visual observations of surface exposure.

10.0 to 40.5 ft. Quaternary Alluvium:

10.0 to 20.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Gradations are estimated from material return outside augers remaining on the center bit as it was extracted from drill hole: About 55% coarse to fine, hard, angular to subrounded gravel; about 40% coarse to fine, hard, subangular to subrounded sand; about 5% nonplastic fines; dry to 16.2, then wet; dark gray to medium brown with a large variety of colors are present in individual particles; uncemented; no to weak reaction with HCl.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; 5% cobbles at 5-12 inches; maximum size recovered, 6.5 inches, determined by visual observations of material returned outside the auger flights.

20.0 to 25.0 ft. SILTY GRAVEL WITH SAND (GM)s: Gradations are estimated from auger cuttings and smoother drilling conditions: About 50% coarse to fine, hard, subangular to subrounded gravel with flat and elongated shapes present; about 35% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; wet; medium brown with a large variety of colors in individual particles; no cementation; weak reaction with HCl.

25.0 to 28.5 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc: A sampling barrel was used to retrieve foundation material from this interval: About 50% coarse to fine, hard, subangular to subrounded gravel; about 35% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines with low dry strength, no toughness, slow dilatancy; wet; light brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

Total sample (by volume): About 15-20% cobbles at 3-5 inches; maximum size recovered, 4 inches.

28.5 to 37.0 ft. CLAYEY GRAVEL WITH SAND AND COBBLES (GC)sc: About 45% coarse to fine, hard, subangular to subrounded gravel with some flat and elongated shapes present; about 40% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines, low to medium dry strength, no dilatancy, low to medium toughness; wet; medium brown with a large variety of colors present in individual particles; no reaction with HCl.

Total sample (by volume): About 10% cobbles at 3-5 inches; maximum size recovered, 4 inches.

37.0 to 40.5 ft. SILTY GRAVEL WITH SAND (GM)s: About 50% coarse to fine, hard, subangular to subrounded gravel; about 35% coarse to fine, hard, subangular to rounded sand; about 15% low

COMMENTS:

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-G

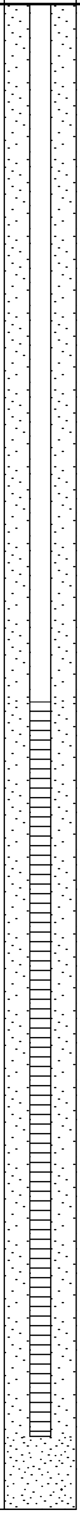
SHEET 2 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Peninsula along left bank of St. Mary River
BEGUN: 9/13/13 FINISHED: 9/14/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 8.7 (4476.3) 09/14/13

PROJECT: Milk River
COORDINATES: N 1,701,710.0 E 1,025,963.0
TOTAL DEPTH: 40.5
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4485.0 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES	DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
		(GM)s	c bit			plasticity fines with low dry strength, no toughness, slow dilatancy; maximum size recovered, 2 inches; wet; light brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.
	25	(GM)sc	62			
	30	(GC)sc	54	Qal		
	35		40			
	40	(GM)s				



BOTTOM OF HOLE

GEOLOGIC LOG OF DRILL HOLE NO. OW-13-H

SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Peninsula left of St. Mary River
BEGUN: 9/14/13 FINISHED: 9/15/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 20.2 (4464.8) 09/15/13

PROJECT: Milk River
COORDINATES: N 1,702,019.0 E 1,025,938.0
TOTAL DEPTH: 40.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4485.0 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES

LOCATION:
Peninsula between St. Mary River and St. Mary Canal, about 518 ft from the NW corner of the diversion structure

All measurements in feet unless otherwise noted

PURPOSE OF HOLE:
Investigate foundation physical properties and install observation well

DRILLING EQUIPMENT:
Truck mounted CME-85 drill; 4-¼" Hollow Stem Augers (HSA) with 5-foot long split sample barrel

DRILLING METHODS:
0.0 to 25.0 cored with 4-¼ " I.D. HSA and center bit.
25.0 to 40.0 cored with 4-¼ " I.D. HSA and split barrel sampler.

DRILLER:
S. Rafferty (USBR)
R. Perez, helper

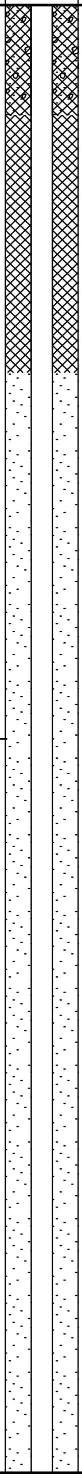
DRILLING COMMENTS:
None

WATER LEVELS:
Date/ hole depth/ water level
09-14-13, 20.0, 18.5
09-15-13, 40.0, 20.2

HOLE COMPLETION:
40.0 - 39.0 filter sand #10-20
39.0 - 29.0 10-ft long slotted pipe section of white 2-inch diameter PVC pipe surrounded by sand
29.0 - 5.0 filter sand #10-20 for influence zone
5.0 - 1.5 filled with bentonite chips
1.5 - 0.0 placed mortar cement and set steel stand pipe
3.26 ft = stickup on PVC (elev = 4488.26)

DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.
	(GP)scb		
5			fill
	cobble		
	(GP)c		
10		c bit	
	(GP)sc		
	cobble		
15			Qal
	(GP)sc		
	(SM)gc		

HOLE COMPLETION



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 10.0 ft. Embankment Fill:

0.0 to 10.0 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:
Gradations are estimated from auger cuttings and drilling conditions: About 70-75% coarse to fine, hard, angular to subrounded gravel with flat and elongated shapes present; about 15-20% coarse to fine, hard, subangular to subrounded sand; about 5-10% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 2.5 inches; dry; no cementation; overall light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

Total sample (by volume): About 30% cobbles at 3-5 inches; about 20% cobbles at 5-12 inches; about 5% boulders maximum size, 14 inches, determined by visual observations of surface exposure.

10.0 to 40.0 ft. Quaternary Alluvium:

10.0 to 18.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: Gradations are estimated from auger cuttings and drilling conditions: About 45-50% coarse to fine, hard, angular to subrounded gravel, with some elongated shapes; about 40-45% coarse to fine, hard, subangular to rounded sand; about 5-10% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 2.5 inches; dry; light to medium brown; no reaction with HCl.

Cobble to boulder sized rocks were encountered at 13.0, 14.5 and 18.5 feet which temporarily stopped progress and took time to break or move past the centerbit so progress could continue.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; 10% cobbles at 5-12 inches; maximum size, 5 inches, determined by visual observations of material returned outside the auger flights.

18.5 to 20.5 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:
Gradations are estimated from auger cuttings and drilling conditions: About 45% coarse to fine, hard, subangular to rounded sand; about 40% coarse to fine, hard, subangular to subrounded gravel; about 15% nonplastic fines with rapid dilatancy; maximum size recovered, 3 inches; wet; light to medium brown with a large variety of colors present in individual particles; no cementation; firm consistency; weak reaction with HCl.

Total sample (by volume): About 10-15% cobbles at 3-5 inches; about 5% cobbles at 5-12 inches; maximum size, 6 inches, determined by visual observations of material returned outside the auger flights.

20.5 to 23.5 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:
Gradations are estimated from auger cuttings and drilling conditions: About 50% coarse to fine, hard, subangular to subrounded gravel; about 35% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 3 inches; wet; medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

Total sample (by volume): About 10% cobbles at 3-5 inches; about 5% cobbles at 5-12 inches; maximum size, 6.5 inches, determined by visual observations of material returned outside the auger flights.

23.5 to 27.8 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: A sampling barrel was used to retrieve foundation material from most of this interval: About 75% coarse to fine, hard, subangular to rounded sand; about 20% coarse to fine, hard, angular to subrounded gravel;

COMMENTS:

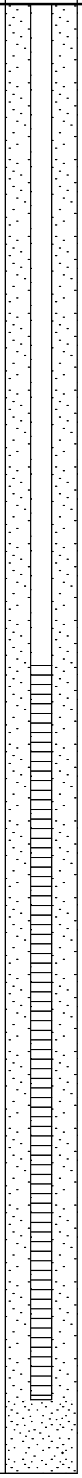
GEOLOGIC LOG OF DRILL HOLE NO. OW-13-H

FEATURE: St. Mary Diversion Dam Modifications
LOCATION: Peninsula left of St. Mary River
BEGUN: 9/14/13 FINISHED: 9/15/13
DEPTH AND ELEVATION OF WATER
AND DATE MEASURED: 20.2 (4464.8) 09/15/13

PROJECT: Milk River
COORDINATES: N 1,702,019.0 E 1,025,938.0
TOTAL DEPTH: 40.0
DEPTH TO BEDROCK: N/E

STATE: Montana
GROUND ELEVATION: 4485.0 ft.
ANGLE FROM HORIZONTAL: -90 AZIMUTH:
HOLE LOGGED BY: C. Sullivan
REVIEWED BY: J. Earle

NOTES	DEPTH	FLD. CLASS/LITH.	% CORE RECOVERY	GEOL. UNIT SYM.	HOLE COMPLETION
		(SM)gc	c bit	Qal	
		(GM)sc			
	25	(SP)g	70		
		(GP)sc			
		(GM)sc			
	30	(GC)sc	60		
	35		60		
	40				



BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

about 5% low plasticity fines, low dry strength, slow dilatancy, low toughness; maximum size recovered, 1.5 inches; wet; light to medium brown with a large variety of colors in individual particles; no reaction with HCl.

27.8 to 28.2 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 50% coarse to fine, hard, subangular to subrounded gravel; about 40% coarse to fine, hard, subangular to rounded sand; about 10% nonplastic fines; maximum size recovered, 2.25 inches; wet; medium brown with a large variety of colors in individual particles; no cementation; firm consistency; weak reaction with HCl.

Total sample (by volume): About 15% cobbles at 3-5 inches; maximum size recovered, 5.2 inches.

28.2 to 29.8 ft. SILTY GRAVEL WITH SAND WITH COBBLES (GM)sc: About 45% coarse to fine, hard, subangular to subrounded gravel; about 40% coarse to fine, hard, subangular to rounded sand; about 15% low plasticity fines with low dry strength, low toughness, slow dilatancy; maximum size recovered, 2.5 inches; wet; medium brown with a large variety of colors in individual particles; no cementation; no reaction with HCl.

Total sample (by volume): About 5% cobbles at 3-5 inches; maximum size recovered, 5 inches.

29.8 to 40.0 ft. CLAYEY GRAVEL WITH SAND AND COBBLES (GC)sc: About 45-55% coarse to fine, hard, subangular to subrounded gravel with some flat and elongated shapes present; about 20-35% coarse to fine, hard, subangular to rounded sand; about 15-25% medium plasticity fines, medium dry strength, low toughness, no dilatancy; maximum size recovered, 3 inches; wet; medium gray to medium brown with a large variety of colors in individual particles, very firm consistency, no reaction with HCl.

Total sample (by volume): About 5-10% cobbles at 3-5 inches; maximum size recovered, 5 inches.

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO: TP11-1BC** **SHEET 1 OF 2**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Temp. bypass channel
COORDINATES: N52010.1; E25855.8
APPROXIMATE DIMENSIONS: 13.0’x 3.0’x 12.5’ deep
DEPTH TO WATER: 12.5 ft. DATE: 6/7/2011

PROJECT: Milk River Project
GROUND ELEVATION: 4481.7
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 inch (BY VOLUME)		
		3 – 5 inch	5 – 12 inch	PLUS 12 Inch
(visual) Cobbles and Boulders (Lab Class) GP-GC 12.5ft	0.0 to 12.5 ft. COBBLES AND BOULDERS WITH GRAVEL AND SAND: Total Sample (by volume) - Approximately 45% 5-to-12in., hard, rounded cobbles; Approximately 25% 3-to-5 in., hard, rounded cobbles; and approximately 5% plus 12-inch. Rock is approximately 80% sedimentary: (~55% limestone/dolomite; ~25% sandstone); approximately 15% metamorphic rock composed of predominantly of quartzite; approximately 5 percent or less of igneous rock composed of granite and gabbro; Quartzite, granite, and gabbro rocks are moderately weathered (W5) – rock surface chipped into approximately diameter or less when struck with heavy manual pressure by a rock hammer. Quartzite is sugary textured and red and green in color while granite and gabbro are coarse-grained and varicolored. Limestone and dolomite rocks are fine-grained, light yellow to tan, moderately hard (H4), can be scratched with moderate pressure with a knife. Limestone had vigorous reaction with HCl; Dolomite had vigorous reaction with HCl after being scratched. Sandstone is tan to yellow-brown, fine-grained, soft (H6), can be scratched with light moderate pressure with a fingernail. All rocks appeared to have a visual field durability index of DI0. Minus 3-inch fraction (by mass): Approximately 70% fine to predominantly coarse sand; approximately 30% fine to coarse, hard, subrounded to rounded gravel composed predominantly of quartzite; maximum dimension recovered, 1.5 ft.; no reaction with HCl. IN-PLACE CONDITION: Relatively homogenous, light brown; dry to 10.0 ft.; moist to12.0 ft.; and wet 12.0-12.5ft. LAB TEST DATA: 6 50lb bag sample (0.0 to 12.5ft): +3 in. 95.2%; 3.3% Gravel; 1.2% Sand; 0.3% fines. +3 in.% scrapped off: 69.1% Gravel; 23.7% Sand; 7.2% Fines. PL=20; PL=27; PI=7 GEOLOGIC INTERPRETATION: Quaternary alluvium	45	25	5

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO: TP11-1BC** **SHEET 2 OF 2**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Temp. bypass channel
COORDINATES: N52010.1; E25855.8
APPROXIMATE DIMENSIONS: 13.0’x 3.0’x 12.5’ deep
DEPTH TO WATER: 12.5 ft. **DATE:** 6/7/2011

PROJECT: Milk River Project
GROUND ELEVATION: 4481.7
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	**CLASSIFICATION AND DESCRIPTION OF MATERIAL** **SEE USBR 5000, 5005**	**% PLUS 3 inch (BY VOLUME)**		
		3 – 5 inch	**5 – 12 inch**	**PLUS 12 Inch**

REMARKS: Site is covered in boulders, cobbles and gravels composed of predominantly quartzite. Few rocks on the ground surface exhibited fracturing on their faces; some open as much as 1/4 in. with no infilling, subsurface materials outside of the selected test pit area may also contain surface fracturing on rock faces. These rocks should be avoided. Grasses and some shrubs are common; shrubs were avoided. The test pit was terminated at 12.5 ft after equipment encountered (repeated) excessive caving due to loosely compacted material. Pump tests could not be performed due to excessive caving. Excavations were slow and difficult as a consequence to oversize material. Encountered water at 12.5 ft. Flow rates were documented at approximately 50 gallons per minute based on visual classification from ground surface.

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO: TP11-2BC** **SHEET 1 OF 3**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Temp. bypass channel
COORDINATES: N52759.8; E26016.2
APPROXIMATE DIMENSIONS: 12.5'x 5.2'x 12.0' deep
DEPTH TO WATER: 12.0 ft. DATE: 6/7/2011

PROJECT: Milk River Project
GROUND ELEVATION: 4477.8
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	**CLASSIFICATION AND DESCRIPTION OF MATERIAL** **SEE USBR 5000, 5005**	**% PLUS 3 inch (BY VOLUME)**		
		3 – 5 inch	**5 – 12 inch**	**PLUS 12 Inch**
(visual) SC (Lab Class) SC 4.0ft	0.0 to 4.0 ft. CLAYEY SAND: Approximately 50% predominantly fine sand; approximately 35% medium plasticity fines; approximately 30% fine sand; approximately 15% fine to coarse, hard, subrounded to rounded gravel composed of quartzite; maximum dimension recovered, 2.5in.; Heavily rooted from approximately 0.0 to 3.5 feet. No reaction with HCl. IN-PLACE CONDITION: Relatively homogenous, light brown; dry. LAB TEST DATA: 1 50lb bag sample (0.0 to 2.0 ft.); 42.1% Fines; 40.4% Sand; 17.5% Gravel; PL =18; LL=26; PI=8 GEOLOGIC INTERPRETATION: Quaternary alluvium			
(visual) ((GP)s) (Lab Class) GP-GC 5.0 ft	4.0 to 5.0 ft. POORLY GRADED GRAVEL WITH SAND WITH A TRACE OF COBBLES: Approximately 65% fine to predominantly fine to coarse, hard, subrounded to rounded gravel composed predominantly of weathered quartzite; Approximately 35% coarse sand; approximately 5% fines; trace of hard, subrounded to rounded cobbles composed predominantly of weathered limestone, dolomite, and sandstone with traces of quartzite, granite, and gabbro; maximum dimension recovered, 8 in. Quartzite, granite, and gabbro rocks are moderately weathered (W5) – rock surface chipped into approximately 1/4 in. diameter or less when struck with heavy manual pressure by a rock hammer. Quartzite is sugary textured and red and green in color while granite and gabbro are coarse-grained and varicolored. Limestone and dolomite rocks are fine-grained, light yellow to tan, moderately hard (H4), can be scratched with moderate pressure with a knife. Limestone had vigorous reaction with HCl; Dolomite had vigorous reaction with HCl after being scratched. Sandstone is tan to yellow-brown, fine-grained, soft (H6), can be scratched with light moderate pressure with a fingernail. All rocks appeared to have a visual field durability index of DI0. IN-PLACE CONDITION: Relatively homogenous, light brown, dry, loose. LAB TEST DATA: 4 50lb bag sample (2.0 to 12.5 ft.): +3 in. 67.3%; 3.3% Gravel; 1.2% Sand; 0.3% fines. +3 in. % scalped off: 61.9% Gravel; 30.5% Sand; 7.6% Fines. PL=17; PL=21; PI=4. GEOLOGIC INTERPRETATION: Quaternary alluvium	T	T	

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO: TP11-2BC** **SHEET 2 OF 3**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Temp. bypass channel
COORDINATES: N52759.8; E26016.2
APPROXIMATE DIMENSIONS: 12.5’x 5.2’x 12.0’ deep
DEPTH TO WATER: 12.0 ft. **DATE:** 6/7/2011

PROJECT: Milk River Project
GROUND ELEVATION: 4477.8
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 inch (BY VOLUME)		
		3 – 5 inch	5 – 12 inch	PLUS 12 inch
(visual) ((GP)sc)	5.0 to 12.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES: Approximately 65% fine to predominantly fine to coarse, hard, subrounded to rounded gravel composed predominantly of weathered quartzite; Approximately 35% coarse sand; approximately 5% fines; trace of hard, subrounded to rounded cobbles composed predominantly of weathered limestone, dolomite, and sandstone with traces of quartzite, granite, and gabbro; maximum dimension recovered, 8 in.; No reaction with HCl.			
(Lab Class) GP-GC	Total Sample (by volume) - Approximately 15% 3-to-5 in., hard, rounded cobbles composed predominantly of quartzite; approximately 10% 5-to-12in., hard, rounded cobbles composed predominantly of quartzite; trace of 5% plus 12-inch. Rock is approximately 75% sedimentary: (~45% limestone/dolomite; ~30% sandstone); approximately 20% metamorphic rock composed of predominantly of quartzite; and approximately 5% or less of igneous rock composed of granite and gabbro. Quartzite, granite, and gabbro rocks are moderately weathered (W5) – rock surface chipped into approximately 1/4 in. diameter or less when struck with heavy manual pressure by a rock hammer. Quartzite is sugary textured and red and green in color while granite and gabbro are coarse-grained and varicolored. Limestone and dolomite rocks are fine-grained, light yellow to tan, moderately hard (H4), can be scratched with moderate pressure with a knife. Limestone had vigorous reaction with HCl; Dolomite had vigorous reaction with HCl after being scratched. Sandstone is tan to yellow-brown, fine-grained, soft (H6), can be scratched with light moderate pressure with a fingernail. All rocks appeared to have a visual field durability index of DI0.	15	10	T
	IN-PLACE CONDITION: Relatively homogenous, light brown, dry, loose; dry 5.0 to 10.0 ft; moist to wet 10.0 to 12.0 ft.			
	LAB TEST DATA: 4 50lb bag sample (2.0 to 12.5 ft.): +3 in. 67.3%; 3.3% Gravel; 1.2% Sand; 0.3% fines. +3 in. % scalped off: 61.9% Gravel; 30.5% Sand; 7.6% Fines. PL=17; PL=21; PI=4.			
12.0 ft	GEOLOGIC INTERPRETATION: Quaternary alluvium			

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO:** **TP11-2BC** **SHEET 3 OF 3**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Temp. bypass channel
COORDINATES: N52759.8; E26016.2
APPROXIMATE DIMENSIONS: 12.5’x 5.2’x 12.0’ deep
DEPTH TO WATER: 12.0 ft. **DATE:** 6/7/2011

PROJECT: Milk River Project
GROUND ELEVATION: 4477.8
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	**CLASSIFICATION AND DESCRIPTION OF MATERIAL** **SEE USBR 5000, 5005**	**% PLUS 3 inch (BY VOLUME)**		
		3 – 5 inch	**5 – 12 inch**	**PLUS 12 inch**

REMARKS: Site is covered in boulders, cobbles and gravels composed of predominantly quartzite. Grasses and some shrubs are common; shrubs were avoided.

The test pit was terminated at 12.0 ft after equipment encountered (repeated) excessive caving due to loosely compacted material. Pump tests could not be performed due to excessive caving.

Excavations were relatively easy and quick due to less oversize material and more sand and gravels.

Encountered water at 12.0 ft. Flow rates were documented at approximately 30 gallons per minute based on visual classification from ground surface.

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO: TP11-3BC** **SHEET 1 OF 2**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Temp. bypass channel
COORDINATES: N53439.9; E26041.2
APPROXIMATE DIMENSIONS: 13.0’x 5.0’x 9.0’ deep
DEPTH TO WATER: 8.5 ft. **DATE:** 6/7/2011

PROJECT: Milk River Project
GROUND ELEVATION: 4472.6
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 inch (BY VOLUME)		
		3 – 5 inch	5 – 12 inch	PLUS 12 inch
(visual) (s(CL)) (Lab Class) CL 5.0ft	0.0 to 5.0 ft. SANDY LEAN CLAY: Approximately 65% predominantly medium plasticity fines; approximately 30% fine sand; 5% fine to coarse, hard, subrounded to rounded gravel composed of quartzite; maximum dimension recovered, 2.5 in. in diameter; no reaction with HCl. Heavily rooted from approximately 0.0 to 3.5 feet. IN-PLACE CONDITION: Relatively homogenous, light brown; dry. LAB TEST DATA: 2 50lb bag sample (0.0 to 4.0 ft.); 57.2% Fines; 33.8% Sand; 9% gravel. PL=18; LL=31; PI=13. GEOLOGIC INTERPRETATION: Quaternary alluvium			
(visual) Cobbles and boulders (Lab Class) GC-GM 9.0 ft	5.0 to 9.0 ft. COBBLES AND BOULDERS WITH GRAVEL AND SAND: Total Sample (by volume) - Approximately 45% 3-to-5 in., hard, rounded cobbles composed predominantly of quartzite; approximately 20% 5-to-12in., hard, rounded cobbles composed predominantly of quartzite; and approximately 5% plus 12-inch. Rock is approximately 75% sedimentary: (~55% limestone/ dolomite; ~25% sandstone); approximately 20% metamorphic rock composed of predominantly of quartzite; and approximately 5% or less of igneous rock composed of granite and gabbro. Quartzite, granite, and gabbro rocks are moderately weathered(W5) – rock surface chipped into approximately 1/4 in. diameter or less when struck with heavy manual pressure by a rock hammer. Quartzite is sugary textured and red and green in color while granite and gabbro are coarse-grained and varicolored. Limestone and dolomite rocks are fine-grained, light yellow to tan, moderately hard (H4), can be scratched with moderate pressure with a knife. Limestone had vigorous reaction with HCl; Dolomite had vigorous reaction with HCl after being scratched. Sandstone is tan to yellow-brown, fine-grained, soft (H6), can be scratched with light moderate pressure with a fingernail. All rocks appeared to have a visual field durability index of DI0. Minus 3-inch fraction (by mass): Approximately 65% predominantly coarse sand; approximately 30% fine to coarse, hard, subrounded to rounded gravel composed predominantly of quartzite; approximately 5% fines; maximum dimension recovered, 2.5 in.; no reaction with HCl.	45	20	5

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO: TP11-3BC** **SHEET 2 OF 2**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Temp. bypass channel
COORDINATES: N53439.9; E26041.2
DIMENSIONS: 13.0’x 5.0’x 9.0’ deep
DEPTH TO WATER: 8.5 ft. **DATE:** 6/7/2011

PROJECT: Milk River Project
GROUND ELEVATION: 4472.6
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	**CLASSIFICATION AND DESCRIPTION OF MATERIAL** **SEE USBR 5000, 5005**	**% PLUS 3 inch (BY VOLUME)**		
		3 – 5 inch	**5 – 12 inch**	**PLUS 12 inch**
(visual) Cobbles and boulders (Lab Class) GC-GM 9.0 ft	5.0 to 9.0 ft. COBBLES AND BOULDERS WITH GRAVEL AND SAND: IN-PLACE CONDITION: Relatively homogenous, light brown; dry to 7.5 ft.; moist to wet 7.5 to 9.0 ft. LAB TEST DATA: 4 50lb bag sample (5.0-9.0ft.): 77.1% +3 in.; 10.8% gravel; 7.3% Sand; 4.8% Fines. +3% scrapped off: 53.5% Sand; 35.7% Fines; 10.8% gravel. PL=18; LL=25; PI=7. GEOLOGIC INTERPRETATION: Quaternary alluvium	45	20	5

REMARKS: Excavations were smooth and easy yet challenging consequent to oversize material and (repeated) excessive hole cave. Test pit was terminated at 9.0 ft due to excessive wall cave due to loose materials and encountering water at 8.5ft. Once water was encountered materials became saturated. Flow rates were documented at approximately 45-50 gallons per minute based on visual classification from ground surface.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT

HOLE NO: **TP11-1OBP**
SHEET 1 OF 2

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Old Gravel Pit
COORDINATES: N52787.5; E24644.9
DIMENSIONS: 12.0′x 4.5′x 11.0′ deep
DEPTH TO WATER: N/A DATE: N/A

PROJECT: Milk River Project
GROUND ELEVATION: 4490.4
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	**CLASSIFICATION AND DESCRIPTION OF MATERIAL** **SEE USBR 5000, 5005**	**% PLUS 3 inch (BY VOLUME)**		
		3 – 5 inch	**5 – 12 inch**	**PLUS 12 inch**
(visual) Cobbles and Boulders (Lab Class) GW-GC 11.0 ft.	0.0 to 11.0 ft. COBBLES AND BOULDERS WITH GRAVEL AND SAND: Total sample (by volume) – Approximately 35% 5-to-12-inch hard (H3), predominantly rounded cobbles; approximately 15% 3-to-5-inch, hard (H3), predominantly subrounded to rounded cobbles with traces of angular, flat, and elongate cobbles; approximately 5% hard (H3), rounded boulders; remainder minus 3-inch; maximum dimension recovered, 1.8 ft. Rock is approximately 80% sedimentary: (~55% limestone/dolomite; ~25% sandstone); approximately 15% metamorphic rock composed of predominantly of quartzite; and approximately 5% or less of igneous rocks composed of granite and gabbro. Quartzite, granite, and gabbro rocks are moderately weathered (W5) – rock surface chipped into approximately 1/4 in. diameter or less when struck with heavy manual pressure by a rock hammer. Quartzite is sugary textured and red and green in color while granite and gabbro are coarse-grained and varicolored. Limestone and dolomite rocks are fine-grained, light yellow to tan, moderately hard (H4), can be scratched with moderate pressure with a knife. Limestone had vigorous reaction with HCl; Dolomite had vigorous reaction with HCl after being scratched. Sandstone is tan to yellow-brown, fine-grained, soft (H6), can be scratched with light moderate pressure with a fingernail. All rocks appeared to have a visual field durability index of DI0. Minus 3-inch fraction (by mass): Approximately 60% fine to coarse, subrounded to rounded gravel composed predominantly of quartzite; approximately 35% fine to coarse sand; approximately 5% fines; maximum dimension recovered, 2.5 in.; no reaction with HCl. IN-PLACE CONDITION: Relatively homogenous, light brown; dry. LAB TEST DATA: 4 50lb bag sample (0.0 to 9.0ft); 52.9% +3 in.; 28.5% Gravel; 16% Sand; 2.6% Fines. +3 in.% scalped off: 60.5% Gravel; 34% Sand; 5.5% Fines. PL=14; LL=20; PI=6. GEOLOGIC INTERPRETATION: Quaternary alluvium	35	15	5

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT

HOLE NO: **TP11-1OBP**
SHEET 2 OF 2

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Old Gravel Pit
COORDINATES: N52787.5; E24644.9
DIMENSIONS: 12.0'x 4.5'x 11.0' deep
DEPTH TO WATER: N/A DATE: N/A

PROJECT: Milk River Project
GROUND ELEVATION: 4490.4
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 inch (BY VOLUME)		
		3 – 5 inch	5 – 12 inch	PLUS 12 inch

REMARKS: Site is covered in boulders, cobbles and gravels composed of predominantly quartzite. Few rocks on the ground surface exhibited fracturing on their faces; some open as much as 1/4 in. with no infilling, subsurface materials outside of the selected test pit area may also contain surface fracturing on rock faces. These rocks should be avoided. Grasses and some shrubs are common; shrubs were avoided. The test pit was terminated at 12.5 ft after equipment encountered (repeated) excessive caving due to loosely compacted material. Pump tests were not performed due to encountering no water. Excavations were slow and difficult as a consequence to oversize material.

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO:** **TP11-2OPB** **SHEET 1 OF 2**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Old Gravel Pit
COORDINATES: N52414.5; E24294.7
DIMENSIONS: 13.5’x 4.0’x 10.0’ deep
DEPTH TO WATER: N/A DATE: N/A

PROJECT: Milk River Project
GROUND ELEVATION: 4500.3
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	**CLASSIFICATION AND DESCRIPTION OF MATERIAL** **SEE USBR 5000, 5005**	**% PLUS 3 inch (BY VOLUME)**		
		3 – 5 inch	**5 – 12 inch**	**PLUS 12 Inch**
1.0 ft	0.0 to 1.0 FILL – Mixture of rock chips and soil.			
(visual) Cobbles and Boulders (Lab Class) GP-GC 10.0ft	1.0 to 10.0 ft. COBBLES AND BOULDERS WITH GRAVEL AND SAND: Total sample (by volume) – Approximately 40% 5-to-12-inch hard (H3), predominantly rounded cobbles; approximately 15% 3-to-5-inch, hard (H3), predominantly subrounded to rounded cobbles with traces of angular, flat, and elongate cobbles; approximately 5% hard (H3), rounded boulders; remainder minus 3-inch; maximum dimension recovered, 1.8 ft. Rock is approximately 80% sedimentary: (~55% limestone/dolomite; ~25% sandstone); approximately 15% metamorphic rock composed predominantly of quartzite; and approximately 5% or less of igneous rock composed of granite and grabbro. Quartzite, granite, and gabbro rocks are moderately weathered (W5) – rock surface chipped into approximately 1/4 in. diameter or less when struck with heavy manual pressure by a rock hammer. Quartzite is sugary textured and red and green in color while granite and gabbro are coarse-grained and varicolored. Limestone and dolomite rocks are fine-grained, light yellow to tan, moderately hard (H4), can be scratched with moderate pressure with a knife. Limestone had vigorous reaction with HCl; Dolomite had vigorous reaction with HCl after being scratched. Sandstone is tan to yellow-brown, fine-grained, soft (H6), can be scratched with light moderate pressure with a fingernail. All rocks appeared to have a visual field durability index of DI0. Minus 3-inch fraction (by mass): Approximately 60% fine to coarse, subrounded to rounded gravel composed predominantly of quartzite; approximately 35% fine to coarse sand; maximum dimension recovered, 2.5 in.; approximately 5% fines; no reaction with HCl. IN-PLACE CONDITION: Relatively homogenous, light brown; dry. LAB TEST DATA: 5 50lb bag samples (0.0 to 10.0ft.): 61.6% +3 in.; 20.3% Gravel; 13.5% Sand; 4.6% Fines. +3 in. scalped off: 52.8% Gravel; 35.3% Sand; 11.9% Fines. GEOLOGIC INTERPRETATION: Quaternary alluvium	15	40	5

7-1336-A (1-86) Bureau of Reclamation	**LOG OF TEST PIT**	**HOLE NO: TP11-2OPB** **SHEET 2 OF 2**

FEATURE: St. Mary Diversion Dam
AREA DESIGNATION: Old Gravel Pit
COORDINATES: N52414.5; E24294.7
APPROXIMATE DIMENSIONS: 13.5’x 4.0’x 10.0’ deep
DEPTH TO WATER: N/A DATE: N/A

PROJECT: Milk River Project
GROUND ELEVATION: 4500.3
METHOD OF EXPLORATION: CAT 420E Backhoe
LOGGED BY: K.Baker
DATE(S) LOGGED: 6/7/2011

CLASSIFICATION GROUP SYMBOL (describe sample taken)	**CLASSIFICATION AND DESCRIPTION OF MATERIAL** **SEE USBR 5000, 5005**	**% PLUS 3 inch (BY VOLUME)**		
		3 – 5 inch	**5 – 12 inch**	**PLUS 12 Inch**

REMARKS: Site is covered in boulders, cobbles and gravels composed of predominantly quartzite. The test pit was terminated at 10.0 ft after equipment encountered (repeated) excessive caving due to loosely compacted material. Pump tests were not performed due to encountering no water. Excavations were slow and difficult as a consequence to oversize material.

5

GEOLOGIC LOG OF DRILL HOLE: DH02-FSN

SHEET 1 OF 1

FEATURE: No. Central Montana Regional Feasibility Study
LOCATION: North Side of Proposed Fish Screen
BEGUN: 4/26/02 FINISHED: 4/26/02
DEPTH AND ELEV. OF WATER
LEVEL AND DATE MEASURED: -14.5 (4466.5) 04/26/02

PROJECT: Milk River Project
COORDINATES: N 1,701,557 E 1,025,816
TOTAL DEPTH: 30.6
DEPTH TO BEDROCK: N. R.

STATE: Montana
GROUND ELEVATION: 4481.0
ANGLE FROM HORIZONTAL: -90 AZIMUTH: 0
HOLE LOGGED BY: P. Atherton
REVIEWED BY: L. Crutchfield

NOTES

Notes:
All measurements are in feet, from ground surface, unless otherwise noted.
N.M. = Not Measured
N.R. = Not Reached or not encountered.

LOCATION:
50 feet west of the turnout at St. Mary Diversion Dam, downstream from the existing dam, on the north bank of St. Mary Canal, Montana.

PURPOSE OF HOLE:
Investigate foundation conditions for building a fish screen at St. Mary River Turnout.

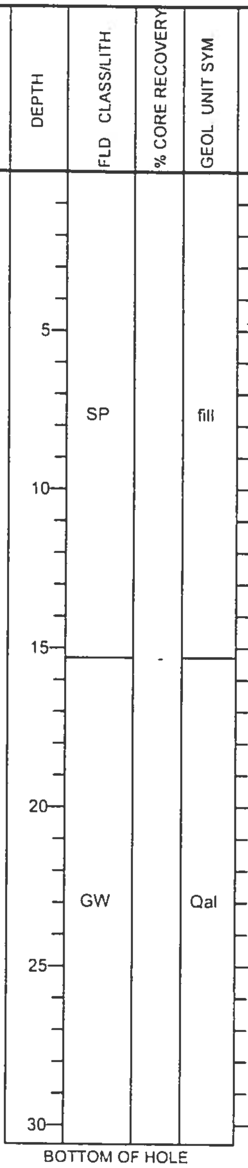
DRILL EQUIPMENT:
Truck mounted SIMCO AV5000, 3-1/2" O.D. rods, 5-7/8" tricone roller rockbit, 6" Aardvark casing.

DRILLING METHODS:
Rockbit and advance casing 0.0' to 30.6' with air as drilling medium

DRILLER
J. McLaughlan - USBR

WATER LEVEL:
14.5' on 04/26/02

HOLE COMPLETION:
Pulled Casing. Backfilled hole with 3/8" bentonite chips mixed with hole cuttings, then set fence post marker.



CLASSIFICATION AND PHYSICAL CONDITION

No intact sample recovered, hole drilled with tricone roller rockbit, the following estimates are based upon observation of cuttings and drilling conditions. Generally, recovered angular, fine hard gravel with varying amounts of angular to rounded fine to coarse sand with varying amounts of fines; predominantly flat fragments of volcanic, metamorphic, and sedimentary rock; moderate reddish brown to tan; moist to wet; maximum size recovered, 1".

0.0' to 15.3' - FILL:

0.0' to 15.3' - POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP): About 55% subrounded, fine to coarse, predominantly fine, sand; about 40% subrounded, fine to coarse, predominantly coarse gravel; about 5% fines of undetermined plasticity.

Total sample (by volume): About 10% 3-5"cobbles, a trace of 5-12" cobbles; maximum size, 7"

15.3' to 30.6' - QUATERNARY ALLUVIUM (Qal):

15.3' to 30.6' - WELL GRADED GRAVEL WITH SAND, COBBLES, AND BOULDERS (GW): About 50 to 60% subrounded, fine to coarse gravel; about 30 to 40% fine to coarse sand; about 5% fines of undetermined plasticity

Total sample (by volume): About 5% 3-5 " cobbles, a trace of 5-12" cobbles and boulders; maximum size, 13".

10

GEOLOGIC LOG OF DRILL HOLE: DH02-FSS

SHEET 1 OF 1

FEATURE: No. Central Montana Regional Feasibility Study
LOCATION: South Side of Proposed Fish Screen
BEGUN: 4/28/02 **FINISHED:** 4/28/02
DEPTH AND ELEV. OF WATER
LEVEL AND DATE MEASURED: -17.0 (4468.2) 04/28/02

PROJECT: Milk River Project
COORDINATES: N 1,701,563 E 1,025,959
TOTAL DEPTH: 33.7
DEPTH TO BEDROCK: N. R.

STATE: Montana
GROUND ELEVATION: 4485.2
ANGLE FROM HORIZONTAL: -90 **AZIMUTH:** 0
HOLE LOGGED BY: P. Atherton
REVIEWED BY: L. Crutchfield

NOTES

Notes:
All measurements are in feet, from ground surface, unless otherwise noted.
N.M. = Not Measured
N.R. = Not Reached or not encountered.

LOCATION:
50 feet southwest of the turnout at St. Mary Diversion Dam, upstream from the existing dam, north bank of St. Mary Canal, Montana.

PURPOSE OF HOLE:
Investigate foundation conditions for building a fish screen at St. Mary River Turnout.

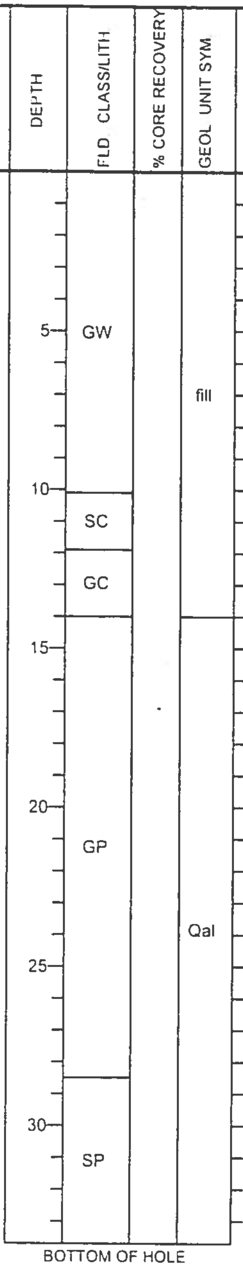
DRILL EQUIPMENT:
Truck mounted SIMCO AV5000, 3-1/2" O.D. rods, 5-7/8" tricone roller rockbit, 6" Aardvark casing.

DRILLING METHODS:
Rockbit and advance casing 0.0' to 33.7' with air as drilling medium.

DRILLER
J. McLaughlan - USBR

WATER LEVEL:
17.0' on 04/28/02

HOLE COMPLETION:
Pulled Casing. Backfilled hole with 3/8" bentonite chips mixed with hole cuttings, then set fence post marker.



CLASSIFICATION AND PHYSICAL CONDITION

No intact sample recovered, hole drilled with tricone roller rockbit, the following are estimates based upon observation of cuttings and drilling conditions. Generally, recovered angular, fine hard gravel with varying amounts of angular to rounded fine to coarse sand with varying amounts of fines; predominantly flat fragments of volcanic, metamorphic, and sedimentary rock; moderate reddish brown to tan; moist to wet; maximum size recovered, 1".

0.0' to 14.0' - FILL:

0.0' to 10.1' - WELL GRADED GRAVEL WITH SAND AND COBBLES (GW): About 55% fine to coarse, subrounded gravel; about 40% fine to coarse sand; about 5% fines of undetermined plasticity.

Total sample (by volume): About 5 to 10% 3-5" cobbles and a trace to 5% 5-12" cobbles; maximum size, 7".

10.1' to 11.9' - CLAYEY SAND WITH GRAVEL (SC): About 60% fine to coarse, subrounded sand; about 25% low plasticity fines; about 15% fine, hard, subrounded gravel; maximum size, 3/4"; dark brown; moist; very soft.

11.9' to 14.0' - CLAYEY GRAVEL WITH SAND AND COBBLES (GC): About 50 to 60% fine to coarse, predominantly coarse, subrounded hard gravel; about 25 to 35% fine to coarse sand; about 15% low plasticity fines.

Total sample (by volume): About 5 to 10% 3-5" cobbles and 5 to 10% 5-12" cobbles; maximum size, 10"

14.0' to 33.7' - QUATERNARY ALLUVIUM (Qal):

14.0' to 28.5' - POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): About 60% fine to coarse, predominantly coarse, subrounded hard gravel; about 25 to 35% fine to coarse sand; about 5 to 10% fines of undetermined plasticity.

Total sample (by volume): About 5-10% 3-5" cobbles and a trace - 5% 5-12" cobbles; maximum size, 11"

28.5' to 33.7' - POORLY GRADED SAND WITH GRAVEL (SP): About 60% subrounded, fine to coarse, predominantly fine sand; about 30% fine to coarse, predominantly fine, subrounded, hard gravel; 5% fines of undetermined plasticity.

10

GEOLOGIC LOG OF DRILL HOLE: DH02-DDL

SHEET 1 OF 1

FEATURE: No. Central Montana Regional Feasibility Study
LOCATION: New Diversion Dam Left Abutment
BEGUN: 4/29/02 FINISHED: 4/29/02
DEPTH AND ELEV. OF WATER
LEVEL AND DATE MEASURED: -18.4 (4466.5) 04/29/02

PROJECT: Milk River Project
COORDINATES: N 1,701,619 E 1,025,977
TOTAL DEPTH: 50.4
DEPTH TO BEDROCK: N.R.

STATE: Montana
GROUND ELEVATION: 4484.9
ANGLE FROM HORIZONTAL: -90 AZIMUTH: 0
HOLE LOGGED BY: P. Atherton
REVIEWED BY: L. Crutchfield

NOTES

Notes:
All measurements are in feet, from ground surface, unless otherwise noted.
N.M. = Not Measured
N.R. = Not Reached or not encountered.

LOCATION:
On the south canal bank, 100 feet northwest of the left abutment of St. Mary Diversion Dam, downstream from the existing turnout, St. Mary Canal, Montana.

PURPOSE OF HOLE:
Investigate foundation conditions for replacing the diversion dam across St. Mary River.

DRILL EQUIPMENT:
Truck mounted SIMCO AV5000; 3-1/2" O.D. rods; 5-7/8" tricone-roller-rockbit; 6" Aardvark casing.

DRILLING METHODS:
Rockbit and advance casing 0.0' to 50.4' with air as drilling medium

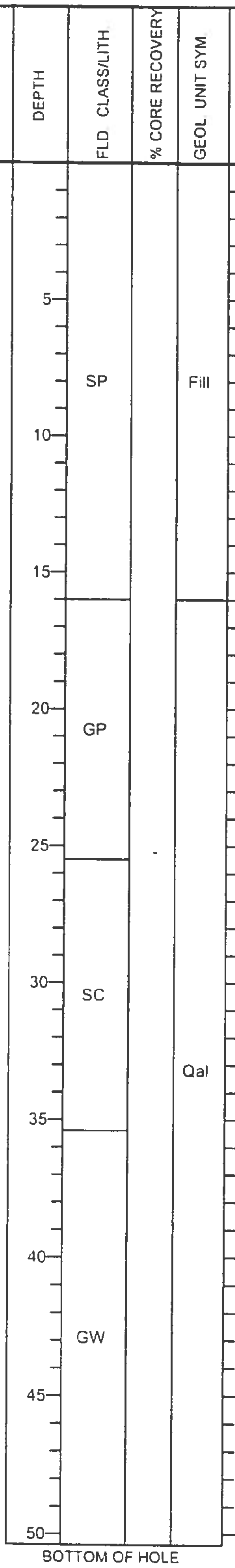
DRILLER
R. Boespflug - USBR

WATER LEVEL:
18.4' on 04/29/02

WATER TESTING:
Gravity head water tests performed inside 6" aardvark casing, head is distance from top of casing to static water level, depth is bottom of casing (bottom of hole).

Depth	Head	Loss (GPM)
15.4	20.8	3.2
20.4	23.8	7.85
25.4	23.8	1.5
30.4	23.8	0.15
35.4	23.8	0.07
40.4	23.8	0.52
45.4	23.8	0.8
50.2	19.0	0.88

HOLE COMPLETION:
Pulled Casing. Backfilled hole with 3/8" bentonite chips mixed with hole cuttings, then set fence post marker.



CLASSIFICATION AND PHYSICAL CONDITION

No intact sample recovered, hole drilled with tricone roller rockbit, the following estimates are based upon observation of cuttings and drilling conditions. Generally, recovered angular, fine hard gravel with varying amounts of angular to rounded fine to coarse sand with varying amounts of fines; predominantly flat fragments of volcanic, metamorphic, and sedimentary rock; moderate reddish brown to tan; moist to wet; maximum size recovered is 3/4".

0.0' to 16.0' - FILL:

0.0' to 16.0' - POORLY GRADED SAND WITH GRAVEL, COBBLES, AND BOULDERS (SP): About 50 to 60% subrounded, fine to coarse, predominantly fine, sand; about 35 to 45% fine to coarse, predominantly coarse, subrounded gravel; about 5% fines of undetermined plasticity.

Total sample (by volume): About 5% 3-5" cobbles, 5% 5-12" cobbles, and trace of boulders; maximum size, 15".

16.0' to 50.4' - QUATERNARY ALLUVIUM (Qal):

16.0' to 25.5' - POORLY GRADED GRAVEL WITH SAND, COBBLES, AND BOULDERS (GP): About 60 to 70% subrounded, predominantly fine gravel; about 25 to 30% fine to coarse sand; about 5 to 10% fines with undetermined plasticity.

Total sample (by volume): About 10% 3-5" cobbles, 5% 5-12" cobbles, and trace of boulders; maximum size, 16".

25.5' to 35.4' - CLAYEY SAND WITH GRAVEL (SC): About 60% fine to coarse subrounded sand; about 25% low plasticity fines; about 15% fine to coarse, predominantly fine, hard, subrounded gravel; maximum size, 1"; dark brown; moist; very soft.

35.4' to 50.4' - WELL GRADED GRAVEL WITH SAND AND COBBLES (GW): About 50 to 60% subrounded gravel; about 35 to 45% fine to coarse sand; about 5% fines with undetermined plasticity.

Total sample (by volume): About 5% 3-5" cobbles, and trace of 5-12" cobbles; maximum size, 8".

GEOLOGIC LOG OF DRILL HOLE: DH02-DDO

SHEET 1 OF 1

FEATURE: No. Central Montana Regional Feasibility Study
LOCATION: Near Diversion Dam Outlet
BEGUN: 4/25/02 FINISHED: 4/25/02
DEPTH AND ELEV. OF WATER
LEVEL AND DATE MEASURED: -15.6 (4468.2) 04/25/02

PROJECT: Milk River Project
COORDINATES: N 1,701,381 E 1,025,827
TOTAL DEPTH: 24.1
DEPTH TO BEDROCK: N.R.

STATE: Montana
GROUND ELEVATION: 4483.8
ANGLE FROM HORIZONTAL: -90 AZIMUTH: 0
HOLE LOGGED BY: P. Atherton
REVIEWED BY: L. Crutchfield

NOTES	DEPTH	FLD CLASS/LITH	% CORE RECOVERY	GEOL UNIT SYM	CLASSIFICATION AND PHYSICAL CONDITION

NOTES

Notes:
All measurements are in feet, from ground surface, unless otherwise noted.
N.M. = Not Measured
N.R. = Not Reached

LOCATION:
On access road, 100' left & 200' upstream of the existing outlet works to St. Mary Canal, Montana.

PURPOSE OF HOLE:
Investigate foundation conditions for replacing the turnout from St. Mary River to the canal.

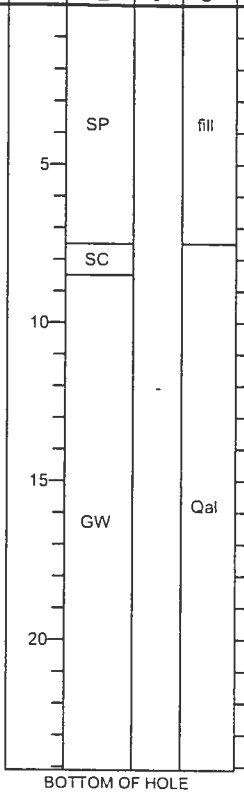
DRILL EQUIPMENT:
Truck mounted SIMCO AV5000, 3-1/2" O.D. rods, 5-7/8" tricone roller rockbit, 6" Aardvark casing.

DRILLING METHODS:
Rockbit and advance casing to final depth with air as drilling medium.

DRILLER
J. McLaughlan - USBR

WATER LEVEL:
15.6' on 4/25/02

HOLE COMPLETION:
Pulled casing. Hole caved from 24.1' back to 8.0' depth. Backfilled hole with 3/8" bentonite chips from 8.0' back to ground surface, then set fence post marker.



CLASSIFICATION AND PHYSICAL CONDITION

No intact sample recovered, hole drilled with tricone roller rockbit, the following are estimates based upon observation of cuttings and drilling conditions. Generally, recovered angular, fine hard gravel with varying amounts of angular to rounded fine to coarse sand with varying amounts of fines; predominantly flat fragments of volcanic, metamorphic, and sedimentary rock; moderate reddish brown to tan; moist to wet; maximum size recovered, 1-1/2 ".

0.0' to 7.5' - FILL:

0.0' to 7.5' - POORLY GRADED SAND WITH GRAVEL, COBBLES AND BOULDERS (SP): About 50% subrounded fine to coarse, predominantly fine, sand; about 45% subrounded, fine to coarse, predominantly coarse gravel; about 5% fines of undetermined plasticity.

Total sample (by volume): About 5% 3-5" cobbles, 5% 5-12" cobbles, and a trace of boulders; maximum size, 14";

7.5' to 24.1' - QUATERNARY ALLUVIUM (Qal):

7.5' to 8.5' - CLAYEY SAND WITH GRAVEL (SC): About 60% fine to coarse, subrounded sand; about 25% low plasticity fines; about 15% fine, hard, subrounded gravel; maximum size, 3/4"; dark brown; moist; very soft.

8.5' to 24.1' - WELL GRADED GRAVEL WITH SAND AND COBBLES (GW): About 60 to 65% subrounded gravel; about 30 to 35% fine to coarse sand; about 5% fines of undetermined plasticity.

Total sample (by volume): About 5% 3-5" cobbles, trace of 5-12" cobbles; maximum size, 10".

3

GEOLOGIC LOG OF DRILL HOLE: DH02-DDC

SHEET 1 OF 1

FEATURE: No. Central Montana Regional Feasibility Study
LOCATION: New Diversion Dam Channel Section
BEGUN: 10/24/02 FINISHED: 10/26/02
DEPTH AND ELEV. OF WATER
LEVEL AND DATE MEASURED: -3.3 (4465.7) 10/26/02

PROJECT: Milk River Project
COORDINATES: N 1,701,546 E 1,026,120
TOTAL DEPTH: 40.5
DEPTH TO BEDROCK: 37.0

STATE: Montana
GROUND ELEVATION: 4469.0
ANGLE FROM HORIZONTAL: -90 AZIMUTH: 0
HOLE LOGGED BY: P. Atherton
REVIEWED BY: L. Crutchfield

NOTES

Notes:
All measurements are in feet, from ground surface, unless otherwise noted.
N.M. = Not Measured
N.R. = Not Reached or not encountered.

LOCATION:
About 100 feet downstream from St. Mary Diversion Dam, on the island in the middle of St. Mary River, Montana.

PURPOSE OF HOLE:
Investigate foundation conditions for replacing the diversion dam across St. Mary River.

DRILL EQUIPMENT:
Truck mounted SIMCO AV5000, 3-1/2" O.D. rods, 6" ODEX system, 6" Aardvark casing.

DRILLING METHODS:
ODEX to advance casing 0.0' to 40.5' with air as drilling medium, 3" drive sample from 38.5 to 39.0'.

DRILLING COMMENTS:
ODEX stopped going at 38.5, removed bit and cleaned out packed sand and clay. ODEX stopped going at 40.5', called hole.

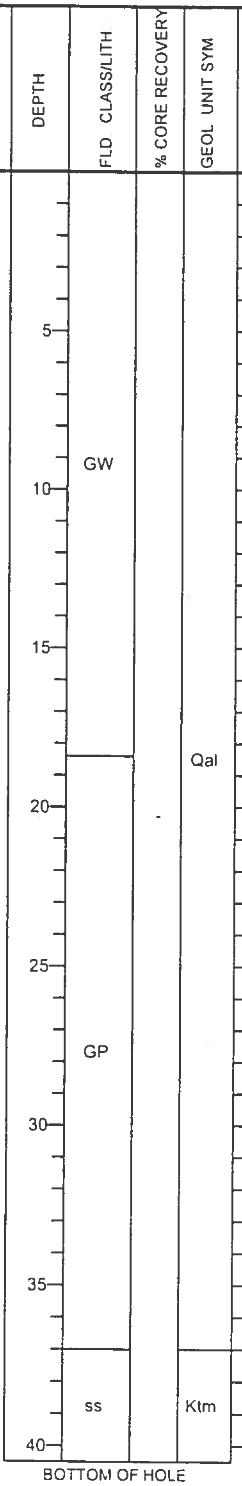
DRILLER
M. Edmondson - USBR

WATER LEVEL:
3.3' on 10/26/2002

WATER TESTING:
Gravity water tests performed inside 6" aardvark casing to test material at the bottom of the drill hole. Head is distance from top of casing to static water level, depth is the bottom of the casing (bottom of hole).

Depth	Head	Loss (GPM)
10'	1.8'	2.34
20'	1.7'	1.24
30'	1.7'	4.0

HOLE COMPLETION:
Casing unscrewed 3.0' below ground surface, had to dig down with backhoe and re-attach casing prior to pulling it. Backfilled hole with 3/4" bentonite chips from 40.5 to 14.0' below ground surface, then local material back to original ground surface, set fence post marker.



CLASSIFICATION AND PHYSICAL CONDITION

Note: No intact sample recovered, hole drilled with ODEX system, the following estimates are based upon observation of cuttings and drilling conditions. Generally, recovered angular, fine hard gravel with varying amounts of angular to rounded fine to coarse sand with varying amounts of fines; predominantly flat fragments of volcanic, metamorphic, and sedimentary rock; moderate reddish brown to tan; moist to wet; maximum size recovered 1".

0.0' to 37.0' - QUATERNARY ALLUVIUM (Qal):

0.0' to 18.4' - WELL GRADED GRAVEL WITH SAND AND COBBLES (GW): About 60% fine to coarse, hard gravel; about 35% fine to coarse, predominantly fine, subrounded sand; 5% fines of unknown plasticity; dark brown; soft; wet; spotty but overall, no to weak reaction with HCl.

Total sample (by volume): About 10% 3-5" cobbles, 5% 5-12" cobbles, and a trace of boulders; maximum size 12"

18.4' to 37.0' - POORLY GRADED GRAVEL WITH SAND, COBBLES, AND BOULDERS (GP): About 70% fine to coarse, predominantly coarse, subrounded to rounded, hard gravel; about 25% fine to coarse, predominantly fine, sand; about 5% fines of undetermined plasticity; dark brown; wet; very soft.

Total sample (by volume): About 5% 3-5" cobbles, 5% 5-12" cobbles, and a trace of boulders; maximum size, 18"

37.0' to 40.5' - CRETACEOUS TWO MEDICINE FORMATION (Ktm):
37.0' to 40.5' - SANDSTONE - Tan sand returned in air medium, no sample retained, (some, thin, moderately hard zones below 39.0'). 0.5' long drive sample from 38.5' to 39.0' (to confirm bedrock) is fine to medium grained; pale yellowish brown to gray; soft to moderately soft; displays some cross bedding, bedding is thin, dips about 10 degrees; interval contains a few randomly spaced very thin mudstone beds less than 1/4" thick; moderate to strong reaction with HCl.

GEOLOGIC LOG OF DRILL HOLE: DH02-DDR

SHEET 1 OF 1

FEATURE: No. Central Montana Regional Feasibility Study
LOCATION: New Diversion Dam Right Abutment
BEGUN: 4/27/02 **FINISHED:** 4/27/02
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: N.M.

PROJECT: Milk River Project
COORDINATES: N 1,701,525 E 1,026,341
TOTAL DEPTH: 28.7
DEPTH TO BEDROCK: 8.4

STATE: Montana
GROUND ELEVATION: 4481.9
ANGLE FROM HORIZONTAL: -90 **AZIMUTH:** 0
HOLE LOGGED BY: P. Atherton
REVIEWED BY: L. Crutchfield

NOTES

Notes:
All measurements are in feet, from ground surface, unless otherwise noted.
N.M. = Not Measured
N.R. = Not Reached or not encountered.

LOCATION:
250 feet northeast of the right abutment of St. Mary Diversion Dam, near east end of the old highway bridge, St. Mary Canal, Montana.

PURPOSE OF HOLE:
Investigate foundation conditions for replacing the diversion dam across St. Mary River.

DRILL EQUIPMENT:
Truck mounted SIMCO AV5000, 0.0 to 9.8': 3-1/2" O.D. rods, 5-7/8" tricone roller rockbit, 6" Aardvark casing; 9.8' to 28.7': HQ wireline rods and 10' HQD3 core barrel .

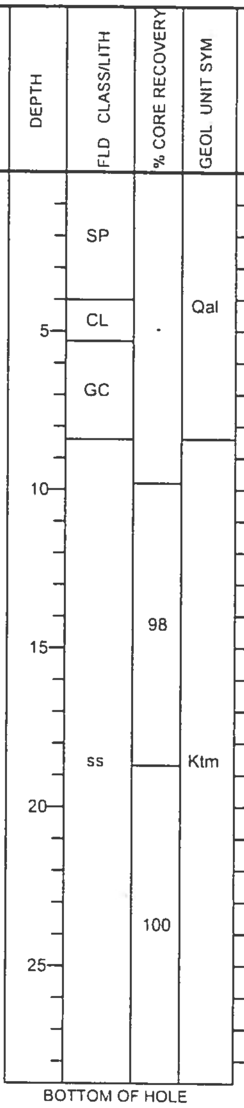
DRILLING METHODS:
Rockbit and advance casing 0.0' to 9.8' with air as drilling medium; HQ3 core with clear water as drilling medium from 9.8' to 28.7'.

DRILLER
J. McLaughlan - USBR

WATER LEVEL:
N. M.

WATER TESTING:
Gravity water tests performed inside 6" aardvark casing. Head 5.5' above ground surface, test at 5.3', no loss. Head 1' above ground surface test from 9.8' to 28.7' loss of 0.5 GPM.

HOLE COMPLETION:
Pulled Casing. Backfilled hole with 3/8" bentonite chips, then set fence post marker.



CLASSIFICATION AND PHYSICAL CONDITION

No intact sample recovered, interval from 0.0 to 9.8' is drilled with tricone roller rockbit, the following estimates are based upon observation of cuttings and drilling conditions. Generally, recovered angular, fine hard gravel with varying amounts of angular to rounded fine to coarse sand with varying amounts of fines; predominantly flat fragments of volcanic, metamorphic, and sedimentary rock; moderate reddish brown to tan; moist to wet; maximum size recovered, 1".

0.0' to 8.4' - QUATERNARY ALLUVIUM (Qal):

0.0' to 4.0' - POORLY GRADED SAND WITH GRAVEL, COBBLES AND BOULDERS (SP): About 60% subrounded fine to coarse, predominantly fine sand; about 35% subrounded fine to coarse gravel; 5% fines of undetermined plasticity.

Total sample (by volume): About 5% 3-5" cobbles, 5% 5-12" cobbles, and a trace of boulders; maximum size, 13"

4.0' to 5.3' - SANDY LEAN CLAY WITH GRAVEL (CL): About 60% low plasticity fines; about 25% fine to coarse, predominantly fine, sand; about 15% fine, hard, subrounded gravel; maximum size, 3/4"; dark brown; wet; very soft.

5.3' to 8.4' - CLAYEY GRAVEL WITH SAND AND COBBLES (GC): About 50 to 55% fine to coarse, subrounded, hard gravel; about 30% fine to coarse, subrounded sand; about 15 to 20% low plasticity fines; a trace of cobbles; maximum size, 6".

8.4' to 28.7' - CRETACEOUS TWO MEDICINE FORMATION (Ktm):

8.4' to 9.8' - SANDSTONE: No sample retained, rockbitted to confirm not on a boulder, tan sand returned in air medium.

9.8' to 28.7' - SANDSTONE: Fine to medium grained; pale yellowish brown to gray; slightly fractured (except 25.9' to 28.5' displays numerous, closely spaced, sub-parallel fractures which dip 40 to 50 degrees, are open 0.1" to 0.3", are clean and slightly rough); soft to moderately soft (moderately hard from 21' to 28.7'); displays some cross bedding, bedding is thin, dips about 10 degrees; interval displays a few randomly spaced very thin mudstone beds less than 1/4" thick; moderate to strong reaction with HCl.

Appendix E – Core Photographs

Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By C. Clark

Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By C. Clark

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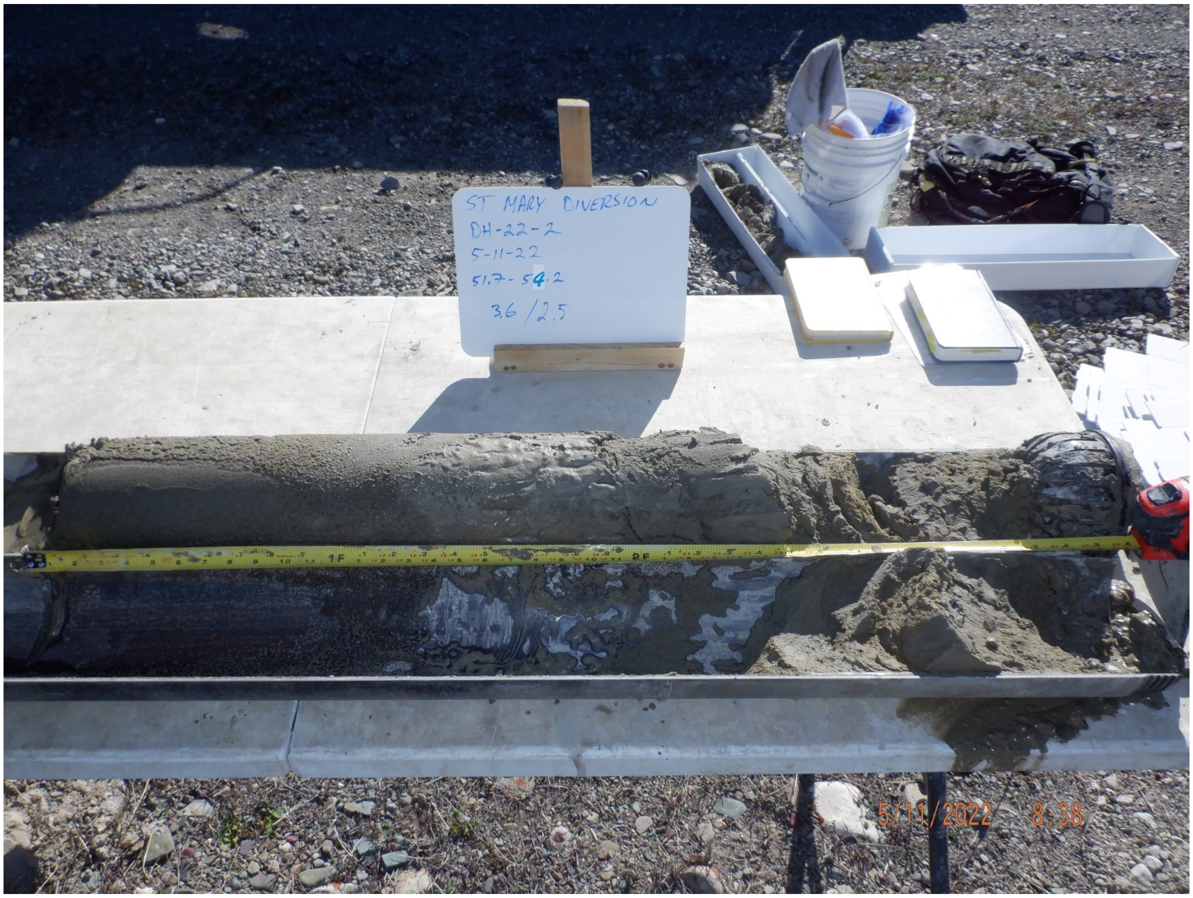
Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By C. Clark

Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By E. Hammers

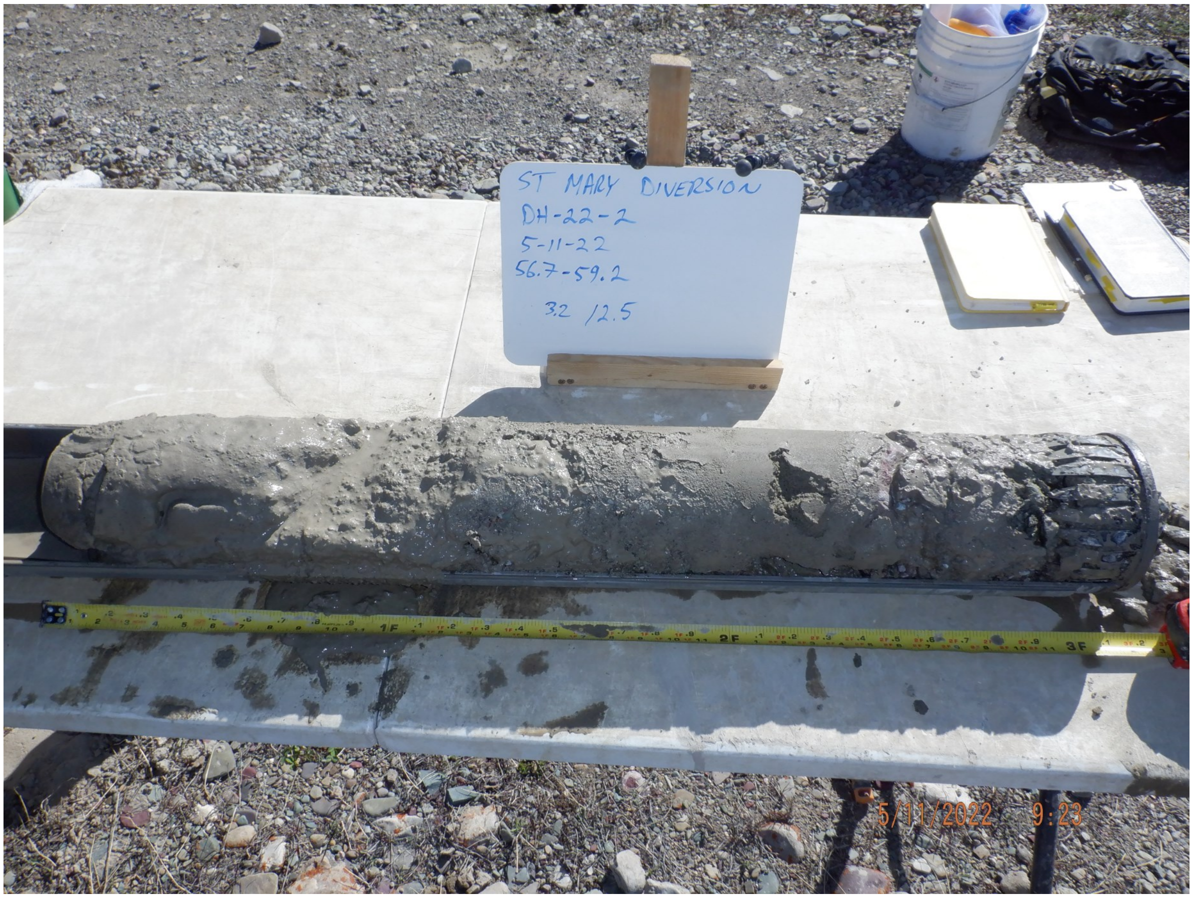
Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By E. Hammers

Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By E. Hammers



Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By E. Hammers

Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By E. Hammers



Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By E. Hammers

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Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By E. Hammers

Core Photograph: DH-22-02 U.S. Bureau of Reclamation Photograph By E. Hammers

Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By C.Clark

Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By C.Clark

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Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By C. Clark

Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By A. Brusak

Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By A. Brusak

Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By A. Brusak

No Photograph for 49.0 feet to 59.0 feet

Core Photograph: PW-22-1A

U.S. Bureau of Reclamation Photograph By A. Brusak

Core Photograph: PW-22-1A

U.S. Bureau of Reclamation Photograph By A. Brusak

Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By A. Brusak

Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By C. Clark

Core Photograph: PW-22-1A U.S. Bureau of Reclamation Photograph By C. Clark

Core Photograph: DH19-04 U.S. Bureau of Reclamation Photograph By C. Clark

Appendix F – Survey Data

SAINT MARY DIVERSION DAM - 11/14/2013 OBSERVATION WELL & TEST PIT LOCATIONS (MTAO LAND SURVEYOR)

11/03/13 DRAWING NAME (PREL.)	12/03/13 DRAWING NAME (FINAL)	LOCAL PROJECT NORTHING (USSF)	LOCAL PROJECT EASTING (USSF)	TOP PVC ELEVATION (NAVD 88) (USSF)	TOP CASING ELEVATION (NAVD 88) (USSF)	GROUND ELEVATION (NAVD 88) (USSF)	CODE	DESCRIPTION	NOTE
OW-A	OW13-A	51899.38	26163.62	4486.45	4486.58	4483.4	MW	PVC Observation Well, in Steel Casing	The "Top Casing Elevation" for OW13-A through OW13-H is at the top of the actual steel casing, **not** on any part of locking lid assembly.
OW-B	OW13-B	51939.91	26134.33	4484.36	4484.50	4481.6	MW	PVC Observation Well, in Steel Casing	
OW-C	OW13-C	51915.52	26031.40	4481.72	4481.77	4479.0	MW	PVC Observation Well, in Steel Casing	
OW-D	OW13-D	52023.41	26081.21	4484.22	4484.31	4481.2	MW	PVC Observation Well, in Steel Casing	
OW-E	OW13-E	52033.62	26140.69	4482.92	4482.98	4480.7	MW	PVC Observation Well, in Steel Casing	
OW-F	OW13-F	52068.14	26256.83	4487.14	4487.16	4485.4	MW	PVC Observation Well, in Steel Casing	
OW-G	OW13-G	52218.14	26269.69	4488.66	4488.78	4485.0	MW	PVC Observation Well, in Steel Casing	
OW-H	OW13-H	52526.98	26244.53	4488.26	4488.37	4485.0	MW	PVC Observation Well, in Steel Casing	
PW-A	(None)								Not installed to date.
SPT-A	SPT13-A	52020.01	26637.63	4482.00	4482.18	4482.1	MW	PVC Observation Well, in Steel Casing	The "Top Casing Elevation" is the centerline top of the bolted cap.
TP-1	TP13-1	52100.4	26029.8	N/A	N/A	4477.9	TP	Centerline End Backhoe Trench	The locations of the backhoe trenches are approximate, based on observing the unmarked, backfilled area.
TP-1	TP13-1	52117.2	26032.5	N/A	N/A	4478.2	TP	Centerline End Backhoe Trench	
TP-2	TP13-2	52202.6	25987.5	N/A	N/A	4477.7	TP	Centerline End Backhoe Trench	
TP-2	TP13-2	52211.6	25985.9	N/A	N/A	4477.3	TP	Centerline Backhoe Trench	
TP-2	TP13-2	52220.0	25982.9	N/A	N/A	4477.9	TP	Centerline End Backhoe Trench	

OW13-A through OW13-H locations are based on GNSS RTK Survey, Trimble R8 Model 2 Receivers, fixed height pole, one direct - 180 observations. Their elevations are based on differential leveling from Sherburne 2.

SPT13-A location and top of casing elevation is based on GNSS RTK Survey, Trimble R8 Model 2 Receivers, fixed height pole, one direct - 180 observations. Its top of PVC elevation is based on GNSS RTK Survey, Trimble R8 Model 2 Receivers, fixed height pole, three direct - 180 observations each, from Sherburne 2. The elevation differential from top of PVC to top of casing was checked by field measurement.

TP13-1 and TP13-2 locations and elevations are based on GNSS RTK Survey, Trimble R8 Model 2 Receivers, fixed height pole, one direct - 3 observations.

SAINT MARY DIVERSION DAM & INTAKE - 05/17/2022 MONITORING WELL, PERCOLATION TEST, & PUMP WELL LOCATIONS

MTAO Land Surveyor 05/17/2022

NAME	LOCAL PROJECT NORTHING (USSF)	LOCAL PROJECT EASTING (USSF)	TOP PVC ELEVATION (NAVD 88) (USSF)	TOP CASING ELEVATION (NAVD 88) (USSF)	TOP CAP ELEVATION (NAVD 88) (USSF)	GROUND ELEVATION (NAVD 88) (USSF)	CODE	DESCRIPTION	NOTE
DH-22-2	52607.46	26237.01	4486.94	4487.15	N/A	4484.2	MW	PVC Well, in Round Metal Casing	Labeled as a drill hole.
PT-1	52029.4	25806.3	N/A	N/A	N/A	4482.4	PT	Percolation Test	Marked with a white wire flag.
PT-2	52011.7	25794.7	N/A	N/A	N/A	4482.3	PT	Percolation Test	Marked with a white wire flag.
PT-3	51981.9	25792.7	N/A	N/A	N/A	4482.4	PT	Percolation Test	Marked with a white wire flag.
PW-22-1	51924.61	26078.04	4481.34	4481.57	N/A	4478.6	MW	PVC Pump Well, in a Round Metal Casing	
PW-22-1A	51933.36	26075.26	4481.50	4481.43	4481.77	4478.6	MW	PVC Pump Well, in a Square Metal Casing	

Drill Hole and Pump Well elevations and locations are based on a GNSS RTK Survey from Sherburne 2 with Trimble R10 Model 2 Receivers using a fixed height pole and one direct survey control grade measurement (180 observations).

Percolation Test elevations and locations are based on a GNSS RTK Survey from Sherburne 2 with Trimble R10 Model 2 Receivers using a fixed height pole and one direct topographic grade measurement (3 observations).

SAINT MARY DIVERSION DAM & INTAKE - 05/17/2022 MONITORING WELL, PERCOLATION TEST, & PUMP WELL LOCATIONS

MTAO Land Surveyor 05/17/2022

NAME	NORTH LATITUDE (DECIMAL DEGREES) (NAD 83 2007)	WEST LONGITUDE (DECIMAL DEGREES) (NAD 83 2007)	CODE	DESCRIPTION	NOTE
DH-22-2	48.853857753	113.416847577	MW	PVC Well, in Round Metal Casing	Labeled as a drill hole.
PT-1	48.852216633	113.418513922	PT	Percolation Test	Marked with a white wire flag.
PT-2	48.852166703	113.418558098	PT	Percolation Test	Marked with a white wire flag.
PT-3	48.852084883	113.418560218	PT	Percolation Test	Marked with a white wire flag.
PW-22-1	48.851967133	113.417365131	MW	PVC Pump Well, in a Round Metal Casing	
PW-22-1A	48.851990685	113.417378478	MW	PVC Pump Well, in a Square Metal Casing	

Drill Hole and Pump Well elevations and locations are based on a GNSS RTK Survey from Sherburne 2 with Trimble R10 Model 2 Receivers using a fixed height pole and one direct survey control grade measurement (180 observations).

Percolation Test elevations and locations are based on a GNSS RTK Survey from Sherburne 2 with Trimble R10 Model 2 Receivers using a fixed height pole and one direct topographic grade measurement (3 observations).

Appendix G – Lab Data

Bureau of Reclamation
Provo Area Office Materials Laboratory

Summary of Gradation and Hydrometer Analysis

BUREAU OF
RECLAMATION

302 E. Lakeview Parkway
Provo, Utah 84606
(801) 379-1000

Project: Milk River Project **Feature: St. Mary's Diversion Dam** **Description: PW-22-1A**

						Gradation -- Particle Size Fraction in Percent Passing													**Hydrometer Analysis (min.)**							
Sample	**Top**	**Bottom**	**Elevation**	**USCS**	**Group**	304.8	127.0	76.2	38.1	19.0	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075	0.037	0.019	0.009	0.005	0.002	0.001	**Date**	**Date**
No.	**Depth**	**Depth**		**Classification**	**Sym.**	**12"**	**5"**	**3"**	**1 1/2"**	**3/4"**	**3/8"**	**#4**	**#8**	**#16**	**#30**	**#50**	**#100**	**#200**	**1**	**4**	**19**	**60**	**435**	**1545**	**Sampled**	**Tested**
1	3.5	6.5		Well-graded gravel with silty clay and sand	(GW-GC)s			100.0	74.7	54.5	41.3	34.9	22.4	15.9	11.1	8.5	6.9	5.5	4.9	3.6	2.3	2.0	1.6	1.0		
2	11.5	19.0		Well-graded gravel with silt and sand	(GW-GM)s			100.0	92.6	73.2	55.7	46.0	33.9	25.0	18.7	14.3	11.2	9.4	7.8	6.2	4.5	2.9	2.1	1.2		
3	26.0	29.0		Well-graded gravel with clay and sand	(GW-GC)s			100.0	88.7	73.3	57.4	45.7	31.3	22.9	17.3	13.1	10.8	9.4	6.3	3.6	2.7	0.9	0.9	0.0		
4	30.5	33.3		Lean clay	(CL)							100.0	99.0	98.8	98.4	95.3	95.0	89.4	74.5	55.1	35.8	28.0	18.4	12.6		
5	33.5	37.4		Silty sand	(SM)				100.0	95.1	91.2	85.6	80.1	73.6	57.3	25.2	19.4	15.5	9.8	8.1	6.4	3.8	2.1	0.4		
6	42.0	45.0		Silty clayey gravel with sand	(GC-GM)s			100.0	91.8	74.2	60.0	51.1	45.1	39.5	35.6	24.9	20.3	20.1	16.5	12.6	8.7	6.8	5.8	3.9		
6	42.0	45.0		**Total Sample Gradation**			100.0	96.9	88.9	71.8	58.1	49.5	43.7	38.3	34.5	24.1	19.7	19.5	16.0	12.2	8.5	6.7	5.6	3.8		
7	51.0	51.2		Clayey sand with gravel	(SC)g				100.0	97.5	87.2	69.3	48.6	35.7	28.9	25.5	23.0	19.2	12.8	10.3	6.4	5.1	3.8	1.3		
8	54.0	59.0		Silt with sand	(ML)s							100.0	98.8	98.3	97.7	97.1	94.2	79.7	54.1	32.0	18.4	10.7	8.7	4.8		
9	62.0	65.0		Silt	(ML)									100.0	99.8	99.6	98.6	90.6	65.9	53.9	24.0	18.0	14.0	10.0		
10	72.0	76.0		Silty, clayey sand with gravel	(SC-SM)g			100.0	97.1	90.3	82.6	74.2	62.8	49.4	39.9	31.8	27.2	25.1	17.0	12.6	8.1	5.2	3.7	2.2		
11	76.0	78.0		Silty, clayey gravel with sand	(GC-GM)s			100.0	86.6	76.1	66.8	61.8	57.1	53.1	50.0	45.9	39.2	32.0	29.8	23.9	16.7	13.1	9.5	7.2		

Bureau of Reclamation
Provo Area Office Materials Laboratory

Summary of Physical Properties

302 E. Lakeview Parkway
Provo, Utah 84606
(801) 379-1000

Project: Milk River Project **Feature: St. Mary's Diversion Dam** **Description: PW-22-1A**

					Fines		Sand	Gravel	Cobble	Cobble	Atterberg Limits							In-Place						ASTM D698		Vibe Hammer, ASTM D7382			Notes
Sample No.	Top Depth	Bottom Depth	Elevation	Group Symbol	Less Than .005 mm	.005 to .075 mm	.075 mm to #4	#4 to 3 in.	3 in. to 5 in.	5" to 12"				Cu - Cc		S.S.D. Sp.G.	Rock Absorp.	Wet Dens. in pcf	Dry Dens. in pcf	% Compaction	Water Content		Moisture Bag	Max Density	Optimum Moisture	3/4" Control Fraction		Total Sample Corrected Max	
											%LL	%PI	%SL	Cu	Cc						Tot. %	(-) #4 %				Dry	Wet		
1	3.5	6.5		(GW-GC)s	2	4	19	75			20.9	17.2		46.94	1.28	2.70	1.4%				1.8%	3.5%				127.8	136.8	148.8	
2	11.5	19.0		(GW-GM)s	3	6	37	54				N/P		120.00	2.70	2.72	0.7%				2.1%	3.7%				131.2	138.8	145.7	
3	26.0	29.0		(GW-GC)s	1	8	37	54			23.4	7.8		110.00	1.10	2.70	1.1%				7.3%	13.8%				125.0	134.3	141.7	
4	30.5	33.3		(CL)	28	61	11	Trace - MSA 3/8"			26.0	17.0										22.6%							
5	33.5	37.4		(SM)	4	12	70	14				N/P									12.0%	13.8%							
6	42.0	45.0		(GC-GM)s	7	13	30	50			19.4	4.4				2.69	1.4%				6.8%	11.4%		140.1	6.4%				
6	42.0	45.0																											**Total Sample Gradation**
7	51.0	51.2		(SC)g	5	14	50	31			24.0	8.1									9.0%	11.9%							
8	54.0	59.0		(ML)s	11	69	20				20.5	2.2										22.2%							
9	62.0	65.0		(ML)	18	73	9				20.7	1.8										22.5%							
10	72.0	76.0		(SC-SM)g	5	20	49	26			21.0	6.4				2.72	0.9%				10.0%	13.1%		137.0	6.6%				
11	76.0	78.0		(GC-GM)s	13	19	30	38			18.1	4.0				2.74	0.8%				7.1%	10.8%		142.1	5.7%				
		Moisture Tins																											
A	0.0	4.0																					2.5%						
B	9.0	11.5																					3.2%						
C	19.0	22.0																					9.5%						
D	30.5	33.3																					25.8%						
E	33.3	37.2																					13.0%						
F	37.7	39.0																					18.3%						
G	42.0	45.0																					9.9%						
H		51.0																					12.5%						
I		56.0																					22.2%						
J	65.0	68.0																					20.4%						
K	73.0	75.0																					22.0%						
L	76.0	78.0																					9.5%						

Bureau of Reclamation
Provo Area Office Materials Laboratory

BUREAU OF RECLAMATION

302 E. Lakeview Parkway
Provo, Utah 84606
(801) 379-1000

Summary of Gradation and Hydrometer Analysis

Project: Milk River Project **Feature: St. Mary's Diversion Dam** **Description: 2022 FER - DH-22-2**

Sample No.	Top Depth	Bottom Depth	Elevation	USCS Classification	Group Sym.	Gradation -- Particle Size Fraction in Percent Passing													Hydrometer Analysis (min.)						Date Sampled	Date Tested
						304.8	127.0	76.2	38.1	19.0	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075	0.037	0.019	0.009	0.005	0.002	0.001		
						12"	5"	3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200	1	4	19	60	435	1545		
1	0.0	6.2		Well-graded gravel with silty clay and sand	(GW-GC)s			100.0	71.5	55.9	44.4	36.8	28.9	22.3	17.2	13.4	11.1	9.5	6.5	5.1	3.8	3.1	2.4	1.4		
2	11.7	16.7		Poorly graded gravel with silt and sand	(GP-GM)s			100.0	81.4	61.7	46.1	37.8	31.1	24.8	18.1	11.4	8.5	7.2	6.5	5.2	3.9	3.2	2.6	2.3		
3	21.2	29.2		Well-graded gravel with silt and sand	(GW-GM)s			100.0	78.6	65.9	52.9	44.4	32.9	23.9	17.0	11.0	8.3	7.1	4.8	4.1	2.6	1.8	1.1	0.7		
4	29.2	30.2		Silty sand	(SM)				100.0	96.1	92.8	89.8	78.6	57.0	36.6	23.2	15.6	12.7	10.1	7.4	6.0	4.7	3.4	2.0		
5	33.8	36.7		Silty gravel with sand	(GM)s			100.0	82.7	72.5	63.5	56.7	49.4	44.4	41.1	36.6	28.7	22.8	15.2	13.4	11.6	8.9	6.3	5.4		
5	33.8	36.7		**Total Sample Gradation**			100.0	81.5	67.5	59.1	51.8	46.3	40.4	36.3	33.6	29.9	23.4	18.6	12.4	11.0	9.5	7.3	5.1	4.4		
6	39.2	40.1		Silty sand	(SM)			100.0	89.4	87.0	86.5	86.4	85.4	83.4	81.4	72.5	52.2	36.4	22.7	17.6	10.9	9.2	7.6	5.0		
7	42.0	44.0		Silty gravel with sand	(GM)s			100.0	77.7	58.5	47.6	41.2	34.0	29.3	26.7	23.0	17.2	13.5	11.0	8.1	5.9	5.1	4.4	2.6		
8	44.2	45.2		Silt	(ML)									100.0	99.6	98.6	97.7	94.0	63.1	49.1	31.6	24.6	22.8	12.3		
9	46.7	49.7		Silty gravel with sand	(GM)s			100.0	88.3	77.8	65.7	56.0	44.7	39.4	35.9	30.5	21.3	15.7	10.8	8.0	5.2	4.2	3.3	2.4		
9	46.7	49.7		**Total Sample Gradation**			100.0	86.2	76.1	67.1	56.6	48.3	38.6	33.9	30.9	26.2	18.4	13.5	9.3	6.9	4.5	3.6	2.8	2.0		
10	50.9	51.7		Silty sand	(SM)							100.0	99.9	99.2	98.0	85.9	40.8	26.9	20.2	15.3	12.3	9.4	6.4	3.9		
11	55.5	56.7		Silty sand with gravel	(SM)g			100.0	88.1	82.8	72.7	67.2	62.8	60.3	58.4	52.3	36.4	26.5	19.9	15.1	11.4	8.7	6.3	3.6		
11	55.5	56.7		**Total Sample Gradation**			100.0	68.7	60.5	56.8	49.9	46.2	43.2	41.5	40.2	35.9	25.0	18.2	13.7	10.4	7.9	6.2	4.6	2.5		
12	61.7	62.2		Silty gravel with sand	(GM)s			100.0	93.9	76.7	65.5	52.8	47.9	46.4	45.1	40.8	25.9	13.3	7.3	4.7	3.6	3.1	2.1	1.3		
13	62.2	64.2		Silty sand with gravel	(SM)g			100.0	86.0	73.3	61.8	55.2	50.0	45.1	42.2	36.1	24.7	18.6	12.6	11.0	8.5	6.1	4.5	2.4		
14	73.2	74.2		Silty sand with gravel	(SM)g				100.0	92.5	87.5	84.8	81.5	78.6	75.6	67.4	42.3	28.7	22.0	19.4	12.9	11.6	7.8	5.2		

Bureau of Reclamation
Provo Area Office Materials Laboratory

Summary of Physical Properties

302 E. Lakeview Parkway
Provo, Utah 84606
(801) 379-1000

Project: Milk River Project **Feature: St. Mary's Diversion Dam** **Description: 2022 FER - DH-22-2**

					Fines		Sand	Gravel	Cobble	Cobble	Atterberg Limits			Cu - Cc				In-Place						ASTM D698		Vibe Hammer, ASTM D7382			Notes
Sample No.	Top Depth	Bottom Depth	Elevation	Group Symbol	Less Than .005 mm	.005 to .075 mm	.075 mm to #4	#4 to 3 in.	3 in. to 5 in.	5" to 12"	%LL	%PI	%SL	Cu	Cc	S.S.D. Sp.G.	Rock Absorp.	Wet Dens. in pcf	Dry Dens. in pcf	% Compaction	Water Content Tot. %	(-) #4 %	Moisture Bag	Max Density	Optimum Moisture	3/4" Control Fraction Dry	Wet	Total Sample Corrected Max	
1	0.0	6.2		(GW-GC)s	3	7	27	63			25.5	6.4		270.00	2.90						4.4%	9.3%							
2	11.7	16.7		(GP-GM)s	3	4	31	62			N/P			72.00	0.89						1.2%	3.4%							
3	21.2	29.2		(GW-GM)s	2	5	37	56			N/P			57.69	1.03						7.9%	14.9%							
4	29.2	30.2		(SM)	5	7	77	13			N/P										19.7%	21.6%							
5	33.8	36.7		(GM)s	9	14	34	43			19.4	3.3									8.6%	16.4%							
5	33.8	36.7			7	12	27	36	18																				**Total Sample Gradation**
6	39.2	40.1		(SM)	9	27	50	14			N/P										18.9%	21.6%							
7	42.0	44.0		(GM)s	5	9	27	59			N/P										7.3%	14.3%							
8	44.2	45.2		(ML)	25	69	6				22.7	2.1										41.2%							
9	46.7	49.7		(GM)s	4	12	40	44													8.6%	15.6%							
9	46.7	49.7			4	10	34	38	14																				**Total Sample Gradation**
10	50.9	51.7		(SM)	9	18	73	Trace - MSA 3/4"														19.0%							
11	55.5	56.7		(SM)g	9	18	40	33			N/P										9.3%	19.0%							
11	55.5	56.7			6	12	28	31	23																				**Total Sample Gradation**
12	61.7	62.2		(GM)s	3	10	40	47			N/P										10.6%	17.4%							
13	62.2	64.2		(SM)g	6	13	64	45			N/P										9.5%	15.3%							
14	73.2	74.2		(SM)g	12	17	56	15			N/P										13.8%	16.0%							
		Moisture Tin Samples																											
1	21.7	24.8																					14.8%						
2		36.7																					8.5%						
3		39.5																					20.9%						
4	46.7	49.2																					13.5%						
5	50.9	51.7																					20.0%						
6	55.5	56.7																					19.0%						
7	62.2	64.2																					15.3%						
8	73.2	74.2																					14.4%						

Appendix H – Percolation Test Data

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
PERCOLATION TEST FORM

Owner Name U.S. Bureau of Reclamation

Project Name St. Mary Diversion Dam, Milk River Project, MT

Lot of Tract Number ____________ Test Number PT-1

Diameter of Test Hole 1.2 Feet Depth of Test Hole 3.5 feet

Date and Time Soak Period Began May 5, 2022 1:15 P.M. Ended 1:38 P.M.

Date Test Began May 5, 2022

Distance of the reference point above the bottom of the hole 1.5 Feet

Test Results

Start Time of Day	End Time of Day	Time Interval (minutes)	Initial Distance Below Reference Point	Final Distance Below Reference Point	Drop in Water Level (inches)	Percolation Rate (mpi)
		2 min 11 sec	0.1 feet	1.5 Feet	16.8 inches	0.13
		3 min 50 sec	0	1.5 Feet	18.0 inches	0.21
		4 min 32 sec	0	1.5 Feet	18.0 inches	0.25

I certify that this percolation test was done by a qualified site evaluator in accordance with DEQ-4 Section 1.2.68 and Appendix A.

Seth Joramo, Geologist		10/3/22
Name (printed)	Signature	Date

U.S. Bureau of Reclamation
Company

St. Mary Diversion Dam, MT

Missouri Basin Region
Mil River Project

Percolation Test Hole #: PT-1
Lat/Long N. 48.853857753 W. 113416847577
Ground Surface El.: 4482.4
Geologic Unit: Glacial Till (Qtg)

USDA Soil Classification:

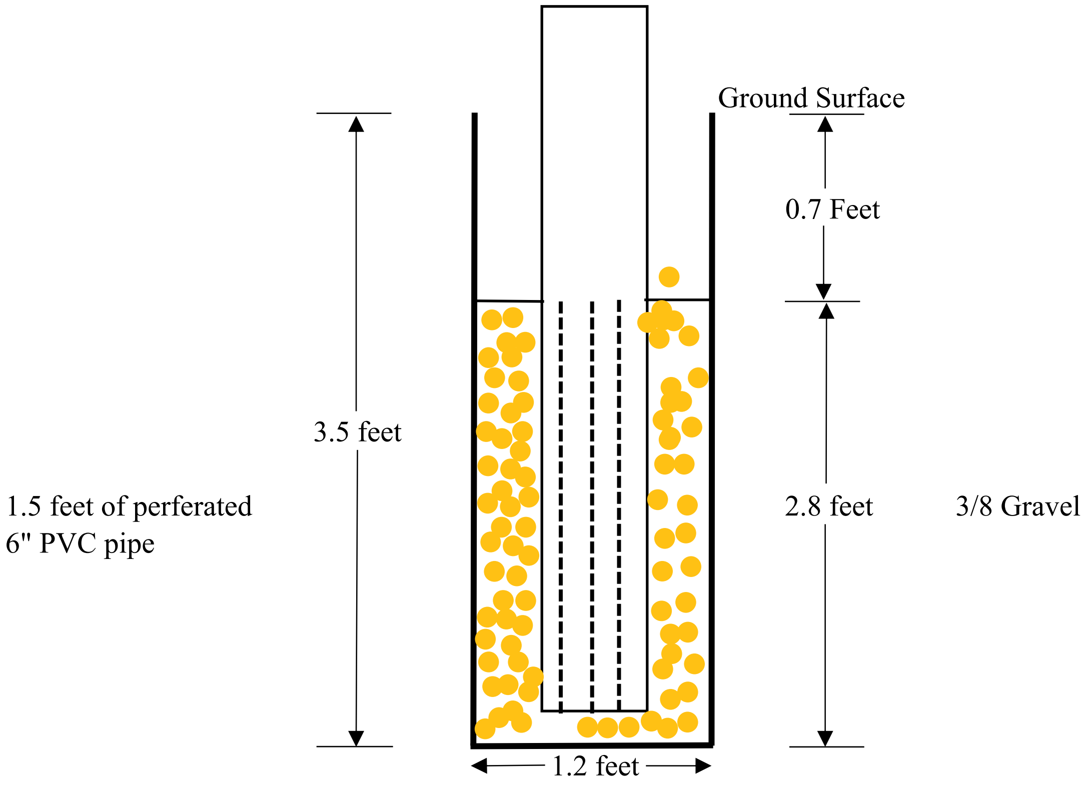
Gravelly Sandy Loam, granular, coarse to very coarse, weak.

Web Soil Survey:

Map Unit Description: TN - Tinsley Soils
0 to 4 inches: gravelly sandy loam
4 to 60 inches: extremely gravelly sand

USCS Visual Classisifcation:

Well-graded Gravel with Sand, Cobbles, and Boulders (GW)scb: Approximately 50% Fine to Coarse, subanguar to subrounded, hard gravel, approximately 45% Fine to Coarse, subangular to subrounded, hard Sand, approximately 5% low plasticity fines with #dry strength, rapid dilatency, low toughness, Moist, brown to dark tan, Strong reaction on caliche and no to weak reaction with HCl in soil, Homogenous, aproximately 5-10% hard subrounded cobbles by volumn.



MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
PERCOLATION TEST FORM

Owner Name U.S. Bureau of Reclamation

Project Name St. Mary Diversion Dam

Lot of Tract Number ____________ Test Number PT-2

Diameter of Test Hole 1.5 Feet Depth of Test Hole 2.7 Feet

Date and Time Soak Period Began May 5, 2022 1:45 P.M. Ended 1:55 P.M.

Date Test Began May 5, 2022

Distance of the reference point above the bottom of the hole 1.5 Feet

Test Results

Start Time of Day	End Time of Day	Time Interval (minutes)	Initial Distance Below Reference Point	Final Distance Below Reference Point	Drop in Water Level (inches)	Percolation Rate (mpi)
		3 min 40 sec	0	1.5 Feet	18.0 inches	0.20
		4 min 1 sec	0	1.5 Feet	18.0 inches	0.22
		4 min 33 sec	0	1.5 Feet	18.0 inches	0.25

I certify that this percolation test was done by a qualified site evaluator in accordance with DEQ-4 Section 1.2.68 and Appendix A.

Seth Joramo, Geologist		9/14/22
Name (printed)	Signature	Date

U.S. Bureau of Reclamation
Company

St. Mary Diversion Dam, MT

Missouri Basin Region
Mil River Project

Percolation Test Hole #: PT-2		
Lat/Long	N. 48.852166703	W. 113.418558098
Ground Surface El.: 4482.3		
Geologic Unit:	Glacial Till (Qtg)	

USDA Soil Classification:

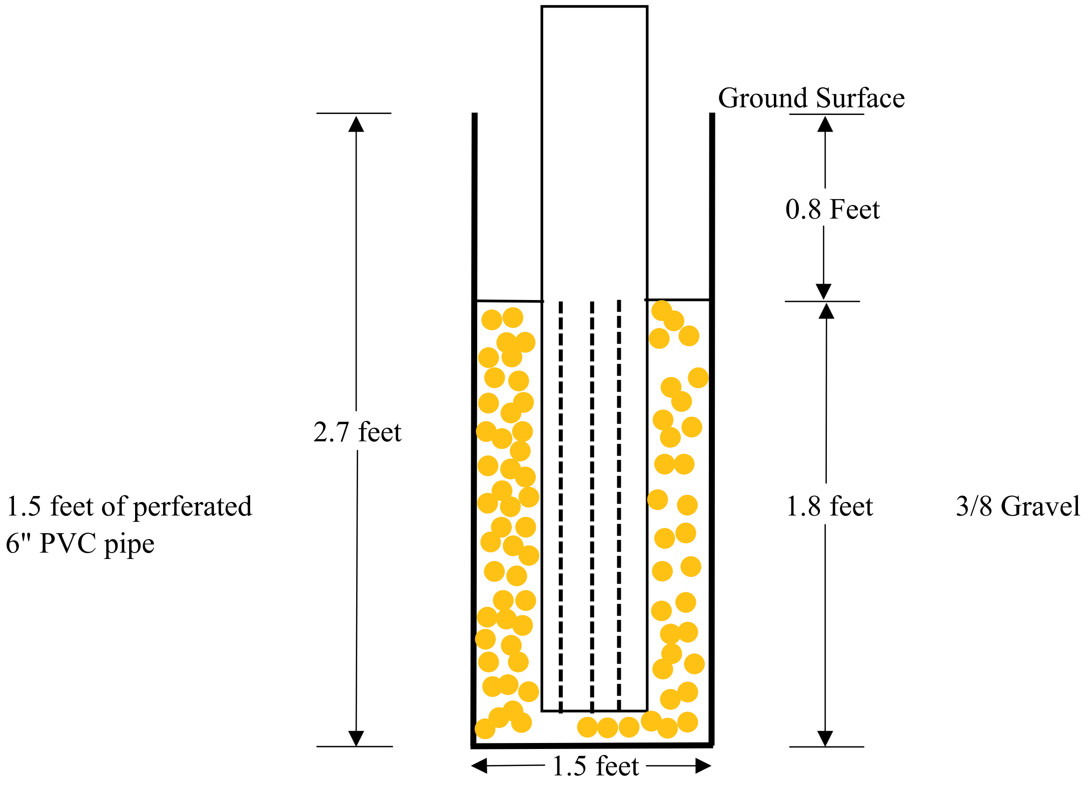
Gravelly Sandy Loam, granular, coarse to very coarse, weak.

Web Soil Survey:

Map Unit Description: TN - Tinsley Soils
0 to 4 inches: gravelly sandy loam
4 to 60 inches: extremely gravelly sand

USCS Visual Classisifcation:

Well-graded Gravel with Sand, Cobbles, and Boulders (GW)scb: Approximately 50% Fine to Coarse, subanguar to subrounded, hard gravel, approximately 45% Fine to Coarse, subangular to subrounded, hard Sand, approximately 5% low plasticity fines with #dry strength, rapid dilatency, low toughness, Moist, brown to dark tan, Strong reaction on caliche and no to weak reaction with HCl in soil, Homogenous, aproximately 5-10% hard subrounded cobbles by volumn.



MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
PERCOLATION TEST FORM

Owner Name U.S. Bureau of Reclamation

Project Name St. Mary Diversion Dam, Milk River Project, MT

Lot of Tract Number ______ Test Number PT-3

Diameter of Test Hole 1.1 Feet Depth of Test Hole 2.6 Feet

Date and Time Soak Period Began May 5, 2022 2:15 P.M. Ended 2:33 P.M.

Date Test Began May 5, 2022

Distance of the reference point above the bottom of the hole 1.5 Feet

Test Results

Start Time of Day	End Time of Day	Time Interval (minutes)	Initial Distance Below Reference Point	Final Distance Below Reference Point	Drop in Water Level (inches)	Percolation Rate (mpi)
		7 min 52 sec	0.1 Feet	1.5 Feet	16.8 inches	0.47
		10min 37 sec	0	1.5 Feet	18.0 inches	0.56
		12min 30 sec	0	1.5 Feet	18.0 inches	0.69

I certify that this percolation test was done by a qualified site evaluator in accordance with DEQ-4 Section 1.2.68 and Appendix A.

Seth Joramo, Geologist		9/14/22
Name (printed)	Signature	Date

U.S. Bureau of Reclamation
Company

St. Mary Diversion Dam, MT

Missouri Basin Region
Mil River Project

Percolation Test Hole #: PT-3
Lat/Long N. 48.852084883 W. 113.418560218
Ground Surface El.: 4482.4
Geologic Unit: Glacial Till (Qtg)

USDA Soil Classification:

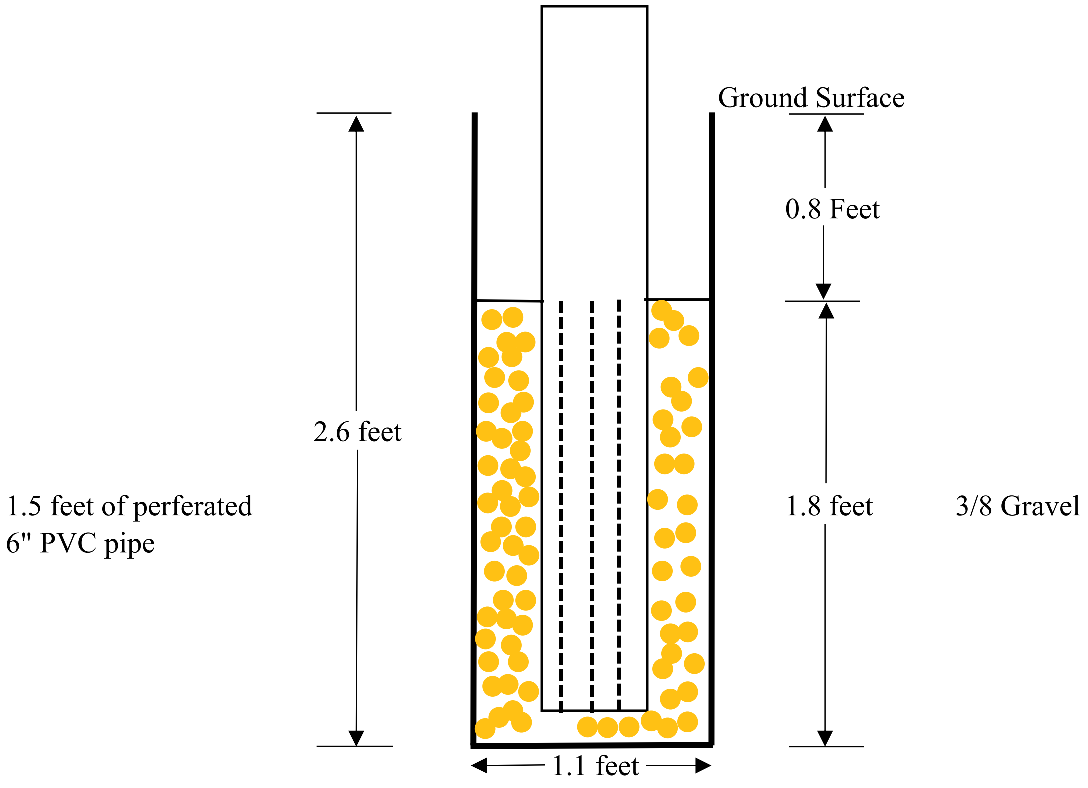
Gravelly Sandy Loam, granular, coarse to very coarse, weak.

Web Soil Survey:

Map Unit Description: TN - Tinsley Soils
0 to 4 inches: gravelly sandy loam
4 to 60 inches: extremely gravelly sand

USCS Visual Classisifcation:

Well-graded Gravel with Sand, Cobbles, and Boulders (GW)scb: Approximately 50% Fine to Coarse, subanguar to subrounded, hard gravel, approximately 45% Fine to Coarse, subangular to subrounded, hard Sand, approximately 5% low plasticity fines with #dry strength, rapid dilatency, low toughness, Moist, brown to dark tan, Strong reaction on caliche and no to weak reaction with HCl in soil, Homogenous, aproximately 5-10% hard subrounded cobbles by volumn.



Glacier County Area and Part of Pondera County, Montana

TN—Tinsley soils

Map Unit Setting

National map unit symbol: 4xx1
Elevation: 3,700 to 4,800 feet
Mean annual precipitation: 14 to 19 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 80 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

Tinsley and similar soils: 50 percent
Tinsley and similar soils: 45 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tinsley

Setting

Landform: Terraces
Down-slope shape: Linear
Across-slope shape: Linear

Typical profile

A - 0 to 4 inches: gravelly sandy loam
C - 4 to 60 inches: extremely gravelly sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R046XN601MT - Gravelly (Gr) RRU 46-N 13-19" p.z.
Hydric soil rating: No

Description of Tinsley

Setting

Landform: Terraces
Down-slope shape: Linear
Across-slope shape: Linear

Typical profile

A - 0 to 4 inches: very gravelly sandy loam
C - 4 to 60 inches: extremely gravelly sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R046XN601MT - Gravelly (Gr) RRU 46-N 13-19" p.z.
Hydric soil rating: No

Minor Components

Gravel outwash

Percent of map unit: 5 percent
Hydric soil rating: No

Data Source Information

Soil Survey Area: Glacier County Area and Part of Pondera County, Montana
Survey Area Data: Version 16, Sep 2, 2021

Appendix I – Field Exploration Request (FER)

United States Department of the Interior

BUREAU OF RECLAMATION
P.O. Box 25007
Denver, CO 80225-0007

IN REPLY REFER TO:
86-68320
2.2.4.21

VIA ELECTRONIC MAIL ONLY

Memorandum

To: Montana Area Office Area Manager
Attn: MT-100 (Ryan Newman)

From: Jared Vauk, P.G., Manager JARED VAUK Digitally signed by JARED VAUK Date: 2022.02.03 10:26:58 -07'00'
Engineering Geology and Geophysics Group

Subject: Field Exploration Request to Collect Geotechnical Data for the St. Mary's Diversion Dam Replacement Project.

Attached is the Field Exploration Request (FER) that details work to collect final design level geotechnical data for the proposed replacement of the St. Mary's Diversion Dam near Babb, Montana. Explorations include two drill holes, groundwater pump testing, laboratory testing and commercial sourced materials surveys.

The majority of the work will be completed by and under the supervision of the Missouri Basin Region Geology and Exploration Services Group (MB-2300). Additional data from samples analyzed for the corrosivity study will be documented by TSC Materials and Corrosion Laboratory (86-68540). Rock and soil laboratory testing will be conducted and documented by TSC Geotechnical Laboratory and Field Support group (86-68550). Additional laboratory work will be performed by the Provo Area Office Materials Laboratory (PRO-770) and documented by the Missouri Basin Region Geology and Exploration Services Group (MB-2300).

For estimating purposes, cost estimates for FER activities have been provided by the Upper Colorado Basin Region Drill Crew (CPN-3620), the TSC Geotechnical Laboratory and Field Services Group (86-68550), TSC Materials and Corrosion Laboratory (86-68540) and the Missouri Basin Geology and Exploration Services (MB-2300).

The estimated cost for this field exploration program is $586,829.

If you have any comments regarding this FER, please contact Geologist Trenton Lewis at 303-445-3365, tlewis@usbr.gov or TSC Team Lead Ryan Kent at 303-445-2014, rkent@usbr.gov.

Attachment

cc: DSDaMS@usbr.gov
RKent@usbr.gov - TSC Team Lead
JBray@usbr.gov – Geotechnical Engineer
NBogenshuetz@usbr.gov – Dewatering engineer
GArany@usbr.gov - GLFS contact
SHarrel@usbr.gov – CSL contact
SProchaska@usbr.gov – MCL contact
TLewis@usbr.gov – TSC Principal Geologist
SDarlington@usbr.gov – Area Office Contact
CClark@usbr.gov – Missouri Basin Regional Geologist
SJoramo@usbr.gov – Project Geologist

TSC FIELD EXPLORATION REQUEST

Sheet 1 of 7

REGION: Missouri Basin
PROJECT: Milk River Project
FEATURE: St. Mary's Diversion Dam
DATE: February 2, 2022

PROGRAM: St. Mary's Diversion Dam Replacement
TSC FER CONTACT: Trenton Lewis (86-68320) 303-601-3365
TSC TEAM LEAD: Ryan Kent (86-68150) 303-445-2014

FER TEAM (= concurred via email)*
Team Leader: R. Kent __*_ Project Geologist: S. Joramo _*__
Principal Geologist: T. Lewis TL Geotech.: J. Bray _____
Dewatering Eng.: N. Bogenschuetz _*__ Laboratory: G. Arany__*___
Concrete Eng. S. Harrell __*_ Materials Lab.: S. Prochaska _*___
Geotech Peer Review: J. Wormer _*_ Peer Review: R. Lung _*__

This Field Exploration Request (FER) is to detail exploration requirements to study foundation and groundwater conditions at the St. Mary's Diversion Dam and to evaluate potential borrow sources for various construction materials. The groundwater conditions will be used to develop de-watering requirements for the development of specifications for the proposed St. Mary's Diversion Dam replacement. This project is managed by the Montana Area Office (MT-710) in Billings, Montana. Technical Service Center (TSC) support activities for the St. Mary's Diversion Dam Replacement Project are coordinated through the TSC Team Leader Ryan Kent. Explorations detailed within this FER were developed with input from the FER Team, Missouri Basin Regional Office, Montana Area Office personnel and other TSC staff.

The Missouri Basin Region geology group (MB-2300) will coordinate, complete and document exploration activities detailed within FER Items 1, 2, 3, 6, 8 and 9; and will complete samples inventory sheet(s) for Items 1, 2, 4, 5, 6, 7, and 8. The Provo Materials Laboratory (PRO-740) will complete the laboratory testing detailed in FER Item 3 and provide the data to the MB Region Geology Group for documentation. The TSC Geotechnical Engineering Group 2 (86-68312) will coordinate, complete and document pump out test activities detailed in FER Item 1 and Appendix A. The TSC Geotechnical Laboratory and Field Support Group (GLFS) (86-68550) will complete the laboratory testing for FER Items 4, 5, 6 and 7. The TSC Materials Corrosion Laboratory (MCL) (86-68540) will complete the laboratory testing for FER Item 8 and 3 if problem soils are encountered.

ITEM NO.	DESCRIPTION	LOCATION	SIZE	DEPTH	TESTING	FIELD EXPLORATION DESCRIPTION
1.	**Pump Well Drill Hole** PW-22-1 Pre-drill and log with Sonic Ream drill hole to 12-inch diameter using - ODEX or similar	See Figure 1 and Appendix A	8-inch dia. Sonic 12-inch dia. ODEX	**To 80 feet or 5 feet into bedrock.**		Purpose: Conduct eccentric duplex percussive drilling (similar to ODEX) methods to install 10-inch diameter pump well for a pump out test. Requirements: Use sonic drilling methods to predrill the pump well with an 8-inch diameter casing until either 5-feet of bedrock or a maximum of 80-feet is drilled. If bedrock is encountered before 80 feet of depth, then advance the drill hole 5 feet into bedrock and terminate drilling. - Box and photograph all samples collected. - Geologically log all soil and rock samples in accordance with Reclamation Engineering Geology Field Manual. - Select representative samples of foundation materials to characterize all material types encountered for laboratory analysis as determined necessary by field geologists. - Samples will be sealed to retain moisture for laboratory analysis. Store and transport samples according to ASTM D 4220. - Backfill Sonic hole with clean gravel or coarse sand (not smaller than the #12 sieve). Use ODEX, or similar drilling methods to advance 12-inch casing to 5 feet into bedrock or to 80 feet of depth as determined by Sonic drilling. Install pump well as described in the completion requirements below. Consult with TSC dewatering engineer N. Bogenschuetz (303)-445-2882 for well screen interval location. Perform pump test in accordance with Appendix A

ITEM NO.	DESCRIPTION	LOCATION	SIZE	DEPTH	TESTING	FIELD EXPLORATION DESCRIPTION
1. Cont.	**Pump Well Drill Hole** PW-22-1 Pre-drill and log with Sonic Ream drill hole to 12-inch diameter using - ODEX or similar	See Figure 1 and Appendix A	8-inch dia. Sonic 12-inch dia. ODEX	**To 80 feet or 5 feet into bedrock.**		<u>Completion Requirements:</u> - The pump well is to be constructed with a 10-inch-diameter blank casing (steel or PVC) and a steel wire wrap well screen with gravel filter pack. The steel wire wrap well screen shall be approximately 60 feet long and have a slot size of 0.02inch. Use a filter pack gradation that is composed of #8/12 sand (uniformly graded filter pack with maximum size of 0.125-inches). The filter pack shall be constructed to about three feet below and three feet above the well screen. Estimate the volume of filter pack material prior to installing filter material. Place filter material gradually, checking depth to filter material regularly using a weighted cloth measuring tape and documenting of the number of bags used. Calculate the volume of filter material placed and compare to the estimated volume and document to ensure no issues are encountered such as bridging of the filter material or large voids are encountered. Install a 2-foot-long overdrill below the screened interval. Estimate the volume of bentonite seal material prior to installing seal material. Place seal material gradually tremie method may be appropriate, checking depth to seal material regularly using a weighted cloth measuring tape and documenting of the number of bags used. Calculate the volume of seal material placed and compare to the estimated volume and document to ensure no issues are encountered such as bridging of the seal material or large voids are encountered. The top of the well shall be protected in an above ground surface steel casing with a locking top. Notes: - The filter pack primary purpose is to keep the bentonite from being in contact with the screen and keep the borehole open during completion. The filter pack capability is coarser than that of the slots, meaning that the slot size is the primary line of defense for filtration. Based on existing gradations, the 0.02 slots will allow approximately 15% of the foundation through, meaning additional development may be necessary.
2.	**Drill Hole** DH-22-1 Sonic	-See Figure 1	8-inch dia. Sonic	**To 5 feet into bedrock or 80 feet.**	NA	<u>Purpose:</u> To determine depth to bedrock for dewatering and geotechnical design of the proposed diversion dam replacement. <u>Requirements:</u> Advance drill hole using Sonic drilling method 5 feet into bedrock or to a maximum of 80 feet of depth. as determined from drill cuttings and drilling action by the geologist. - Box and photograph all samples collected. - Geologically log all soil and rock samples in accordance with Reclamation Engineering Geology Field Manual. - Select representative samples of foundation materials to characterize all material types encountered for laboratory analysis as determined necessary by field geologists. - Samples will be sealed to retain moisture for laboratory analysis. Store and transport samples according to ASTM D 4220, Group B. <u>Completion Requirements</u>: Upon completion of drilling, a groundwater monitoring well shall be installed. The well shall be constructed with 2-inch-diameter, schedule 80 PVC well screen and blank length. Well screen shall have a slot size of 0.020. The screened interval shall be 30 feet long and located at the bottom of the well with a 1-foot-long overdrill. If bedrock is encountered, the screened interval shall start above the bedrock contact. Consult with TSC dewatering engineer N. Bogenschuetz (303)-445-2882 for well screen interval location. The field team shall determine the appropriate sand gradation to construct a sand filter (#8/12 sand may be appropriate). The sand filter shall be constructed to about 2 feet below and above the well screen. The well should be thoroughly developed in accordance with Appendix A. The top of the well shall be protected by an above ground surface steel casing with a locking top, as determined by the field geologist.

ITEM NO.	DESCRIPTION	LOCATION	SIZE	DEPTH	TESTING	FIELD EXPLORATION DESCRIPTION
3.	**Lab Testing**	NA	NA	NA	Lab Testing	Purpose: Laboratory analysis of samples transferred from field geologist. Requirements: Samples collected will be submitted for standard physical properties laboratory testing including gradations, moisture content and Atterberg limits, according to ASTM and Reclamation (Earth Manual) laboratory standards. Laboratory analysis will include: gradation plots, liquid limit, plastic limit, moisture content, and Unified Soil Classification System name and symbol. - Number of samples tested will be determined upon receipt of samples to the designated laboratory. - Particle size analysis will include hydrometer readings for selected soil samples with greater than 15% passing the #200 sieve size (when required, perform hydrometer test for 24-hour duration to quantify the percentage of silt- and clay-size particles). Samples selected for hydrometer readings will include potentially problematic soils that could shrink, swell, disperse, are collapsible etc. as determined by the FER team. - Conduct moisture content tests at 60° C for 48 hours on samples potentially containing gypsum. - Conduct screening-level tests (dispersivity, swell/consolidation, or other) on potential problem soils identified by field geologists. - Conduct standard Proctor compaction tests according to ASTM D 698 on material collected from in-place density tests with greater than or equal to 15% fines content. - Conduct vibratory hammer compaction tests according to ASTM D 7382 on material collected from in-place density tests with less than 15% fines content. All samples to be shipped or delivered to the Provo Lab, except for soils identified as potential problems. Potential problem soils should be shipped to GLFS.
4.	**Water Quality Sampling**					Purpose: Test water quality to determine appropriate cement type for concrete mix. Requirements: Collect water quality samples from both upstream and downstream of the St. Mary's Diversion dam and submit to GLFS for water dispersivity, sulfate, chloride and conductivity testing. Collect water quality samples in sealed containers and ship overnight (for best results samples must be tested within 48 hours of collection) to GLFS. Water quality samples are to be a minimum of 500mL per sample location. In addition to the water quality samples collect two (2) 5-gallon buckets of water and ship to GLFS to be used for laboratory testing. • Collect representative samples from body of water close to structures that are to be protected. • Collect samples as detailed below: o To avoid sample contamination, collect sample using clean sealable bottle and clean hands or latex gloves. o Fill one liter-sized bottle with water and seal tightly. o Label all bottles with permanent marker or water-proof label: ▪ sample location (GPS coordinates, if available) and depth of sample below waterline ▪ date and time ▪ name of sample ▪ name of project ▪ field pH, when available

ITEM NO.	DESCRIPTION	LOCATION	SIZE	DEPTH	TESTING	FIELD EXPLORATION DESCRIPTION
4. Cont.	**Water Quality Sampling**					○ Place sample in a cooler with cooling packs (must survive shipping!) ○ Fill out duplicate Inventory Sheets for each sample batch. Place one copy in a sealable bag and ship with the samples. The second copy will be kept with the field notes. Inventory Sheets should have spaces designated for signatory/date blocks for the field geologist and lab technicians to form a chain of custody. ○ Seal the cooler/box with strapping tape and ship to the lab. ○ Note: Chloride testing requires no preservatives, but testing should be performed within 28 days of sample collection. • Samples are to be shipped directly to a local testing lab, or to the Reclamation GLFS (86-68550), which can then coordinate testing. Results should be sent to MCL for analysis.
5.	**Water Quality and Microbiological Testing**					<u>Purpose</u>: From the pump well discharge, conduct a series of inorganic chemical and microbiological tests to identify the potential impacts of fouling and corrosion during the operation of the sampled well. <u>Requirements</u>: Testing will be performed by Water Systems Engineering Inc. The tests include a number of inorganic chemical parameters such as pH, total dissolved solids/conductivity, hardness, alkalinity, oxidation reduction potential (ORP), bicarbonate, carbonates, silica, sodium, potassium, chloride, iron, manganese, phosphate, nitrate, sulfate, and total organic carbon (TOC). Biological assessment is designed to quantify the total bacterial population, identify two dominant populations of bacteria, assess anaerobic conditions, and identify the presence of iron related bacteria and sulfate reducing organisms. Also included are tests for Adenosine triphosphate (ATP), heterotrophic plate count (HPC), total coliform and E. coli coliform, and a microscopic evaluation. Sample collection and shipment is to be performed according to protocol and procedures defined by the laboratory in advance of the sampling event with regards to the specific project and nature of the problem. All sample containers are to be shipped to Water Systems Engineering, Inc. coordinated through TSC GLFS Gergo Arany.
6.	**Sampling and Questionnaire Commercial Borrow Sources**	See Figures 2 through 6 150 Mile Radius of St Mary's Diversion Dam				<u>Purpose</u>: Evaluate local commercial borrow areas for cofferdam plastic fine-grained core material, rip rap, rock fill, large fish passage boulders, and concrete aggregate. Materials of interest include: filter sand (commonly sold as C33 sand), gravel drain material, concrete sand, or #67/#57 and/ or #467 for concrete aggregates), cement, slag cement, fly ash, and pozzolans. <u>Requirements</u>: Collect samples for laboratory testing of core material, filter sand, gravel drain material, rip rap and rock fill from local commercial quarries and borrow areas 1, 2 and 3. Collect information from local commercial quarries and batch plants utilizing the attached questionnaire for concrete.

ITEM NO.	DESCRIPTION	LOCATION	SIZE	DEPTH	TESTING	FIELD EXPLORATION DESCRIPTION
6. Cont.	**Sampling and Questionnaire Commercial Borrow Sources** Rip Rap (angular and rounded), Large Boulders and Concrete Aggregate	See Figures 2 through 6 150 Mile Radius of St Mary's Diversion Dam (Whiskey Gap Canada, Shelby MT, Trails End Concrete in Browning MT, 3 pits north of Babb MT)				Quantities of materials required are as follows: 1) rip rap and rock fill - 10,000 cubic yards 2) filter sand - 1,000 cy 3) gravel drain – 1,000 cy 4) Core material – 5,000 cubic yards 5) Large boulders – approximately 15 ft. diameter (20 total) for fish passage placement. Minimum sample size requirements: Filter Sand – Eight 5-gallon buckets Gravel Drain – Four 5-gallon buckets Core Material – Six 5-gallon buckets Rip Rap – (ideally 24" diameter) Five 12" to 24" diameter boulders representative of the rock mass if macroscopically uniform. If macroscopically non-uniform: Eight 12" to 24" diameter boulders Uniformity should be judged with respect to the material's anticipated performance as riprap and is left to the discretion of the field geologist. All samples to be shipped to GLFS for testing. GLFS is responsible for testing and report documentation. - All testing will be performed in accordance with ASTM standards and USBR in-house procedures. Testing for core material may include: standard soil physical properties, compaction, 1-D swell/collapse, 1-D consolidation, dispersive soils testing, permeability, shear strength testing (triaxial shear, direct shear or direct simple shear). Testing for filter sand material may include: modified sand castle testing (Filter cementation), unconfined compression test, durability and soundness, lightweight particles, clay lumps and friable particles, petrography and mica count. Testing for gravel drain, rip rap and large bolder may include: rock physical properties, durability (freeze-thaw and wet-dry) and soundness, abrasion testing, and petrography.
7.	**Corrosivity Testing** Collect 1 sample per drill hole	Testing to be coordinated by the Denver TSC GLFS	two quart-sized bags per sample	2-15 feet	Lab Testing Corrosivity Testing	<u>Purpose:</u> Determine design requirements for cathodic protection for buried metallic structures and for concrete material selection. Samples are to be tested to determine pH, resistivity, sulfate concentration, and chloride concentration. <u>Requirements:</u> - Collect samples from drill hole between 2 and 15 feet of depth. - Collect samples as detailed below:

ITEM NO.	DESCRIPTION	LOCATION	SIZE	DEPTH	TESTING	FIELD EXPLORATION DESCRIPTION
7. Cont.	**Corrosivity Testing** Collect 1 sample per drill hole	Testing to be coordinated by the Denver TSC GLFS	two quart-sized bags per sample	2-15 feet	Lab Testing Corrosivity Testing	• To avoid sample contamination, collect sample using clean sealable bags, clean hands or latex gloves, and a rust-free tool (ideally stainless steel). • Fill two quart-sized bags with soil (min. 1 lb. each), remove as much air as possible, and seal tightly. Place the two-quart bags inside a gallon-sized bag and seal. • Label all bags with permanent marker or water-proof label: ▪ sample location (GPS coordinates, if available) and depth of sample ▪ date and time ▪ name of sample ▪ name of project ▪ field pH, when available • Place sample on ice in a picnic cooler (must survive shipping!). • Field geologists will develop two duplicate Inventory Sheets for samples collected. One copy of the Inventory Sheet will be kept with field notes and the second Inventory Sheet will be shipped with the samples to the laboratory. Inventory Sheets should have spaces designated for signatory/date blocks for the field geologist and lab technicians to form a chain of custody. Seal the cooler with strapping tape and ship to the lab. • Note: Chloride testing requires no preservatives, but testing should be performed within 28 days of sample collection. Sulfate testing recommends that the sample be kept cool at ~40°F. Testing should also be performed within 28 days of sample collection. Samples for soil box testing of resistivity must maintain the original moisture content for an accurate measurement. - Samples are to be shipped directly to GLFS (see NOTE), which will coordinate testing. Results should be sent to MCL for analysis and reporting.
8.	**Location Survey**	NA	NA	NA	Survey	Purpose: Survey locate drill holes, the ground surface and the top of the well casing for pump/observation wells. Requirements: Accuracy of survey should be to the nearest 0.1 foot reported in U.S. Survey Feet in the appropriate datum. Units and applicable datum should be included with the coordinate data documentation and data transfer to team members. MB-2300 field geologists will coordinate with MB Region surveyors to assure all required features are surveyed or perform surveys with handheld GPS to the required accuracy. - Locate any features as determined necessary by field geologists. - Survey the (1) Top of Well Casing and the (2) original ground surface for all pump/observation wells.
9.	**Percolation Test**	Refer to Figure 1				Purpose: To meet tribal requirements for septic system design. Requirements: Perform percolation test in accordance with Montana State Department of Environmental Quality (DEQ) Circular DEQ4 in Attachment B.

ITEM NO.	DESCRIPTION	LOCATION	SIZE	DEPTH	TESTING	FIELD EXPLORATION DESCRIPTION
10.	**Documentation/ Data Transfer**	NA	NA	NA	Report Documentation	<u>Purpose</u>: The MB Region geology group (MB-2300) will document all geologic information collected for FER Items 1, 2, 3, 6, 8 and 9 within a geologic report. - TSC Geotechnical Engineering Group 2 staff (86-68312) will document data outlined in FER item 1, 5 and Appendix A. - TSC GLFS staff (86-68550) will document data for FER Items 4, 5 and 6. - TSC MCL staff (86-68540) will document data for FER Item 7. <u>Requirements:</u> (1) Document and summarize explorations in a geologic report. (2) Enter geologic data into a gINT database to develop Reclamation geologic logs as outlined in the *Engineering Geology Field Manual, Volume I*. (3) Document pump and observation well completion and development. (4) Develop plan drawing(s) with surveyed locations of explorations, and cross-sections. (5) Document and summarize pump out test results in a Technical Memorandum. - Transmit final report to the following; - Send 2 copies to: MB-(2300); Send 1 copy to: 86-68150 (R. Kent) - Send 1 copy to: D-2230 (Archives); 86-68320 (T. Lewis); 86-68313 (J. Bray); 86-68312 (N. Bogenschuetz); 86-68550 (G. Arany); 86-68540 (S. Prochaska); 86-68530 (S. Harrell).

NOTES: FER = field exploration request; bgs = below the groundsurface; USBR = refers to standards and procedures discussed in the Bureau of Reclamation Earth Manual.

Samples collected for FER Items 4, 6, 7 and 8 are to be sent to the TSC Geotechnical Laboratory and Field Support (GLFS) address at: Bureau of Reclamation, Attention: Gergo Arany (86-68550), Denver Federal Center, Building 56 – Entrance S-6, Denver CO 80225-0007.

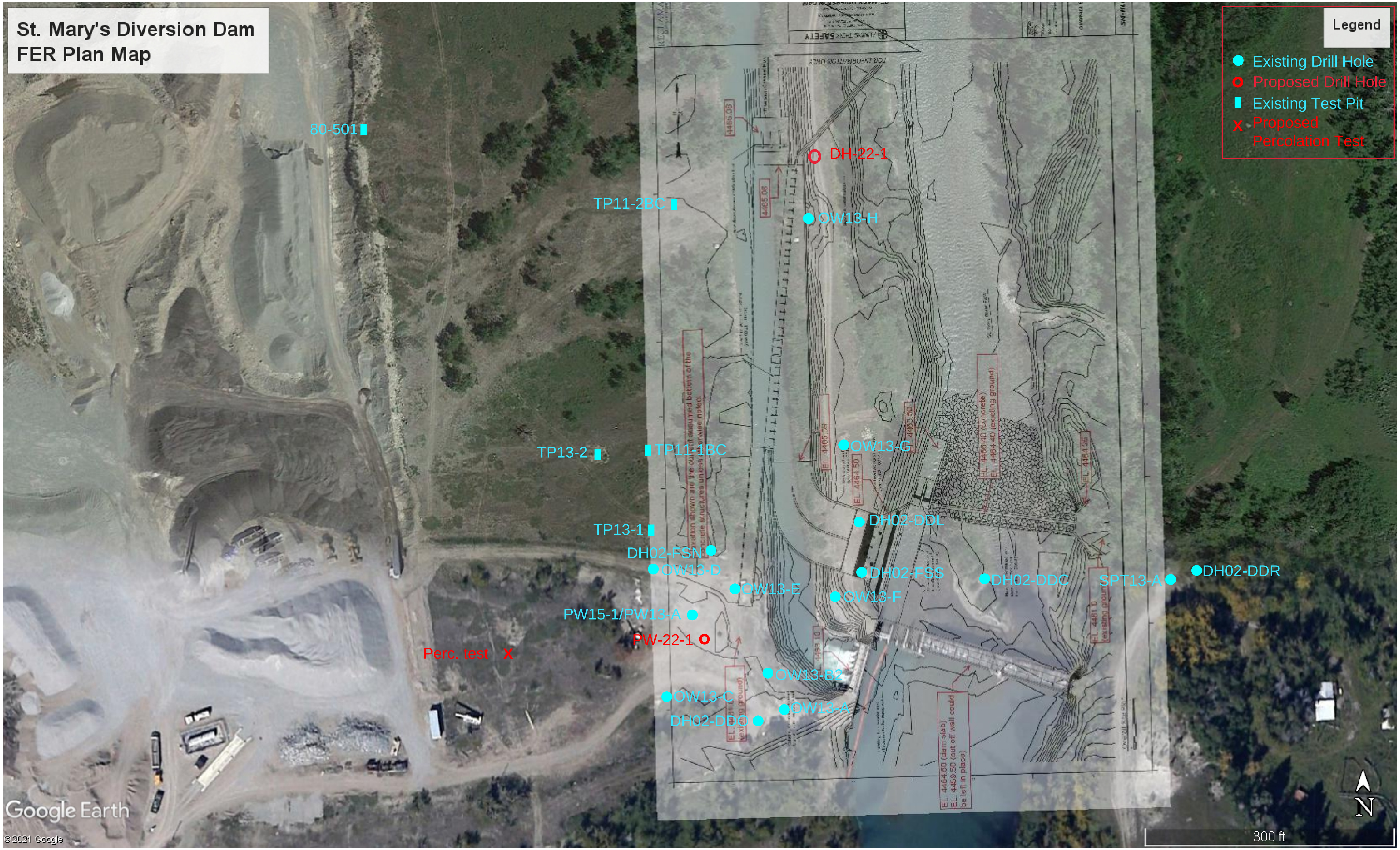
Water samples collected for FER Item 5 are to be sent to Water Systems Engineering address at: 3201 Labette Terrace, PO Box 700, Ottawa, KS 66067

A.Test Pit Source Minimum Sample Size for Laboratory Gradation Analysis Based on Maximum Particle Size Encountered

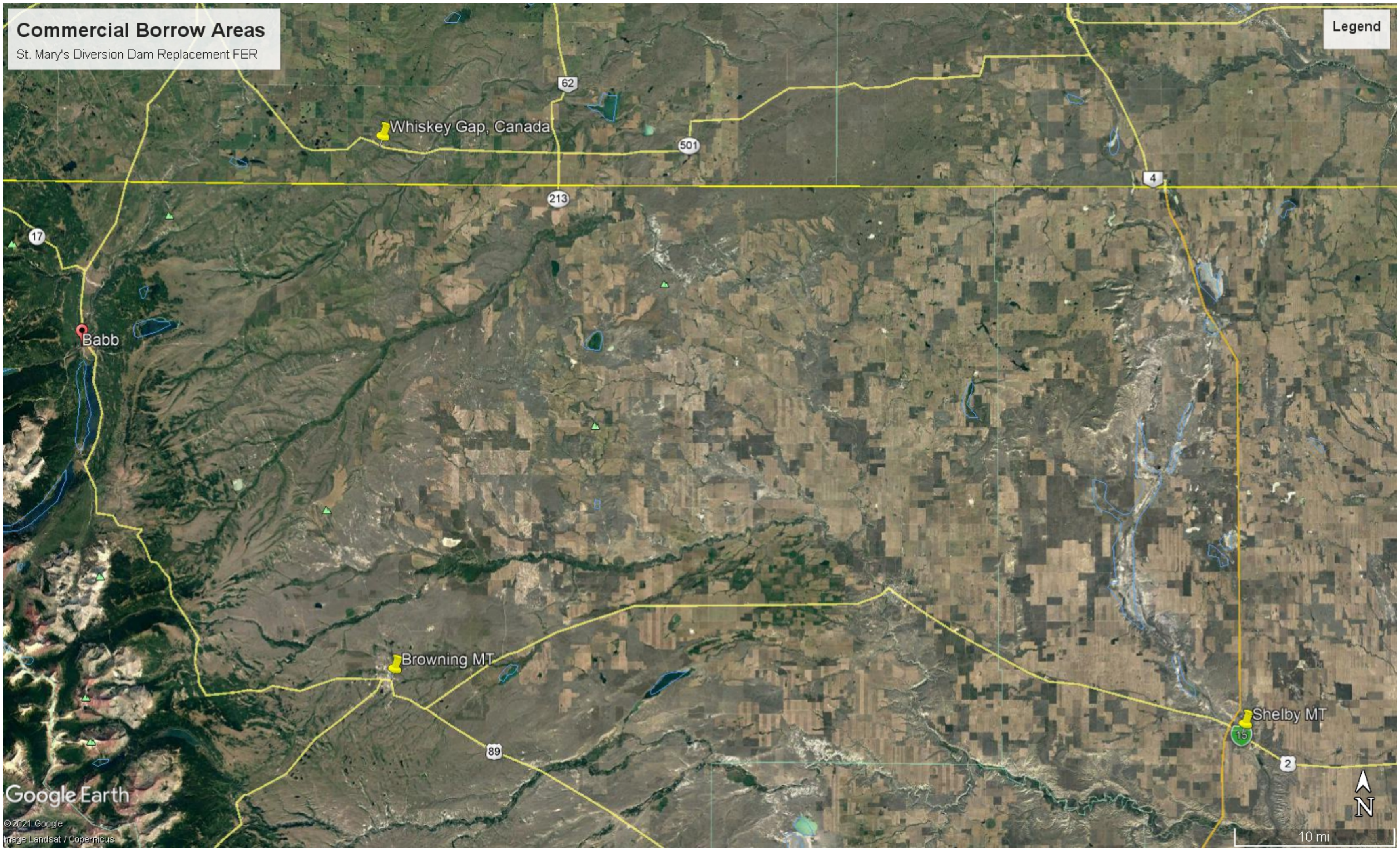
Maximum Particle Size	*Required Test Pit Sample Mass (lbs)*
Minus 3-inch	75
3-inch	150
5-inch	680
8-inch	2800
12-inch	9400

<u>Standards and Testing Procedures:</u>
Visual classification according to the Reclamation Engineering Geology Field Manual, and ASTM D2487 and D2488.
Soil samples will be laboratory tested in strict accordance with ASTM standards D2487, D2216, D421, and D4318. Laboratory samples will be stored and transported according to ASTM D4220.
Well Completion and Development - - - ASTM D5092, D5784 and D6151; and developed according to ASTM D5521.
Consolidation Lab Test Procedure - - - ASTM D2435 (1D Incremental Load Consolidation Test).
Expansive or Collapsible Soil Lab Test Procedure - - - ASTM D4546 (1D swell or collapse of Soils).
Dispersive Soil Test Procedure - - - USBR 5400 (Determining Dispersibility of Clayey Soils by the Crumb Test Method).
Dispersive Soil Laboratory Test Procedure - - - USBR 5410 (Determining Dispersibility of Clayey Soils by the Pinhole Test Method).

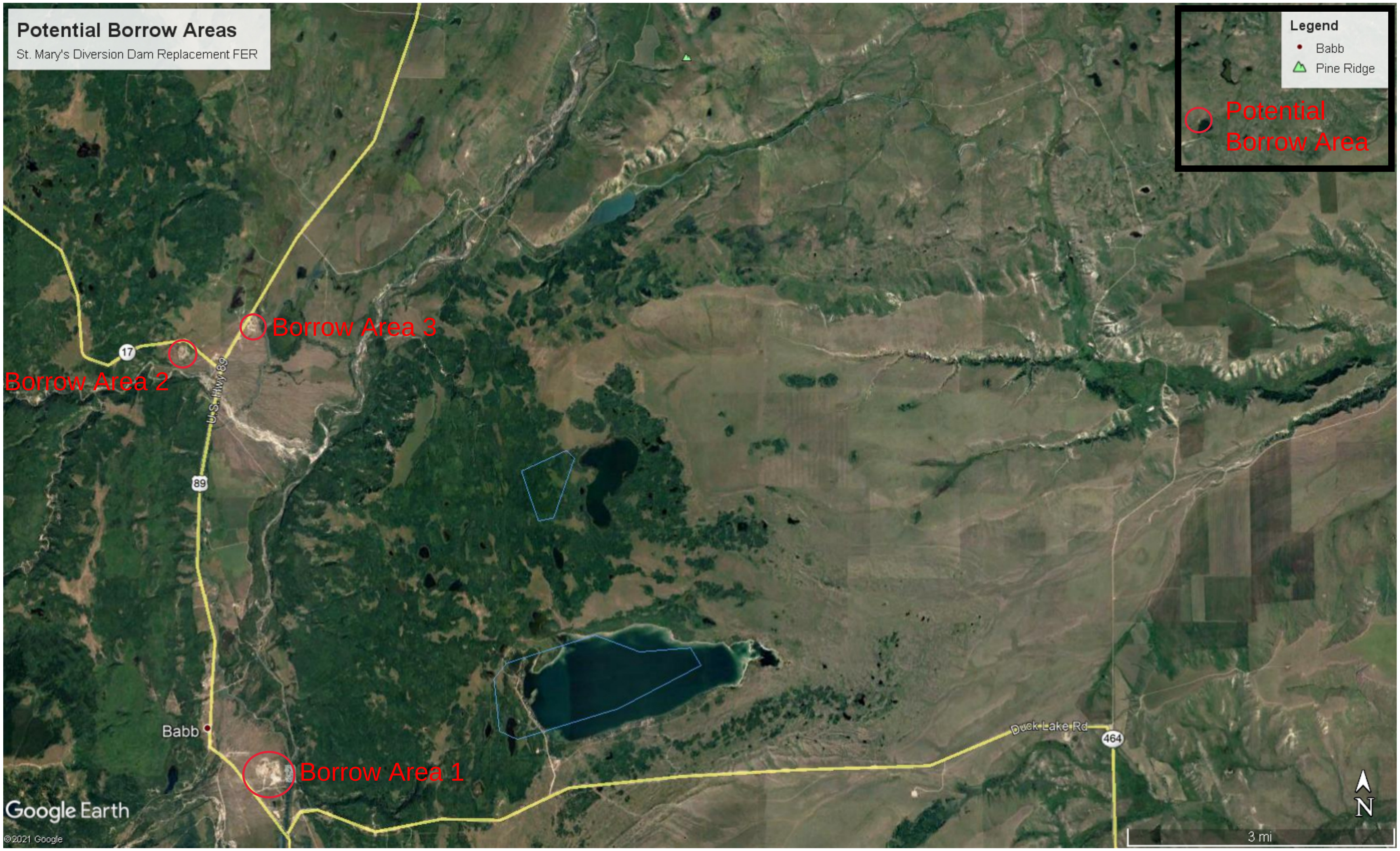
FER Figure 1


St. Mary's Diversion Dam
FER Plan Map
Legend
● Existing Drill Hole
○ Proposed Drill Hole
▮ Existing Test Pit
X Proposed Percolation Test
80-501
DH-22-1
TP11-2BC
OW13-H
TP13-2
TP11-1BC
OW13-G
DH02-DDL
TP13-1
DH02-FSN
OW13-D
DH02-FSS
DH02-DDC
SPT13-A
DH02-DDR
OW13-E
OW13-F
PW15-1/PW13-A
PW-22-1
Perc. test
OW13-B2
OW13-C
OW13-A
DH02-DDO
N
300 ft
Google Earth
© 2021 Google

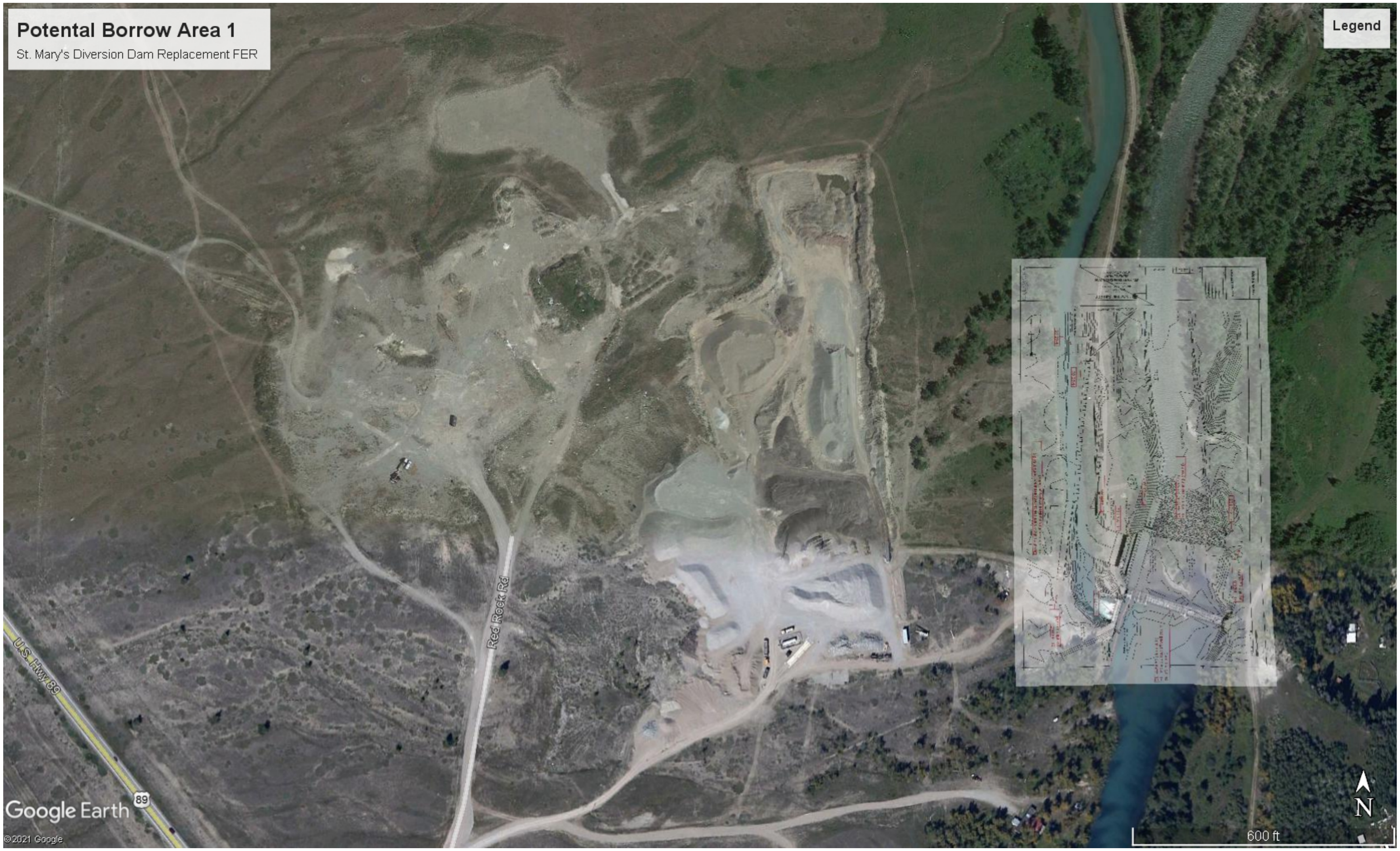
FER Figure 2


Commercial Borrow Areas
St. Mary's Diversion Dam Replacement FER
Legend
Whiskey Gap, Canada
62
501
213
4
17
Babb
Browning MT
89
Shelby MT
15
2
N
10 mi
Google Earth
© 2021 Google
Image Landsat / Copernicus

FER Figure 3


Potential Borrow Areas
St. Mary's Diversion Dam Replacement FER
Legend
Babb
Pine Ridge
Potential Borrow Area
Borrow Area 3
Borrow Area 2
Borrow Area 1
Babb
17
U.S. Hwy 89
89
Duck Lake Rd
464
N
3 mi
Google Earth
©2021 Google

FER Figure 4


Potental Borrow Area 1
St. Mary's Diversion Dam Replacement FER
Legend
Red Rock Rd
US Hwy 89
89
Google Earth
©2021 Google
N
600 ft

FER Figure 5


Potental Borrow Area 2
St. Mary's Diversion Dam Replacement FER
Legend
3825476
17
89
U.S. Hwy 89
N
600 ft
Google Earth
©2021 Google

FER Figure 6

Potental Borrow Area 3
St. Mary's Diversion Dam Replacement FER
Legend
Siers Rd
89
U.S. Hwy 89
Google Earth
©2021 Google
N
600 ft

Appendix A

St. Mary's Diversion Dam

Aquifer Testing Protocols and Well Design

Step-drawdown (step) and pump out tests are requested to be performed as part of this FER to characterize the hydrogeologic characteristics of the Quaternary glacial-alluvial deposits (Qal) for use in the dewatering design associated with the replacement of St. Mary's Diversion Dam. One step test and one pump out tests are included in this FER. The tests are to be completed within PW-22-1 and monitored in the following eight observation wells: OW13-A, OW13-B2, OW13-C, OW13-D, OW13-E, OW13-F, OW13-G, and OW13-H. TSC in conjunction with regional geology will provide equipment and personnel to conduct the tests.

Development

The existing observation wells and PW-22-1 will need to be developed after drilling, prior to the step test. Follow ASTM D5521/5521M-18 for development protocol. Given the coarse nature of the material involved, and the steel screen of the pump well, higher energy techniques may be available. The observation wells are constructed of PVC, so lower energy techniques may be more appropriate.

During development, test the effluent water with a Rossum Sand Tester and a nephelometer for the sanding rate and turbidity, respectively. The target sanding rate is less than 5 ppm, and the target turbidity is less than 15 NTUs. Take measurements at multiple times throughout the development process; start with measurements every hour and modify per the field personnel's best judgement. Note that documentation of the sanding rate and turbidity in relation to the development effort and techniques will be critical to the design.

If the target sanding rate and turbidity is not able to be reached, continue development until sanding rate and turbidity level off and do not decrease with further development. The decision to stop development should be made concurrently between TSC, regional geology, and field staff.

Monitoring St. Mary River

Due to the proximity of the pump out test to the St. Mary River and St. Mary Canal, rigorous monitoring is going to need to occur throughout the duration of the tests. The flows of the river and canal both need to be monitored either by an existing staff gauge or a temporary gauge needs to be installed. The flow rates through the river/canal should be constant before the quiet period, during the test, and through the recovery phase. If testing discharge lines terminate in the river or canal, the water level at this location should be recorded as well.

Step Test Protocol

Results of the step test for PW-22-1 will be used to determine the appropriate pump and pumping rates, as well as determine if the observation well locations are adequate for the pump out tests.

Water level readings in the pumping well should be taken continuously using a transducer. Use of a laptop and central unit (hermit) are recommended. Manual readings should be taken at set intervals for verification of automated readings. Recommended frequency is once per hour, as well as the following:

- Before and after quiet periods.

- Immediately prior to pumping.
- Pump rate change.
- Beginning of recovery period

Manual checks to include water level within the well, water level of the river, time, turbidity, and flow rate. Barometric pressure should also be measured continuously via transducer onsite. Sand content should be tested with a Rossum Sand Tester, turbidity should be tested with a Nephelometer, and flow rates should be monitored with a flowmeter. Effluent water to be discharged in compliance with environmental regulations and far enough away from the well to not impact the test (at least 1000 feet or more is recommended). A filter sock may be used to remove most particles from the discharge.

A quiet period should occur prior to the test where the water level within the well and barometric pressure are recorded. The quiet period should be a minimum of 8 hours in duration and will likely be the night before the step tests. In person monitoring will not be needed at this time as the transducers will record the necessary data. The quiet period is used for the following:

- Allow equipment to come to temperature equilibrium.
- Allow support cables to stretch and stabilize.
- “Dry run” for setting up transducers and getting readings.
- Track long-term changes in groundwater levels prior to the test.
- Correlate changes in barometric pressure with changes in water level.

Pumping rates will be some fraction of the expected flow rate (e.g. 25%, 50%, 75%, and 100%); the lowest rate would be tested first. Anticipated pumping rates might include 200, 400, 600, and 800 gpm, but will be selected by regional geology in conjunction with the TSC prior to the test. It should be noted that the previous pump out test conducted in PW15-1 had a maximum sustainable yield of 200 gpm. The initial pump rate will be selected based on the stick log from the pump well.

A recommended pump for this test is the Grundfos SP 160-3-AA or SP-215-2-AA (30-kW). The pump can run at approximately 200-800 gpm with NPSH of 12.5-36 feet, respectively.

The pump should operate at a specified flow rate until the drawdown reaches a quasi-steady-state, or the well is pumped dry. Steady-state is defined as less than 0.1 ft of change/hour. Upon reaching steady-state, the pumping rate is to be increased to the next step. Together, TSC and regional geology will determine the appropriate time to increase the pumping rate. This cycle continues until the well is pumped dry, the highest pumping rate is reached without pumping the well dry, or the capacity of the pump is reached. Upon completion of each step test, record the recovery of the well until at least 99.9% of the well drawdown has been recovered.

Pump Out Test Protocol

Upon completion of the step test, conduct the pump out test in PW-22-1. The pump out test should follow the same procedure as the step tests (with quiet period, manual readings, sanding, and turbidity measurements, etc.).

Ensure effluent discharge for the pump out test is at least 1000 feet away from the pumping well and observation wells. The discharge locations should be identified, staked, and surveyed along with the pump well.

Each pump out test shall be completed in accordance with ASTM D4050 and conducted for a minimum of 72 continuous hours. The pump out tests may be terminated early or run longer if equilibrium is or is not reached within the 72 hours.

Monitor the pumping well and observation wells using transducers throughout the tests. Record recovery in the pumping well and observation wells until the water level has recovered at least 99.9% of the original water level.

The water levels should be measured manually once per hour to double check the transducer readings. Manually record the water levels in the standpipes for the pumping wells and filter pack. Additional measurements of the river should be completed from a staff gauge or referencing a stream gauge upstream or downstream in the river.

For each pump out test, the sand rate should be checked multiple times (every two to four hours) through each shift using the Rossum Sand Tester. The turbidity of the effluent water should be tested with the nephelometer. The effluent discharge needs to be compliant with environmental regulations. These regulations may require a settlement basin and/or tank.

Notes

Given the limitations of the borehole size and trying to maximize the I.D. of the casing, a 1-inch thick filter pack composed of 8/12 sand will be installed. There are some uncertainties in the soil profile; however, the slot size of 0.02 will only have 15% native material passing into the well, based on the existing gradations. Steel wire-wrapped screens should be used. The type of steel (stainless, galvanized, or low-carbon steel) should be selected based on lowest price. Extra development maybe required to achieve a natural filter pack around the annulus. The pump capacity and screen length may also need to be updated based on results from drilling.

The pump well and observation well geometry is displayed in Table 1 and Figure 1.

Table 1: Well Information

Name	Distance from Pumping Well (ft)	Hole Diameter	Hole Depth (ft)	Stick-Up Length (ft)	Screen Interval (ft)	Filter Pack Length (ft)	Filter Pack	Slot Size (in)	Pump Capacity (GPM)
Pump Well									
PW-22-1	-	12-inch O.D. borehole 10 inch I.D steel	80	3	60	66	8/12	Steel wire-wrap 0.02	200-800
Observation Well									
DH-22-1	~595	8-inch O.D borehole 2-inch I.D. Sch 80 PVC	80	3	30	34	8/12	Sch. 80 PVC continuous slot 0.02	N/A

*Best estimate, field fitting is required.

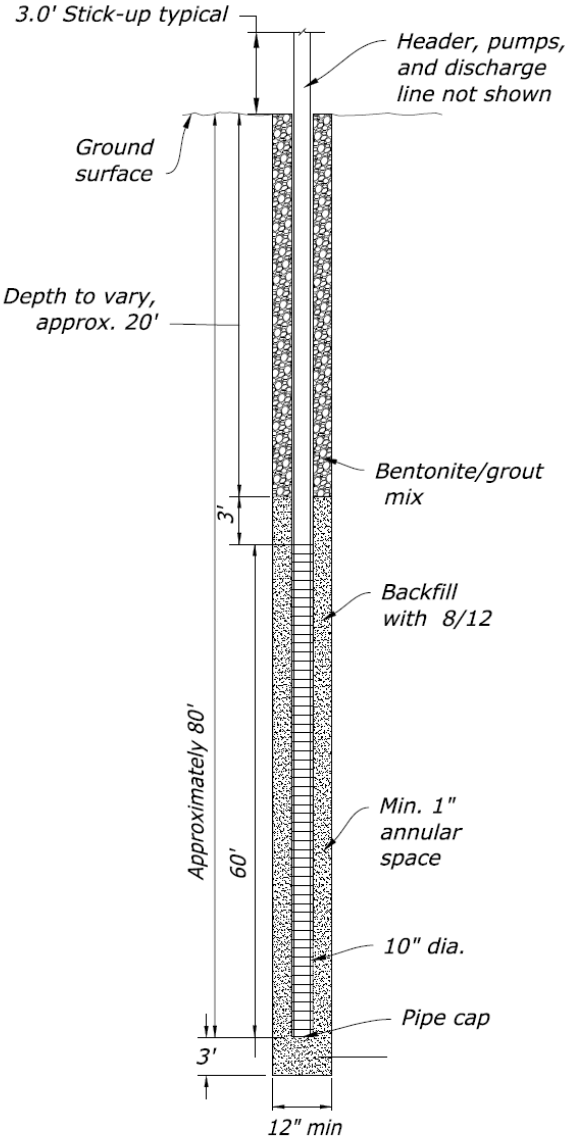


Figure 1: Well diagram for PW-22-1 pump out tests. The screened interval and length of the well may vary based on soil profile.

St. Mary's Diversion Dam Replacement FER – Commercial Material Source Questionnaire
November 2021

The Bureau of Reclamation is seeking sources for construction materials for the proposed replacement of the St. Mary's Diversion Dam located about 1 mile Southeast of Babb, Montana. Anticipated volumes required are provided in Table 1. The required material properties are provided in herein. For each material that can be provided by your company, please select the material type and answer the questions below for each material.

Select Material Type:

- ☐ Core Material
- ☐ Sand Filter
- ☐ Gravel Drain
- ☐ Riprap
- ☐ Large Boulder
- ☐ C33 Sand
- ☐ #67 concrete Aggregate
- ☐ #57 Concrete Aggregate
- ☐ #467 Concrete Aggregate
- ☐ Concrete Sand
- ☐ Fly Ash
- ☐ Pozzolan (type): ______________________________
- ☐ Slag Cement
- ☐ Cement
- ☐ Other ______________________________

To the extent possible, please provide and record the following information about the material selected above:

1. Company Name:
2. Quarry Name:
3. Quarry Address:
4. Distance (miles) to St. Mary's Diversion Dam - Use the following coordinates for reference to the job site:
5. Pit Name/Number/other identifier:
6. How long has this pit been in production, and what is the estimated amount of production remaining?
    a. How long pit has been in production:
    b. What is the estimated amount of production remaining?
7. Typical production rates:
8. Date last sampled:
9. Person responsible for sampling:
10. Provide any recent lab test results, including grading, % passing #200 sieve, durability, plasticity, soundness, deleterious substances, petrography, specific gravity, absorption, and Alkali-Silica Reaction (for concrete aggregates only).
    a. Provided: ☐ Yes ☐ No.
11. Parent/Source Material
    a. Is the material alluvium? ☐ Yes ☐ No. If so, what is the dominate basin rock type(s)?
    b. Is the material from a rock source(s)? ☐ Yes ☐ No. What is (are) the rock type(s)?
    c. For rip rap blocks:

        i. Notable rock mass characteristics (if available)?
        ii. Major defects to blocks (mineralization, weathered areas, etc.)?
        iii. Representative blocks (8) available for shipping (1.5 to 3 ft. blocks are ideal)?
        iv. ASTM D4992 Standard practice for evaluation of rock to be used for erosion control

12. Processing Methods
    a. For alluvium
        i. What are the screening and washing procedures?
    b. For rock source
        i. What are the blasting, crushing, screening and washing procedures?
    c. If any blending is done:
        i. What are the details of that blending process?
        ii. What are the materials that are blended?
        iii. What proportions?
        iv. What additional processing is performed after blending?
13. Past use:
    a. Has the material been used previously as the material type selected above?
        i. If so, by whom and when?
14. Concrete Making Materials: Please provide the following information as it applies to your plant.
    a. Company Name:
    b. Distance from the Plant to the site:
    c. Class of fly ash?
    d. Natural pozzolan type:

e. Slag Cement grade:

f. Cement type:

g. Blended cement type:

h. Nominal maximum size aggregates? (i.e. #67, #57, #467?)

i. ASR testing
    i. When was the last test conducted?
    ii. Is fly ash required to mitigate Alkali-Silica Reaction?

j. Provide any recent lab results including: grading, percent passing #200 sieve, durability, soundness, deleterious substances, petrography, specific gravity, Alkali-Silica Reaction reactivity and batching water quality.

k. Is the batch plant NRMCA certified or equivalent?
    i. Is the certification current?
    ii. If not current, has it been certified in the past?
    iii. When was it last certified?

l. What is the typical batching rate?

Quantities

Table 1: Estimated quantities of construction materials

Material	Volume
Core Material	140,000 CY
Sand Filter	1,00 CY
Gravel Drain	1,00 CY
Riprap	10,000 CY
Rock Fill	10,000 CY
Large Boulders	20 total

Material Specifications

1. Sand Filter – ASTM C33 Fine Aggregate (or similar)

Table 2: Sand Filter Gradation

Sieve	Sieve Size		Percent Passing	
No.	mm	in	Min	Max
3-inch	75	3		
1-1/2-inch	37.5	1.5		
1-inch	25	1		
3/4-inch	19	0.75		
3/8-inch	9.5	0.37	100	
No. 4	4.75	0.187	95	
No. 8	2.36	0.09	80	100
No. 16	1.18	0.045	50	85
No. 30	0.60	0.023	25	60
No. 50	0.300	0.011	5	30
No.100	0.150	0.006	0	10
No.200	0.075	0.003	0	2

2. Gravel Drain – ASTM C33 No. 67 Stone (or similar)

Table 3: Gravel Drain

Sieve	Sieve Size		Percent Passing	
No.	mm	in	Min	Max
3-inch	75	3		
1-1/2-inch	37.5	1.5		
1-inch	25	1	100	
3/4-inch	19	0.75	90	100
3/8-inch	9.5	0.37	20	55
No. 4	4.75	0.187	0	10
No. 8	2.36	0.09	0	5
No. 16	1.18	0.045		
No. 30	0.60	0.023		
No. 50	0.300	0.011		
No.100	0.150	0.006		
No.200	0.075	0.003		

3. Riprap

Size Requirements – Rip Rap shall be 1.5 to 3 feet in diameter with the maximum dimension no greater than 3 times the minimum dimension.

Shape Requirements – Angular, elongated pieces are preferred.

Block Requirements – Uniform block sizes are preferred.

Quality requirements – Riprap should meet or exceed the following requirements in Table 4

Table 4: Quality requirements

Test	Requirements
Specific gravity (saturated surface dry basis)	Average greater than 2.60 (tests of fragments sized between 1 foot and 3 feet diameter)
Soundness (sodium sulfate method)	Less than 10 percent loss of weight after 5 cycles
Abrasion (using Los Angeles machine Grading A)	Less than 30 percent loss of weight after 500 revolutions

FER Attachment B

CIRCULAR DEQ 4

MONTANA STANDARDS
FOR SUBSURFACE WASTEWATER
TREATMENT SYSTEMS

2013 Edition

FOREWORD

These standards, based on demonstrated technology, set forth requirements for the design and preparation of plans and specifications for subsurface wastewater treatment systems.

Users of these standards need to be aware that subsurface wastewater treatment systems are considered by the Environmental Protection Agency to be Class V injection wells and may require associated permits.

These standards are a revision of Department of Environmental Quality (DEQ) Circulars WQB-4, WQB-5, and WQB-6, 1992 Editions, and Circular DEQ-4, 2000, 2002, 2004, and 2009 Editions.

CIRCULAR DEQ-4

CHAPTER

1. INTRODUCTION

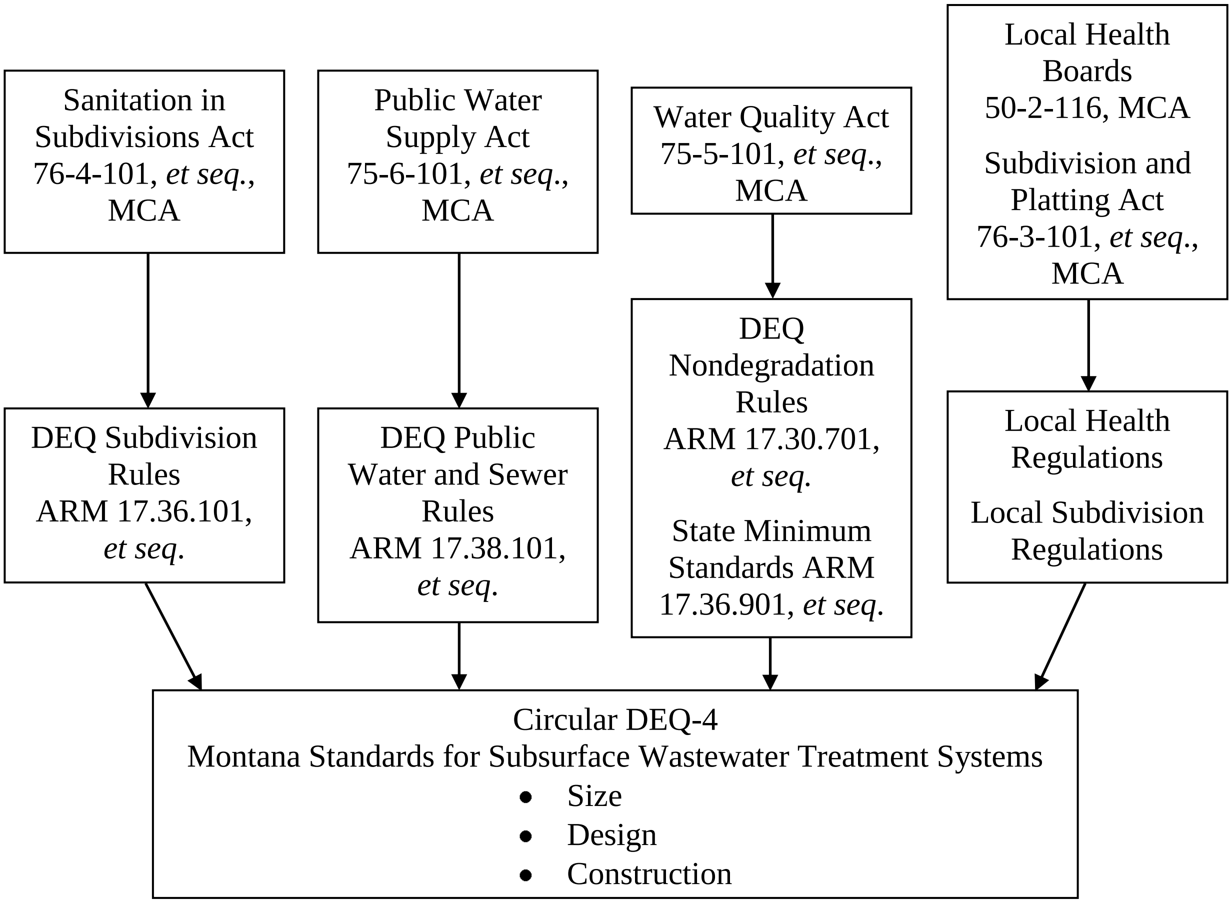
1.1. APPLICABILITY

1.1.1. General

These minimum standards apply to all subsurface wastewater treatment systems in Montana. In some cases, a reviewing authority (other than the Department of Environmental Quality) may have requirements that are more stringent than those set out in this Circular.

The term "reviewing authority," as used in these standards, refers to the Montana Department of Environmental Quality as referenced in the Sanitation in Subdivisions Act, Public Water Supply Act or Water Quality Act. The term "reviewing authority" can also be a division of local government delegated to review public wastewater systems pursuant to Administrative Rules of Montana (ARM) 17.38.102, a unit of local government that has adopted these standards pursuant to 76-3-504, Montana Code Annotated (MCA), or a local board of health that has adopted these standards pursuant to 50-2-116, MCA. Chart 1 shows this relationship graphically.

CHART 1



1.1.2. Types of Systems

This Circular describes different types of wastewater treatment and disposal systems for use in subsurface effluent discharge. These systems typically consist of a collection system, septic tank, distribution box, or manifold and a series of subsurface laterals for effluent allocation. All wastewater applied to the subsurface treatment system must meet residential strength parameters. The method and pattern of effluent discharge in a subsurface absorption system are important design elements; distribution of effluent may be either through gravity flow application or pressure dosing.

The gravity flow method of effluent distribution discharges wastewater from the septic tank or other pretreatment tank directly to the subsurface treatment system as incoming wastewater displaces it from the tank(s). It is characterized by the term "trickle flow" because the effluent is slowly discharged over much of the day. Typically, tank discharges are too low to flow throughout the entire subsurface network; thus, distribution is unequal and localized. Overloading of the infiltration surface may occur. Without extended periods of little or no flow to allow the subsoil to dry, hydraulic failure is possible.

Pressure dose distribution accumulates wastewater effluent in a dose tank from which it is periodically discharged under pressure to the subsurface treatment system by a pump. The pretreated wastewater is allowed to accumulate in the dose tank and is discharged "in doses" when a predetermined water level, water volume, or elapsed time is reached. The dose volumes and discharge rates are usually such that much of the subsurface network is filled, resulting in more uniform distribution over the absorption system area. Periods between doses provide opportunities for the subsoil to drain and re-aerate before the next dose. As a result, dosed-flow systems reduce the rate of soil clogging, more effectively maintain unsaturated conditions in the subsoil, and provide a means to manage wastewater effluent applications to the absorption system. Dosing outperforms gravity-flow systems because distribution is more uniform, controlled, and can be used in any application. Pressure dosed distribution should be the method of choice whenever possible.

The wastewater treatment and disposal systems described by this document include standard absorption trenches, shallow-capped absorption trenches, at-grade absorption trenches, deep absorption trenches, sand-lined absorption trenches, gravelless trenches and other absorption systems, elevated sand mounds, intermittent sand filters, recirculating sand filters, recirculating trickling filters, evapotranspiration absorption systems, evapotranspiration systems, aerobic wastewater treatment units, chemical nutrient reduction systems, waste segregation systems, subsurface drip systems, gray water systems, and experimental systems. Below is a partial list of system applications intended to assist in problem solving for a particular set of site conditions.

1.1.3. System Uses

1.1.3.1. Deep absorption trenches are used to break through an impervious soil layer and allow effluent to infiltrate a deeper and more permeable soil. The bottom of the trench must not be more than 5 feet below natural ground surface.

1.1.3.2. Shallow-capped absorption trenches and elevated sand mounds are used to achieve the minimum separation distance between the treatment system and a limiting layer.

1.1.3.3. Sand-lined absorption trenches are used for rapid permeability situations.

1.1.3.4. Gravelless trenches and other absorption systems are used in lieu of standard absorption trenches within the limitations provided in this Circular.

1.1.3.5. Evapotranspiration absorption systems are used where slow percolation rates or soil conditions would preclude the use of a standard absorption trench.

1.1.3.6. Evapotranspiration systems are used where slow percolation rates or soil conditions would preclude the use of a soil absorption system.

1.1.3.7. Subsurface drip systems are used for irrigation and in cases where the standard absorption system shape must be altered due to topography or natural barriers.

1.1.3.8. Gray water irrigation systems are used for irrigation.

1.1.3.9. Intermittent sand filters are used to provide advanced treatment of septic tank effluent prior to application of effluent to the infiltrative surface and are typically used on small wastewater systems.

1.1.3.10. Recirculating sand filters are used to provide advanced treatment of septic tank effluent prior to application of effluent to the infiltrative surface and are typically used on large wastewater systems.

1.1.3.11. Recirculating media trickling filters, aerobic wastewater treatment units, and chemical nutrient reduction systems are used to provide advanced treatment of septic tank effluent prior to final disposal. They also may be used to provide treatment of high strength wastewater.

1.1.3.12. Absorption beds, holding tanks, sealed pit privies, unsealed pit privies, and seepage pits may only be used as specified in the reviewing authority's regulations. These systems are not allowed as new systems in subdivisions unless authorized by the regulations. Typically, these systems are used for limited areas, replacement systems, or where other systems cannot be installed.

1.1.3.13. Waste segregation systems are used in areas of limited water availability or as a way to implement water saving measures.

1.1.4. Deviations

1.1.4.1. The reviewing authority may grant deviations from the requirements of this Circular. The terms **shall, must,** and **may not** are used where practice is sufficiently standardized to permit specific delineation of requirements or where safeguarding of the public health justifies such definite action. These mandatory items serve as a checklist for the reviewing authority. Other terms, such as **should, may, recommended,** and **preferred** indicate desirable procedures or methods. These non-mandatory items serve as guidelines for designers and do not require specific approval for deviations.

1.1.4.2. A person desiring a deviation shall make a request, in writing, to the reviewing authority having jurisdiction and shall include the appropriate review fee. The request must identify the specific section of the Circular to be considered. Adequate justification for the deviation must be provided. "Engineering judgment" or "professional opinion" without supporting data is considered inadequate justification. The justification must address the following issues:

A. The system that would be allowed by the deviation would be unlikely to cause pollution of state waters in violation of 75-5-605, MCA;
B. The granting of the deviation would protect the quality and potability of water for public water supplies and domestic uses and would protect the quality of water for other beneficial uses, including those uses specified in 76-4-101, MCA; and
C. The granting of the deviation would not adversely affect public health, safety, and welfare.

The reviewing authority having jurisdiction will review the request and make final determination on whether a deviation may be granted.

1.1.4.3. The reviewing authority shall maintain a file of all deviations.

1.1.5. Illustrations and Examples

The images, pictures, examples, and calculations found in this Circular are presented for illustration purposes only and may not include all design requirements. Please refer to the specific rules in this Circular pertaining to each element for details.

1.2 DEFINITIONS

1.2.1. **Absorption area** means that area determined by multiplying the length and width of the bottom area of the disposal trench or bed.

1.2.2. **Absorption bed** means an absorption system that consists of excavations greater than 3 feet in width where the distribution system is laid for the purpose of distributing pretreated waste effluent into the ground.

1.2.3. **Absorption system** means any secondary treatment system, including absorption trenches, elevated sand mounds, evapotranspiration absorption (ETA), gray water irrigation, and subsurface drip systems, used for subsurface disposal of pretreated waste effluent.

1.2.4. **Absorption trench** means an absorption system that consists of excavations 18 to 36 inches in width where the distribution system is laid for the purpose of distributing pretreated waste effluent into the ground.

1.2.5. **Accessory building** means a subordinate building or structure on the same lot as the main building, which is under the same ownership as the main building, and which is devoted exclusively to an accessory use such as a garage, workshop, art studio, guest house, or church rectory.

1.2.6. **Advanced treatment** means a treatment process that provides effluent quality in excess of primary treatment.

1.2.7. **Aerobic wastewater treatment unit** means a wastewater treatment plant that incorporates a means of introducing air and oxygen into the wastewater so as to provide aerobic biochemical stabilization during detention period. Aerobic wastewater treatment facilities may include anaerobic processes as part of the treatment system.

1.2.8. **Bedrock** means material that cannot be readily excavated by hand tools, material that does not allow water to pass through, or material that does not provide for the adequate treatment and disposal of wastewater.

1.2.9. **Bedroom** means any room that is or may be used for sleeping. An unfinished basement is considered an additional bedroom.

1.2.10. **Blackwater** means any wastewater that includes waste from toilets**.**

1.2.11. **BOD_5 (5-day biochemical oxygen demand)** means the quantity of oxygen used in the biochemical oxidation of organic matter in 5 days at 20 degrees centigrade under specified conditions and reported as milligrams per liter (mg/L).

1.2.12. **Building drain** means the pipe extending from the interior plumbing to a point 2 feet outside the foundation wall.

1.2.13. **Building sewer** means the pipe connecting the house or building drain to the public sewer or private sewer.

1.2.14. **Cleanout** means access to a sewer line, extending from the sewer line to the ground surface or inside the foundation, used for access to clean a sewer line.

1.2.15. **Commercial unit** means the area under one roof occupied by a business. For example, a building housing two businesses under one roof is considered two commercial units.

1.2.16. **Composting toilet** means a system consisting of a compartment or a vault that contains or will receive composting materials sufficient to reduce human waste by aerobic decomposition.

1.2.17. **Connection** means a line that provides water or sewer service to a single building or main building with accessory buildings. The term is synonymous with "service connection."

1.2.18. **Design flow** means the flow used for sizing hydraulic facilities, such as pumps, piping, storage, and absorption systems.

1.2.19. **Distribution box** means a watertight receptacle that receives septic tank effluent and distributes it equally into two or more pipes leading to the absorption area.

1.2.20. **Distribution pipe** means a perforated pipe used in the dispersion of septic tank or other treatment facility effluent into a subsurface wastewater treatment system.

1.2.21. **Dosed system** means any system that utilizes a pump, siphon, or actuated valves to deliver treated effluent to a subsurface absorption area.

1.2.22. **Dosing frequency** means the number of times per day that effluent is applied to an absorption system or sand filter.

1.2.23. **Dosing tank** means a watertight receptacle receiving effluent from the septic tank or another treatment device, equipped with a siphon or a pump designed to discharge effluent.

1.2.24. **Dosing volume** means the volume of effluent, in gallons applied to an absorption system or sand filter each time a pump is activated or each time a siphon functions.

1.2.25. **Drain rock** means the rock or coarse aggregate used in an absorption system, sand filter, or seepage pit. Drain rock must be washed, be a maximum of 2.5 inches in diameter and larger than the orifice size unless shielding is provided to protect the orifice, and contain no more than 2 percent passing the No. 8 sieve. The material must be of sufficient competency to resist slaking or dissolution. Gravels of shale, sandstone, or limestone may degrade and may not be used.

1.2.26. **Drop box** means a watertight structure that receives septic tank effluent and distributes it into one or more distribution pipes and into an overflow leading to another drop box and/or absorption system located at a lower elevation.

1.2.27. **Effective size** means the sieve size in millimeters (mm) allowing only 10 percent of the material to pass as determined by wet-test sieve analysis method ASTM C 117-95.

1.2.28. **Effluent** means partially treated wastewater from a primary, advanced, or other treatment facility.

1.2.29. **Effluent filter** means an effluent treatment device installed on the outlet of a septic tank designed to prevent the passage of suspended matter larger than 1/8 inch in size.

1.2.30. **Effluent pump** means a pump used to convey wastewater that has been partially treated from a septic tank or other treatment facility. This wastewater has had settleable or floatable solids removed.

1.2.31. **Ejector pump** means a pump that transports raw sewage.

1.2.32. **Emitter** means orifices that discharge effluent at controlled rates, usually specified in gallons-per-hour (gph). Emitters are typically found in subsurface drip irrigation systems.

1.2.33. **Fats, oils, grease (FOG)** means a component of wastewater typically originating from food stuffs (animal fats or vegetable oils) or consisting of compounds of alcohol or glycerol with fatty acids (soaps and lotions).

1.2.34. **Fill** means artificially placed soil.

1.2.35. **Gravity dose** means a known volume (dose) of effluent that is delivered to an absorption system in a specific time interval. The effluent is delivered either by a siphon or by a pump to a drop box, distribution box, or manifold. The drop box, distribution box, or manifold then distributes effluent into a non-pressurized absorption system.

1.2.36. **Gray water** means wastewater that is collected separately from a sewage flow and that does not contain industrial chemicals, hazardous wastes, or wastewater from toilets.

1.2.37. **Grease trap** means a device designed to separate fats, grease, and oils from the effluent.

1.2.38. **Grinder pump** means a pump that shreds solids and conveys wastewater through a sewer to primary or advanced treatment.

1.2.39. **High-strength waste** means effluent from a septic tank or other treatment device that has BOD_5 greater than 300 mg/L, TSS greater than 150 mg/L, or fats, oils, and grease greater than 25 mg/L.

1.2.40. **Holding tank** means a watertight receptacle that receives wastewater for retention and does not, as part of its normal operation, dispose of or treat the wastewater.

1.2.41. **Horizon** means a layer in a soil profile that can be distinguished from each of the layers directly above and beneath it by having distinctly different physical, chemical, and/or biological characteristics.

1.2.42. **Impervious layer** means any layer of material that has a percolation rate slower than 240 minutes per inch (mpi).

1.2.43. **Incinerating toilet** means a self-contained unit consisting of a holding tank and an adequate heating system to incinerate waste products deposited in the holding tank. The incineration by-products are primarily water and a fine ash.

1.2.44. **Individual wastewater system** means a wastewater system that serves one living unit or commercial unit. The term does not include a public sewage system as defined in 75-6-102, MCA.

1.2.45. **Industrial wastewater** means any waste from industry or from the development of any natural resource, together with any sewage that may be present.

1.2.46. **Infiltrative surface** means the soil interface that receives the effluent wastewater below the drain rock or sand.

1.2.47. **Influent** means the wastewater flow stream prior to any treatment.

1.2.48. **Irrigation** means those systems that provide subsurface application of wastewater to any planted material by means of a piping system.

1.2.49. **Key** means to hollow out in the form of a groove.

1.2.50. **Limiting layer** means bedrock, an impervious layer, or seasonally high ground water.

1.2.51. **Living unit** means the area under one roof that can be used for one residential unit and which has facilities for sleeping, cooking, and sanitation. A duplex is considered two living units.

1.2.52. **Main** means any line providing water or sewer to multiple service connections, any line serving a water hydrant that is designed for firefighting purposes, or any line that is designed to water or sewer main specifications.

1.2.53. **Manhole** means an access to a sewer line for cleaning or repair.

1.2.54. **Manifold** means a solid (non-perforated) wastewater line that distributes effluent to individual distribution pipes.

1.2.55. **Mottling** or **redoximorphic features** means soil properties associated with wetness that result from the reduction and oxidation of iron and manganese compounds in the soil after saturation and desaturation with water.

1.2.56. **Multiple-user wastewater system** means a non-public wastewater system that serves, or is intended to serve, more than two living or commercial units, but which is not a public sewage system as defined in 75-6-102, MCA. The total number of people served may not exceed 24. In estimating the population that will be served by a proposed residential system, the reviewing authority shall multiply the number of living units times 2.5 people per living unit.

1.2.57. **Natural soil** means soil that has developed in place through natural processes and to which no fill material has been added.

1.2.58. **Orifice** means an opening or hole through which wastewater can exit the distribution pipe**.**

1.2.59. **Percolation test** means a standardized test used to assess the infiltration rate of soils performed in accordance with Appendix A.

1.2.60. **Plasticity** means the ability of a soil sample to be rolled into a wire shape with a diameter of 3 mm without crumbling.

1.2.61. **Pressure distribution** means an effluent distribution system where all pipes are pressurized and the effluent is pumped, or delivered by siphon, to the next portion of the treatment system in a specific time interval or volume.

1.2.62. **Pretreatment** means the wastewater treatment that takes place prior to discharging to any component of a wastewater treatment and disposal system including, but not limited to, pH adjustment, oil and grease removal, BOD_5, and TSS reduction, screening, and detoxification.

1.2.63. **Primary treatment** means a treatment system, such as a septic tank, that provides retention time to settle the solids in raw wastewater and that retains scum within the system.

1.2.64. **Private sewer** means a sewer receiving the discharge from one building sewer and conveying it to the public sewer system or a wastewater treatment system.

1.2.65. **Professional engineer** means an engineer licensed or otherwise authorized to practice engineering in Montana pursuant to Title 37, Chapter 67, MCA.

1.2.66. **Proprietary system** means a wastewater treatment method holding a patent or trademark.

1.2.67. **Public wastewater system** means a system for collection, transportation, treatment, or disposal of wastewater that serves 15 or more families or 25 or more persons daily for any 60 days or more in a calendar year. In estimating the population that will be served by a proposed residential system, the reviewing authority shall multiply the number of living units times 2.5 people per living unit, so that 10 or more proposed residential connections will be considered a public system.

1.2.68. **Qualified site evaluator** means a soils scientist, professional engineer, registered sanitarian, hydro geologist, or geologist who has experience and knowledge of soil morphology. Other individuals will be considered qualified after providing, to the reviewing authority, evidence of experience describing soils or experience conducting necessary test procedures.

1.2.69. **Raw wastewater** means wastewater that has not had settleable solids removed through primary treatment or other approved methods.

1.2.70. **Recreational camping vehicle (RV)** means a vehicular unit designed primarily as temporary living quarters for recreation, camping, travel, or seasonal use, and that either has its own power or is mounted on, or towed by, another vehicle. The basic types of RVs are camping trailer, fifth-wheel trailer, motor home, park trailer, travel trailer, and truck camper.

1.2.71. **Redoximorphic or mottling features** means soil properties associated with wetness that result from the reduction and oxidation of iron and manganese compounds in the soil after saturation and desaturation with water.

1.2.72. **Residential strength wastewater** means effluent from a septic tank or other treatment device with a BOD_5 less than or equal to 300 mg/L, TSS less than or equal to 150 mg/L, and fats, oils, and grease less than or equal to 25 mg/L.

1.2.73. **Reviewing authority** means the Department of Environmental Quality, a local department or board of health certified to conduct reviews under 76-4-104, MCA, a division of local government delegated to review public wastewater systems pursuant to ARM 17.38.102, a local unit of government that has adopted these standards pursuant to 76-3-504, MCA, or a local board of health that has adopted these standards pursuant to 50-2-116, MCA.

1.2.74. **Scarify** means to make shallow cuts in order to break the surface.

1.2.75. **Seasonally high ground water** means the depth from the natural ground surface to the upper surface of the zone of saturation, as measured in an unlined hole or perforated observation well during the time of the year when the water table is the highest. The term also means the upper surface of a perched water table.

1.2.76. **Septic tank** means a wastewater settling tank in which settled sludge is in immediate contact with the wastewater flowing through the tank while the organic solids are decomposed by anaerobic action.

1.2.77. **Service connection** means a line that provides water or sewer service to a single building or main building with accessory buildings. The term is synonymous with "connection."

1.2.78. **Sewage** is synonymous with "wastewater" for purposes of this Circular.

1.2.79. **Sewer invert** means the inside bottom, or flow line, of a sewer pipe.

1.2.80. **Shared wastewater system** means a wastewater system that serves, or is intended to serve, two living units, two commercial units, or a combination of one living unit and one commercial unit. The term does not include a public sewage system as defined in 75-6-102, MCA.

1.2.81. **Siphon** means a pipe fashioned in an inverted U shape and filled until atmospheric pressure is sufficient to force a liquid from a reservoir in one end of the pipe over a barrier and out the other end.

1.2.82. **Slope** means the rate that a ground surface declines in feet per 100 feet. It is expressed as percent of grade.

1.2.83. **Soil consistence** means attributes of soil material as expressed in degree of cohesion and adhesion or in resistance to deformation or rupture. For the purposes of this Circular consistence includes resistance of soil material to rupture, resistance to penetration, plasticity, toughness, and stickiness of puddled soil material, and the manner in which the soil material behaves when subject to compression. Although several tests are described, only those should be applied which may be useful.

1.2.84 **Soil profile** means a description of the soil strata to a depth of eight feet using the United States Department of Agriculture (USDA) soil classification system method in Appendix B.

1.2. 85. **Soil texture** means the amount of sand, silt, or clay measured separately in a soil mixture.

1.2. 86. **Surge tank** means a watertight structure or container that is used to buffer flows.

1.2. 87. **Synthetic drainage fabric** means a nonwoven drainage fabric with a minimum weight per square yard of 4 ounces, a water flow rate of 100 to 200 gallons per minute per square foot, and an apparent opening size equivalent to a No. 50 to No. 110 sieve.

1.2. 88. **Total Suspended Solids (TSS)** means solids in wastewater that can be removed by standard filtering procedures in a laboratory and is reported as milligrams per liter (mg/L).

1.2. 89. **Transport pipe** means the pipe leading from the septic tank or dose tank to the distribution box or manifold.

1.2. 90. **Uniformity coefficient (UC)** means the sieve size in millimeters (mm) that allows 60 percent of the material to pass (D60), divided by the sieve size in mm allowing 10 percent of the material to pass (D10), as determined by ASTM C 117-95 (UC=D60/D10).

1.2.91. **Uniform distribution** is a means to distribute effluent into a pressure dosed absorption system or sand filter such that the difference in flow, measured in gallons per day per square foot, throughout the treatment system is less than 10 percent.

1.2.92. **Waste segregation** means a method by which human toilet waste is disposed of through composting, chemical, dehydrating, or incinerator treatment, with a separate disposal method for gray water.

1.2.93. **Wastewater** means water-carried waste including, but not limited to, household, commercial, or industrial wastes, chemicals, human excreta, or animal and vegetable matter in suspension or solution.

1.2.94. **Wastewater treatment system or wastewater disposal system** means a system that receives wastewater for purposes of treatment, storage, or disposal. The term includes all disposal methods described in this Circular.

1.2.95. **Wet well** means a chamber in a pumping station, including a submersible pump station, where wastewater collects.

2. SITE CONDITIONS

2.1. SITE EVALUATION

2.1.1. General

Information concerning soil and site conditions is needed for the design of subsurface wastewater treatment systems. Elements that must be included in the evaluation are:

A. soil profile descriptions as described in Section 2.1.4;
B. soil permeability determined from soil texture or percolation tests described in Section 2.1.5, if required;
C. depth to ground water, bedrock, or other limiting layer;
D. land slope and topographic position;
E. flooding potential;
F. amount of suitable area available; and
G. setback distances required in ARM Title 17, Chapter 36, subchapters 3 or 9, as applicable.

2.1.2. System Evaluation

A qualified site evaluator shall conduct a site evaluation in the location of each proposed system.

2.1.3 Existing Soil Information

Soil surveys are usually found at the local USDA Natural Resources Conservation Service (NRCS) office or through the USDA WebSoil Survey website. Soil surveys offer good preliminary information about an area and can be used to identify potential problems, however, they cannot substitute for a field investigation.

2.1.4 Soil Profile Description

Soils must be described in accordance with Appendix B.

Soil profiles within 25 feet of the boundaries of the proposed absorption system and its replacement area are required. Soil pits should be located outside the boundaries of the proposed absorption system so that they do not act as a conduit for effluent between soil horizons. The number and depth of soil pit descriptions for a subsurface wastewater treatment system must comply with the requirements of ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable.

For proposed primary and replacement absorption systems that are not located in the same immediate area, a soil profile may be required for each proposed absorption system area. The minimum depth of soil profile descriptions must be 8 feet unless a limiting layer is encountered at a shallower depth. If a limiting layer is encountered at less than 8 feet in the soil profile or if the site is in an area where bedrock outcroppings exist, the reviewing authority may require one soil profile at each end of both the absorption system and the replacement area to ensure adequate depth of soil. The soil profile may need to be completed to a greater depth to demonstrate compliance with other applicable rules.

2.1.4.1. Soil Properties

The following soil properties must be evaluated and reported by a qualified site evaluator in accordance with this Circular to the full depth of the hole:

A. thickness of each layer or horizon needs to be described;
B. texture, structure, and consistence of soil horizons;
C. color (preferably described by using the notation of the Munsell color scheme) and color variation (redoximorphic features);
D. depth of water, if observed;
E. estimated depth to seasonally high ground water and basis for the estimate;
F. depth to and type of bedrock or other limiting layer, if observed;
G. stoniness reported on a volume basis (i.e., the percentage of the soil volume occupied by particles greater than 2 mm in diameter);
H. plasticity; and
I. other prominent features such as roots, etc.

2.1.5. Percolation Tests or Infiltrometer Tests

The reviewing authority may require multiple percolation tests when the soils are variable or other conditions create the need to verify system sizing.

Percolation tests, if required, must be conducted at the approximate depth of proposed construction. For elevated sand mounds and at-grade systems, the depth of the percolation test hole must be 12 inches. Additional percolation tests may be required to determine the existence of a limiting layer. The percolation tests must be performed in accordance with the procedures contained in Appendix A.

When more than one percolation test is conducted within the boundaries of a proposed absorption system, the percolation rate will be determined based on the arithmetic mean of similar percolation test values.

2.1.6. Suitable Area Evaluation

The size of the site and the amount of suitable area must be evaluated in conjunction with the size of the proposed subsurface wastewater system and locations of other features requiring a minimum separation distance.

2.1.7. Application Rates

Table 2.1-1 and the soil descriptions outlined in Appendix B must be used to determine application rates for subsurface wastewater treatment systems.

TABLE 2.1-1
Soil Texture Descriptions are found in Appendix B

Texture	Percolation Rate (minutes per inch)	Application rate (gpd/ft^2) (a) (b)
Gravel, gravelly sand, or very coarse sand (c)	<3	0.8
Loamy sand, coarse sand (d)	3-<6	0.8
Medium sand, sandy loam	6- <10	0.6
Fine sandy loam, loam	10- <16	0.5
Very fine sand, sandy clay loam, silt loam	16-<31	0.4
Clay loam, silty clay loam	31-<51	0.3
Sandy clay	51-<121	0.2
Clays, silts, silty clays (e)	121- <240	0.15
Clays, silts, silty clays (f)	>240	Additional Soil Information Required

(a) If more than 500 lineal feet, or 1,000 square feet of distribution line, calculated before applying any reductions, are needed, then pressure distribution must be provided.

(b) Comparison of the soil profile report, percolation rate, and USDA-NRCS soils report should be reviewed. If the information shows a variable application rate, additional site specific information may be required by the reviewing authority.

(c) Systems installed in gravel or coarser textured soils with percolation rates faster than 3 mpi must be pressure dosed and sand lined.

(d) Pressure distribution must be provided for these soils if there is less than 6 feet from the bottom of the trench to a limiting layer.

(e) Percolation tests must be conducted in accordance with Appendix A.

(f) Soils with initial percolation rates greater than 240 mpi must be reevaluated using the double-ring infiltrometer procedure outlined in ASTM D 5093-02. Systems may be proposed for these soils only if the double-ring infiltrometer procedure shows a percolation rate of 240 mpi or less. All calculations and results must be reported to the reviewing authority. Only ETA or ET systems designed in accordance with Subchapter 6.8 may be used.

2.1.8. Site Factors

The land slope, potential for flooding, and amount of suitable area must be evaluated.

2.1.8.1. Type and Percent of Land Slope

The type (concave, convex, or plane), percent, and direction of land slope must be reported along with the method of determination. The reviewing authority may require a 2-foot contour map of the area for sites having slopes exceeding 15 percent within 25 feet of the absorption system or replacement area.

2.1.8.2. Flooding and Surface Water

The potential for flooding or accumulation of surface water from storm events must be evaluated. Floodplain maps, when available, must be included as part of the evaluation.

2.1.8.3. Ground Water and Surface Water Quality Impact

Compliance with the nondegradation requirements of the Montana Water Quality Act (75-5-101, et seq., MCA) must be demonstrated.

2.1.8.4. Ground Water Observation

When required, ground water observation must be conducted in accordance with Appendix C.

2.1.9. Site Evaluation Reporting

Any person performing a site evaluation on a parcel shall submit to the reviewing authority all data and locations of all test holes and percolation tests performed on the parcel.

2.2. SITE MODIFICATIONS

2.2.1. General

Site modifications, as described in Sections 2.2.2, 2.2.3, and 2.2.4 of this Subchapter, may be used only for replacement of failing systems. Site preparation for cut and fill modifications must be completed prior to final approval. Minor leveling, as described in Section 2.2.5 of this Subchapter, will be allowed for both new systems and replacement systems. All new and replacement subsurface wastewater treatment systems must meet the requirements of this Circular.

2.2.2. Artificially Drained Site

Artificially drained site modifications may be used only for the replacement of failing systems and may not be used for new systems.

Prior to construction of any site drainage system such as a field drain, under drain, or vertical drain, an evaluation of the site must be performed including soil profile descriptions, slope, depth to bedrock or other impervious layer, estimation of depth to seasonally high ground water, topography, distance to wells, seeps, streams, ponds, or other open water, and any other pertinent considerations.

2.2.2.1. Design of Drain System

The drainage method chosen (curtain drain, vertical drain, or under drain) and the reason for this choice must be detailed. Drawings showing dimensions of the drain system and materials to be utilized must be provided.

The drainage system must be constructed according to the specific design approved by the reviewing authority.

2.2.2.2. Depth to Ground Water

The type of wastewater treatment system to be approved must depend upon the depth to seasonally high ground water. A minimum of 4 feet of natural soil from the bottom of the infiltrative surface to the seasonally high ground water must be achieved by the site drainage system. An adequate horizontal separation distance must be maintained between the drain and the absorption system to reduce the potential for effluent to enter the drain.

2.2.2.3. Depth to Ground Water Observation

The reviewing authority may require observation of the depth to seasonally high ground water after installation of the drainage system.

2.2.2.4. Operation and Maintenance, Certification, and As-builts

A detailed set of plans, specifications, and an operation and maintenance plan are required, prior to approval by the reviewing authority. The operation and maintenance plan must meet the requirements in Appendix D. Certification and as-built plans are required in accordance with Appendix D.

2.2.3. Cut Systems

Cut systems may be used only for the replacement of failing systems and may not be used for new subsurface wastewater treatment systems. Site modification for replacement subsurface wastewater treatment systems must be completed prior to approval by the reviewing authority.

2.2.3.1. Limiting Layer

A minimum of 4 feet of natural soil from the bottom of the infiltrative surface to a limiting layer must be maintained.

2.2.3.2. Design

A. Cut areas for the replacement absorption system must be physically completed prior to approval. Two soil test holes must be excavated and detailed soil profile descriptions of the final receiving soils must be provided prior to excavation. Percolation tests may be required after the cut has been completed. All soil information must be submitted to the reviewing authority.
B. A complete lot layout must be submitted showing the cut areas, the uphill and downhill slope, and slope across the cut area. Slope across the absorption system site must be a uniform slope.
C. Cut systems will only be considered on slopes that do not exceed 25 percent and where downhill slope below the cut area is not greater than 25 percent.

2.2.3.3. Certification and As-builts

The designer shall submit a letter of verification indicating that the site meets minimum requirements of this Circular after the cut has been completed. Certification and as-builts are required in accordance with Appendix D.

2.2.4. Fill System

Fill systems may be used only for replacement of existing failed systems and may not be used for new subsurface wastewater treatment systems. The reviewing authority must initially approve the fill location with the site modification completed prior to final system approval. Fill areas for replacement absorption systems must be physically completed prior to approval by the reviewing authority.

2.2.4.1. Location

A. The entire area necessary for the replacement absorption system must be filled prior to final approval of the system.
B. Fill systems may not be installed on soils with a percolation rate slower than 60 mpi. Side slopes on the fill may not exceed 25 percent (4:1).

2.2.4.2. Fill Restrictions

A minimum of 4 feet of natural soil from the bottom of the infiltrative surface of the subsurface absorption system to a limiting layer must be maintained. Fill cannot be used to overcome minimum vertical or horizontal separation distances.

2.2.4.3. Fill Material

Soils used for fill may not be finer than sandy loam with a maximum of 20 percent passing the No. 100 sieve.

2.2.4.4. Design

A. System configuration dimensions and orientation must be submitted in a design report. The design report and drawings must be approved by the reviewing authority prior to the placement of fill material.
B. Three percolation tests evenly spaced across the completed fill must be performed at the depth of the proposed infiltrative surface as a basis for design application rate.
C. The absorption system must be sized on the basis of the percolation rate for either the soil beneath the fill material or the percolation rate of the fill material, whichever is slower.

2.2.4.5. Construction

A. All vegetative cover must be removed from the area to be filled.
B. Fill material must not be put in place when the fill or the original soil surface is frozen.
C. Fill material must be placed in lifts and compacted as specified in the design report so that stable soil structure conditions are achieved.
D. Absorption systems must be set back at least 25 feet from the lower edge of the filled area on slopes of 6 percent or greater. For slopes less than 6 percent, absorption systems must be set back at least 10 feet on all sides prior to starting the side slope.
E. The fill area must be seeded with a suitable grass to aid in stabilization.

2.2.4.6. Certification and As-builts

Certification and as-builts are required in accordance with Appendix D.

2.2.5. Minor Leveling

Minor leveling is limited to sites with a natural ground slope of 15 percent or less. A parcel may undergo minor leveling by cutting and/or filling of the natural ground surface up to and no more than a 12-inch depth.

Soil that has undergone minor leveling will not be considered natural soil and all vertical depth requirements must be met.

A minimum of 4 feet of natural soil from the bottom of the infiltrative surface to a limiting layer must be maintained.

The reviewing authority may require a detailed site plan of the area proposed for minor leveling showing the contours and other pertinent land features, both before and after minor leveling.

3. WASTEWATER

3.1. WASTEWATER FLOW

3.1.1. General

The purpose of this chapter is to provide a method for estimating wastewater flows. Subsurface wastewater treatment system flow rates, in gallons per day (gpd), are based on type of use, size of the home, including number of bedrooms, or number of people. The agreements and easements for shared, multi-user, or public subsurface wastewater treatment systems, as required in ARM 17.36.326 must be met.

3.1.2. Residential wastewater design flow rates must be estimated as follows:

A. When the number of individual living units on a single or common absorption system is 9 or less, the following table must be used. Sizing is based on individual living units, not collective number of bedrooms. Living units will be considered to have three bedrooms unless otherwise approved.

1 bedroom	150 gpd
2 bedrooms	225 gpd
3 bedrooms	300 gpd
4 bedrooms	350 gpd
5 bedrooms	400 gpd
Each additional bedroom	add 50 gpd

B. When the number of living units on a single or common absorption system is 10 or more, the design flow rate per living unit may be reduced to 100 gpd per person. An average of 2.5 persons per living unit must be used to calculate total design flow unless the reviewing authority determines that a larger per-living-unit average is appropriate for a given project.

Operation and Maintenance, Certification, and As-builts

A detailed set of plans, specifications, and an operation and maintenance plan are required. The operation and maintenance plan must meet the requirements in Appendix D. Certification and as-built plans are required in accordance with Appendix D.

3.1.3. Nonresidential Wastewater Flow

Typical daily flows for a variety of commercial, institutional, and recreational establishments are presented in this section.

The reviewing authority may require that nonresidential establishments demonstrate that the wastewater meets residential strength standards or complies with the requirements of

Subchapter 3.2.

For design purposes, the typical flows must be used as minimum design flows. Greater design flows may be required where larger flows are likely to occur, such as resort areas. Design flow must be computed using the total number of units in the proposed facility times the typical daily flow in the tables, with no reduction allowed for occupancy rates. Where the system includes several different types of uses from the tables, each use must be computed separately and the design flow must be based on the sum of all of the uses. A means of flow measurement, such as flow meters or pump run-time meters, may be required.

As an alternative to the flows listed in the tables, design flows may be based on actual water use data from similar facilities. If daily flows are used, the design flow must be 1.1 times the highest daily flow. If monthly averages are used, the peak design flow must be a minimum of 1.5 times the average flow of the highest month. The water use data must be representative of the facility proposed and for a time period adequate to evaluate annual use of the system. System components may be added or enlarged to address peak flows to allow absorption systems to be sized based on average flow.

For expansions of existing systems, the reviewing authority may approve the use of actual water use data to determine appropriate flows.

TABLE 3.1-1
TYPICAL WASTEWATER FLOWS FROM COMMERCIAL, INDUSTRIAL, AND OTHER NONRESIDENTIAL SOURCES

Source	**Unit**	**Wastewater**	**Flow, gpd/unit**
		Range	**Typical**
Airport	Passenger	2-4	3
Automobile Service Station	Vehicle Served	7-13	10
	Employee	9-15	12
Bar	Customer	5	3
	Employee	10-16	13
Church	Seat		3
(Not including a kitchen, food service facility, daycare, or camp)			
Church	Seat		5
(Including kitchen, but not including a food service facility, day care, or camp)			
Daycare	Child	10-30	25
	Employee	10-20	15
Department Store	Toilet Room	400-600	500
	Employee	8-12	10
Hospital, medical	Bed	125-240	165
	Employee	5-15	10
Hospital, mental	Bed	75-140	100
	Employee	5-15	10
Hotel/Motel	Guest	40-56	48
	Employee	7-13	10
Industrial Building	Employee	10-16	13
(Sanitary waste only)			
Laundry	Machine	450-650	580
(Self-serve)	Wash	45-55	50
Office	Employee	7-16	13
Prison	Inmate	75-150	115
	Employee	5-15	10
Rest home	Resident	50-120	85
Restaurant	Meal	2-4	3
School, day:			
With cafeteria, gym, showers	Student	15-30	25
With cafeteria only	Student	10-20	15
Without cafeteria, gym, showers	Student	5-17	11
School, boarding	Student	50-100	75
Shopping Center	Parking Space	1-2	2
	Employee	7-13	10
Store	Customer	1-4	3
	Employee	8-12	10

TABLE 3.1-2
TYPICAL WASTEWATER FLOWS FROM RECREATIONAL FACILITIES

Source	**Unit**	**Wastewater Range**	**Flow, gpd/unit Typical**
Apartment, resort	Person	50-70	60
Bed and Breakfast	Person	20-40	40
Cabin, resort	Person	8-50	40
Cafeteria	Customer	1-3	2
	Employee	8-12	10
Campground (developed)	Person	20-40	30
Cocktail lounge	Seat	12-25	20
Coffee shop	Customer	4-8	6
	Employee	8-12	10
Country club	Member (present)	60-130	100
	Employee	10-15	13
Day camp (no meals)	Person	10-15	13
Dining hall	Meal served	4-10	7
Dormitory, bunkhouse	Person	20-50	40
Hotel/Motel, resort	Person	40-60	50
Store, resort	Customer	1-4	3
	Employee	8-12	10
Swimming pool	Customer	5-12	10
	Employee	8-12	10
Theater	Seat	2-4	3
Visitor center	Visitor	4-8	5
Recreational Vehicles without individual hookups for water or sewer	Space		50
Recreational Vehicles with individual hookups for water and/or sewer	Space		100

3.2. HIGH STRENGTH WASTEWATER

3.2.1. General

Nonresidential establishments may have the potential to produce wastewater considered high-strength. Elevated levels of BOD_5, TSS, and FOG will reduce the effectiveness of onsite wastewater treatment systems by increasing the biological demand on downstream components in the system, by containing inorganic compounds that are not easily broken down, and by accelerating mechanical clogging of the infiltrative surface. These establishments often produce effluent with variations of flow including intermittent, seasonal, or sporadic peak events.

The reviewing authority may require that nonresidential establishments demonstrate that the wastewater meets residential strength standards or complies with the requirements of this subchapter.

Nonresidential establishments are listed in Section 3.1.3, Table 3.1-1, 3.1-2 and may also include, but are not limited to:

Athletic facilities
Bakeries
Beauty shops/nail salon
Breweries
Car washes
Food processing facilities
Funeral homes and crematoriums
Facilities with separate gray water plumbing
Hobby woodworking shops or art studios
Manufacturing facilities
Nursing homes
Rest areas
Restaurants
RV dump stations
Schools
Tanneries
Veterinarian clinics

Nonresidential structures or establishments that produce or contain any industrial or chemical components may be required to obtain a Montana ground water pollution control system permit regardless of system size.

3.2.2. Wastewater strength

Systems, accepting wastewater not treated to the following levels, must comply with this section prior to final disposal in a subsurface absorption system. Other conditions of system approval may be required by the reviewing authority.

A. BOD_5 less than or equal to 300 mg/L;
B. TSS less than or equal to 150 mg/L; and
C. FOG less than or equal to 25 mg/L

3.2.2.1. BOD_5 or TSS

All wastewater must meet residential waste standards for BOD_5 and TSS. The reviewing authority may impose additional requirements on systems with low BOD_5 levels where compliance with the Water Quality Act and nondegradation of state waters is a concern.

3.2.2.2. Fats, Oils, and Grease (FOG)

Restaurants, nonresidential kitchens, or other facilities that have FOGs greater than 25 mg/L must include a grease tank or other treatment system approved by the reviewing authority in their design. This treatment must occur prior to wastewater entering the septic tank.

A. Grease Tanks

1. Grease tanks must be sized based upon the daily design flow estimates in this chapter, with the minimum acceptable tank size being 1,000 gallons. Grease tanks must provide a minimum of 24 hours of holding time to allow FOGs to cool and separate out of emulsion. Establishments that experience surge loading must provide larger grease tanks designed for longer holding periods.
2. Grease tanks must be constructed in accordance with Section 5.1.7.
3. Grease tanks must have sanitary Ts on the inlet and sanitary Ts or baffles on the outlet. The baffles must extend down from the top of the tank with the openings near the bottom. The chamber between the baffles must be sized to contain the expected FOG volume between pumping periods.
4. Wastewater from all food preparation and clean-up areas must be plumbed separately into the grease tank. Cross connections with blackwater sewers is not allowed.
5. Effluent from the grease tank must be plumbed into the septic tank.

B. Other treatment systems designed to treat FOGs will be reviewed on a case-by-case basis.

3.2.3. A design report must be submitted along with plans and specifications including:

3.2.3.1. A statement describing the type of business or industry and the end products and byproducts that will be disposed of in the wastewater system; and

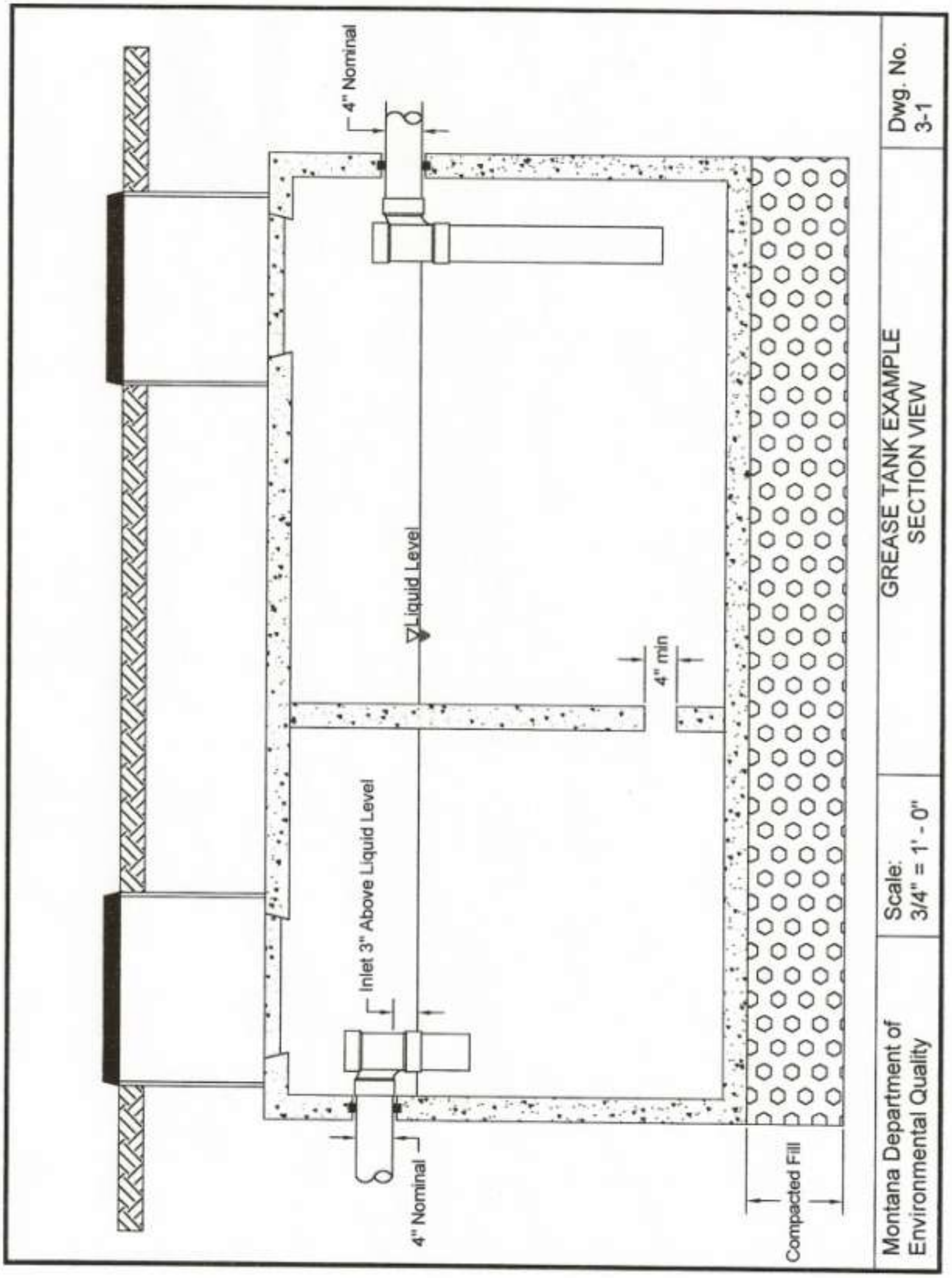
3.2.3.2. Description, plans, and specifications that detail the treatment of the high strength wastewater.

3.2.4. Operation and Maintenance, Certification, and As-builts

All high strength wastewater treatment systems must submit an operation and maintenance plan in accordance with Appendix D and this chapter. Certification and as-built plans are required in accordance with Appendix D.

3.2.4.1. The operation and maintenance plan must include procedures for each component of the wastewater treatment system. Material Safety Data Sheets (MSDS) for chemicals used, as well as a perpetual contract for operation and maintenance of the system must be included.

3.2.4.2. Sampling records, when required, must be kept on site and made available to the reviewing authority upon request.


4" Nominal
Liquid Level
4" min
Inlet 3" Above Liquid Level
4" Nominal
Compacted Fill
Montana Department of
Environmental Quality
Scale:
3/4" = 1' - 0"
GREASE TANK EXAMPLE
SECTION VIEW
Dwg. No.
3-1

3.3. WATER TREATMENT WASTE RESIDUALS

3.3.1. General

Wastewater from ion exchange water treatment systems, water softening treatment systems, demineralization water treatment systems, or other water treatment systems that produce a discharge may be disposed using an onsite wastewater treatment absorption system. A Montana Ground Water Pollution Control System permit and nondegradation analysis may be required.

3.3.2. Water Softener Discharges

The wastewater (backwash) from water softeners may be discharged to a wastewater treatment system only if the installed water softener:

A. regenerates using a demand-initiated regeneration control device; and
B. is connected only to interior plumbing for potable water usage and not to exterior irrigation water lines.

3.3.3. Discharges to Experimental and Proprietary Systems

Wastewater from ion exchange water treatment systems, water softening treatment systems, demineralization water treatment systems, or other water treatment systems that produce a discharge may not be discharged into an experimental, or proprietary on-site wastewater treatment system, unless the quality and quantity of discharge meets the recommended usage, operation, and maintenance specifications of the designer or manufacturer of the system. If such specifications are not available, then approval for the discharge must be obtained from the reviewing authority.

3.3.4. Discharges to Approved Systems

Wastewater from ion exchange water treatment systems, water softening treatment systems, demineralization water treatment systems, or other water treatment systems that produce a discharge may be discharged to a separate drainfield, other approved absorption system, or into the ground, if not prohibited by other rules or regulations.

3.3.5. Operation and Maintenance Plan

An operation and maintenance plan for all components of the water treatment and subsurface wastewater treatment systems must be submitted in accordance with Appendix D.

3.3.6. Other Requirements

The reviewing authority may require that water treatment residuals be disposed in a separate subsurface wastewater treatment system unconnected to the system for the disposal of sanitary wastewater.

4. COLLECTION, PUMPING, AND EFFLUENT DISTRIBUTION SYSTEMS

4.1 COLLECTION SYSTEMS

4.1.1. General

4.1.1.1. Sewer collection systems, as described in this subchapter, are the system of pipes and other appurtenances that receive and convey wastewater or effluent either by gravity or through force mains to a treatment system. This subchapter discusses sewer service connections, gravity mains, force mains, alternative collection systems, and necessary setbacks.

4.1.1.2. Sewer collection systems, including sewer service lines and sewer mains, must maintain the setback distances required in ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable.

4.1.1.3. Sewer collection systems that include inverted siphons or those to be constructed near stream crossings, at water main crossings, or with aerial crossings must be designed in accordance with Department Circular DEQ-2.

4.1.1.4. Sewer collection systems must be designed for wastewater only. Rain water from roofs, streets, and other areas; cooling water, surface water drainage, ground water from foundation drains, etc., are not permitted in wastewater sewers.

4.1.1.5. In general, flow used for designing sewers must consider the ultimate population to be served, maximum hourly wastewater flow, and possible infiltration. Sewer extensions should be designed for projected flows even when the diameter of the receiving sewer is less than the diameter of the proposed extension. A schedule for future downstream sewer relief may be required by the reviewing authority.

4.1.1.6. Sewer collection systems must be designed to prevent freezing. The minimum depth of bury must not be less than 4 feet to the top of the pipe without justification by the designer. Insulation must be provided for sewers that cannot be placed at a depth sufficient to prevent freezing. Insulation used for this purpose must be specifically designed to withstand compaction and for use in subsurface locations. It must retain the insulating value for the design life of the sewer.

4.1.1.7. Schedule 40 PVC sewer pipe must be used leading into and out of the septic tank, and in the area of backfill around the tank for a minimum length of at least 10 feet. Other sewer collection pipes must be made of PVC or High Density Polyethylene (HDPE).

A. PVC sewer pipes must meet the requirements of ASTM D 3034-08, Schedule 40, or Schedule 80 and meet ASTM D 1785-12. Sewer collection pipes must be joined by an integral bell-and-spigot joint with rubber elastomeric gasket or solvent cement joints. When using ASTM D 3034-08, rock-free bedding is required.

B. HDPE sewer pipe must meet the requirements of ASTM D 3350-12, must meet the minimum cell classification of 435400C as defined and described in ASTM D 3350-12, and must be joined by an integral bell-and-spigot joint with rubber elastomeric gasket or butt fusion weld.

4.1.1.8. Transition connections to other materials must be made by adapter fittings or one-piece molded rubber couplings with appropriate bushings for the respective materials. All fittings must be at least of equivalent durability and strength of the pipe itself.

4.1.1.9. Sewer collection pipes must be installed at a uniform slope.

4.1.1.10. Buoyancy of sewer collection systems including pipes, and manholes must be considered and flotation of the component must be prevented with appropriate construction where high ground water conditions are anticipated.

4.1.1.11. Installation specifications must contain appropriate requirements based on the criteria, standards, and requirements established by the industry in its technical publications. Requirements must be set forth in the specifications for the methods of bedding and backfilling the pipe. See ASTM D 2321-11 with respect to PVC pipe installation, when appropriate.

4.1.2. Sewer Service Connections

4.1.2.1. Sewer service connections from the structure to the septic tank must be at least 4 inches in diameter and must be placed at a minimum slope of 1/4 inch per foot toward the point of discharge unless pressurized.

Sewer service connections that are greater than 4 inches in diameter must be designed in accordance with the requirements of Department Circular DEQ-2.

4.1.2.2. Sewer service connections should be sufficiently deep to receive wastewater from basements.

4.1.2.3. Cleanouts are recommended within 3 feet of the building, at angles greater than 45 degrees, and for continuous pipe runs greater than 150 feet in length.

4.1.2.4. Sewer service connections to the sewer main must be watertight and may not protrude into the sewer. If a saddle-type connection is used, it must be a device intended to join with the types of pipe that are to be connected. All materials used to make service connections must be compatible with each other and with the pipe materials to be joined. All materials must be corrosion-proof.

4.1.3. Gravity Sewer Mains

4.1.3.1. Gravity sewer mains conveying raw wastewater must be designed in accordance with the requirements of Department Circular DEQ-2, except where modified by this section. They must be at least 8 inches (203 mm) in diameter, except gravity sewer mains used within private property, trailer courts, condominiums, apartments, etc., are allowed mains no smaller than 6 inches in diameter, provided that the 6-inch diameter main can be shown to be hydraulically feasible, that no future expansion is anticipated, and that maintenance will not be increased due to the smaller diameter.

Gravity sewer mains conveying effluent must be at least 4 inches in diameter and must be designed in accordance with the requirements of Department Circular DEQ-2.

4.1.3.2. Manholes must be installed at the end of each sewer line, at all grade, size, or alignment changes, at all intersections, and at distances not greater than 400 feet (122 m) for sewers 15 inches (381 mm) or less in diameter and 500 feet (152 m) for sewers 18 inches (457 mm) to 30 inches (762 mm) in diameter. Greater spacing may be permitted in larger sewers at the discretion of the reviewing authority.

Distances up to 600 feet (183 m) may be approved where cleaning equipment for the stated spacing is provided. Documentation must be provided that such cleaning equipment is readily available and has the cleaning capability stated.

Manholes must be constructed in accordance with the requirements of Department Circular DEQ-2.

Cleanouts may be used only for special conditions and may not be substituted for manholes or installed at the end of laterals greater than 150 feet (46 m) in length.

Cleanouts may not be used in place of manholes on mains of public wastewater systems conveying raw wastewater, but may be used in place of manholes on lines conveying septic tank effluent. For systems conveying septic tank effluent, manholes or cleanouts must be located at major junctions of 3 or more pipes and should be limited to strategic locations for cleaning purposes.

4.1.4. Force Mains (Pressurized Sewers)

Force mains must be designed in accordance with the requirements of Department Circular DEQ-2.

4.1.5. Alternative Collection Systems, Certification, and As-builts

Alternative wastewater collection systems must be designed in accordance with the requirements of Department Circular DEQ-2. This would include grinder pump systems, septic tank effluent pump systems, and small diameter gravity systems. Certification and as-built plans are required in accordance with Appendix D.

4.2. PUMPING SYSTEMS

4.2.1 General

This subchapter describes pumping systems and appurtenances for both raw wastewater and effluent.

Buoyancy must be considered and flotation of pumping systems prevented with appropriate construction where high ground water conditions are anticipated.

Pumping systems must maintain the setback distances required in ARM Title 17, Chapter 37, subchapters 3 or 9, as applicable.

4.2.2. Raw Wastewater Pumping Stations, Certification, and As-builts

4.2.2.1. Wastewater pumping stations receiving raw wastewater that has not had settleable solids removed and that have design flow rates of 5,000 gpd or greater must be designed in accordance with the requirements of Department Circular DEQ-2. Certification and as-built plans are required in accordance with Appendix D.

4.2.2.2. Wastewater pumping stations receiving raw wastewater that has not had settleable solids removed and that have design flow rates less than 5,000 gpd must be designed in accordance with the requirements of Department Circular DEQ-2, with the following exceptions:

A. Pumps must be capable of passing spheres of at least 2 inches in diameter, or grinder pumps capable of handling raw wastewater must be provided.
B. Submersible pumps and motors must be designed specifically for totally submerged operation and must be submerged at all times.
C. Multiple pumps are not required.
D. Pump suction and discharge piping may be less than 4 inches in diameter.
E. A 4-inch pump is not required.
F. The discharge line must be sized to provide a minimum velocity of 2 feet per second.

Certification and as-built plans are required in accordance with Appendix D.

4.2.3. Effluent Pumping Stations

Effluent pumping stations process partially treated wastewater from a primary, advanced, or other treatment facility. The intent of effluent pumping stations is the distribution of effluent to a receiving component.

Pressure dosing or pumping stations used to dose subsurface treatment or absorption systems include both gravity dosing to a distribution box or a drop box and delivery of effluent to a manifold for pressure distribution to a subsurface treatment or absorption system.

4.2.3.1. Wastewater pumping stations must be provided with effluent pumps, controls, and wiring that are corrosion-resistant and listed by Underwriters Laboratories, Canadian Standards Association, or other approved testing and/or accrediting agency as meeting the requirements for National Electric Code (NEC) Class I, Division 2 locations. An audible or visible alarm must be provided to indicate high water levels.

In lieu of meeting the requirements for NEC Class 1, Division 2 locations, pumping stations receiving effluent from 5 or less living units, those stations vented in accordance with the requirements of Chapter 40 of Department Circular DEQ-2, or advanced treatment effluent pumping units that are preceded by a septic tank, may use submersible pumps and motors designed specifically for totally submerged operation with controls and wiring that are corrosion-resistant.

4.2.3.2. Effluent pumping stations for alternative collection systems must be designed in accordance with the requirements of Department Circular DEQ-2.

4.2.3.3. Dosing and Pressure Distribution - Pumping Stations Used with Subsurface Absorption Systems

A. The intent of dosing is the uniform distribution of effluent to a receiving component. Dosing includes both gravity dosing to a distribution box or a drop box and delivery of effluent to a manifold for pressure distribution to a subsurface wastewater treatment system.

B. Pressure distribution to a subsurface wastewater treatment system should be utilized whenever practical, but must be utilized when the design wastewater flow requires an effective length of more than 500 lineal feet or 1,000 square feet of distribution lines, calculated before applying any reductions. The effective length of the absorption area is the actual length of the trench or bed, calculated prior to any applied reductions. The effective length cannot exceed the length of the pipe by more than one-half the orifice spacing.

C. Dosing may be accomplished with either pumps or siphons, which must be sized for the distribution system. Justification for the pump or siphon model selected must be included for review.

D. The dose volume of a pressure distribution system must be equal to the drained volume of the transport pipe and manifold, plus a volume that should be 5 to 10 times the net volume of the distribution pipe. Where the system is designed to operate on a timer, more frequent, smaller doses may be used. The minimum dose volume must be equal to the drained volume of the transport pipe and manifold, plus a volume equal to at least 2 times the distribution pipe volume. Where timers are used, additional controls are necessary to prevent pump operation at low-water level. For gravity-dosed systems, the volume of each dose must be at least equal to 75 percent of the internal volume of the distribution lines being dosed.

E. The pressure distribution pipe must be at least Class 200 or Schedule 40 PVC or high density polyethylene (HDPE) with a minimum pressure rating of 160 psi. All fittings must be pressure rated to the pipe. The pipe must have a single row of orifices 1/8-inch diameter or larger in a straight line. Design must include orifices to allow for drainage of the pipe and to allow air to be expelled from the pipe. Maximum orifice spacing must be 5 feet. The size of the dosing pumps and siphons must be selected to provide a minimum pressure of 1 psi (2.3 feet of head) at the end of each distribution line. For orifices smaller than 3/16-inch, the minimum pressure must be 2.16 psi (5 feet of head) at the end of each distribution pipe.

F. A hydraulic analysis demonstrating uniform distribution must be provided for all pressure distribution systems. The analysis must show no greater than 10 percent variation in distribution of dose across the entire distribution system. Pressure-dosed systems installed on a sloping site must include means for controlling pressure differences caused by varying distribution pipe elevations across the entire distribution area.

G. Cleanouts must be provided at the end of every lateral. The cleanouts must be within 6 inches of finished grade and should be made with either a long-sweep elbow or 2 45-degree bends. A pressure distribution system designer may specify the use of capped ends that are replaced after flushing if, in the designer's opinion, this is a more feasible option than long sweep cleanouts. A metal location marker or plastic valve cover must be provided for each cleanout.

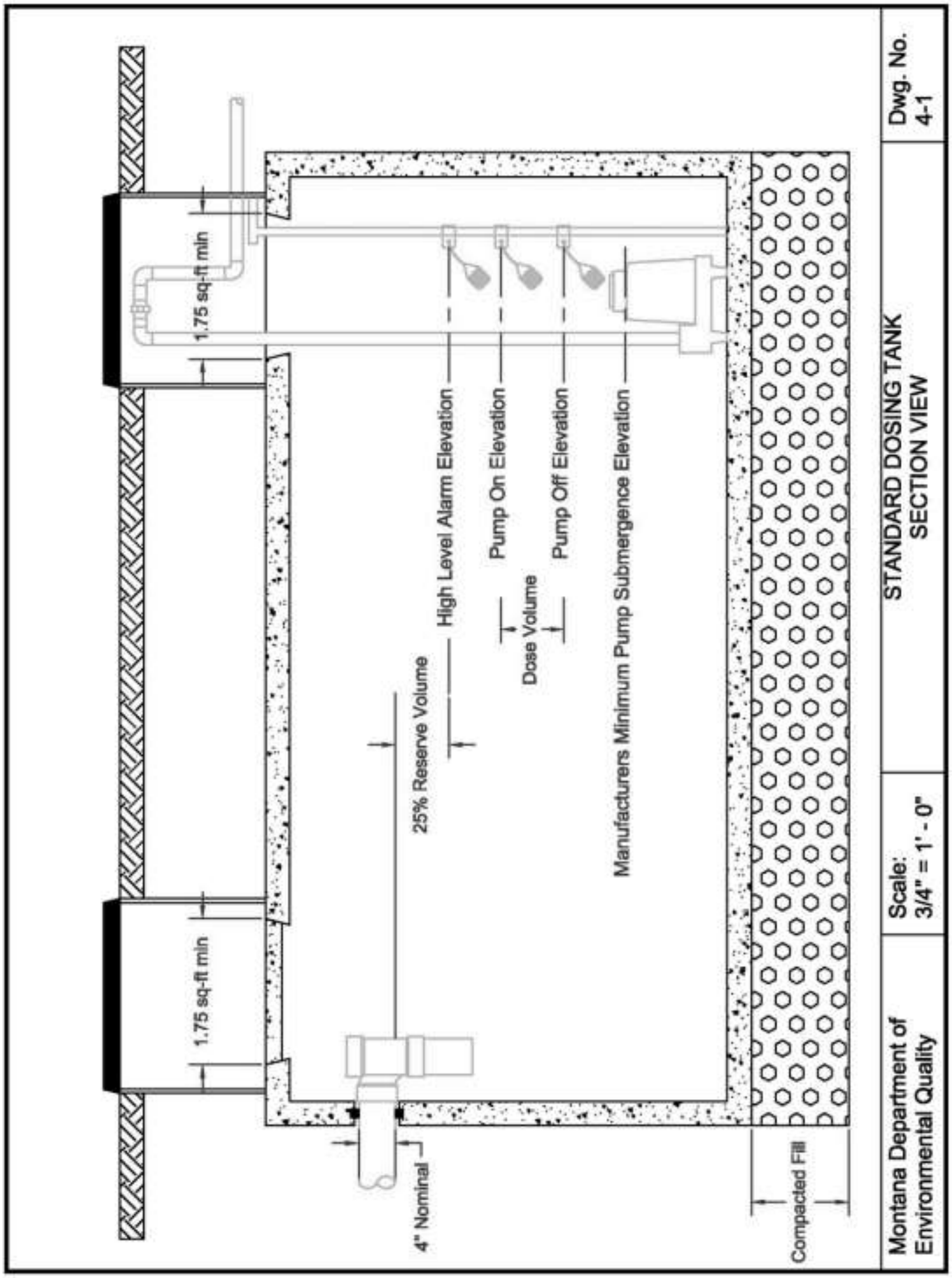
H. Dosing tanks

1. Dose tank volumes are not to be included in primary, advanced, or other required tank volumes.
2. The reserve storage volume of the dosing tank must be at least equivalent to 25 percent of the subsurface distribution system design flow. If a duplex pump station is used, where each pump doses the entire distribution system, then the reserve storage volume of the dosing tank may be reduced. The reserve storage volume is computed from the high-level alarm. If the specified pump requires submergence, the tank must also include adequate liquid capacity for pump submergence and the dose volume.
3. The dosing tank must be separated from the septic tank by an air gap to eliminate the possibility of siphoning from the septic tank. Dosing tanks must be provided with access ports sufficiently large enough to maintain the tank and pumps. Pumps, valves, and other apparatus requiring maintenance must be accessible from the surface without entering the tank or be located in a dry tank adjacent to the wet chamber. Adequate provision must be made to effectively protect maintenance personnel from hazards.
4. Dosing tanks must meet the construction requirements for septic tanks listed in Section 5.1.7.

High-water alarms must be provided for all dosing chambers that utilize pumps.

Dosed systems using a siphon should have a dose counter installed to check for continued function of the siphon.

I. Pressure distribution systems must be field-tested to verify that the pressure across the entire absorption field does not vary by greater than 10 percent.



STANDARD DOSING TANK
SECTION VIEW

Montana Department of
Environmental Quality

Scale:
3/4" = 1' - 0"

Dwg. No.
4-1

4.3. EFFLUENT DISTRIBUTION SYSTEMS

4.3.1. General

This subchapter applies to the transportation and distribution of treated effluent.

NOTE: Effluent transport pipes, distribution boxes, drop boxes, manifolds, and distribution pipes must maintain the setback distances required in ARM Title 17, Chapter 36, subchapters 3 or 9, as applicable.

4.3.2. Pipes

4.3.2.1. Transport pipes

Transport pipes move effluent from the primary or advanced treatment system to the distribution box, drop box, or manifold.

4.3.2.2. Transport, manifold, and distribution pipe materials

A. Gravity-fed distribution lines must be fabricated from 4-inch diameter ASTM D3034-08 sewer pipe with perforations per ASTM D2729-11.
B. Coiled, perforated-plastic pipe may not be used for distribution pipe within absorption systems. Straight lengths of pipe must be used.
C. Pipe used for pressure-dosed distribution lines must be at least Class 200 PVC or Schedule 40 and meet ASTM D1785-12 or ASTM D2241-09 or high density polyethylene (HDPE) with a minimum pressure rating of 160 psi. All fittings must be pressure rated to the pipe. Pressure rated fittings compatible with the materials must be used for pressure-dosed piping.
D. Other distribution pipe materials may be used with prior approval from the reviewing authority.

4.3.3. Distribution Box, Drop Box, and Manifold

Distribution boxes, drop boxes, and manifolds collect effluent from either primary or advanced treatment systems for distribution in subsurface absorption systems.

Distribution boxes, drop boxes, and manifolds must be of watertight construction. Manifolds used in gravity systems must be set level and arranged so that effluent is distributed to an equal length of distribution pipe on both sides of the junction of the transport pipe to the manifold. Distribution boxes or drop boxes may be used in gravity systems in lieu of manifolds.

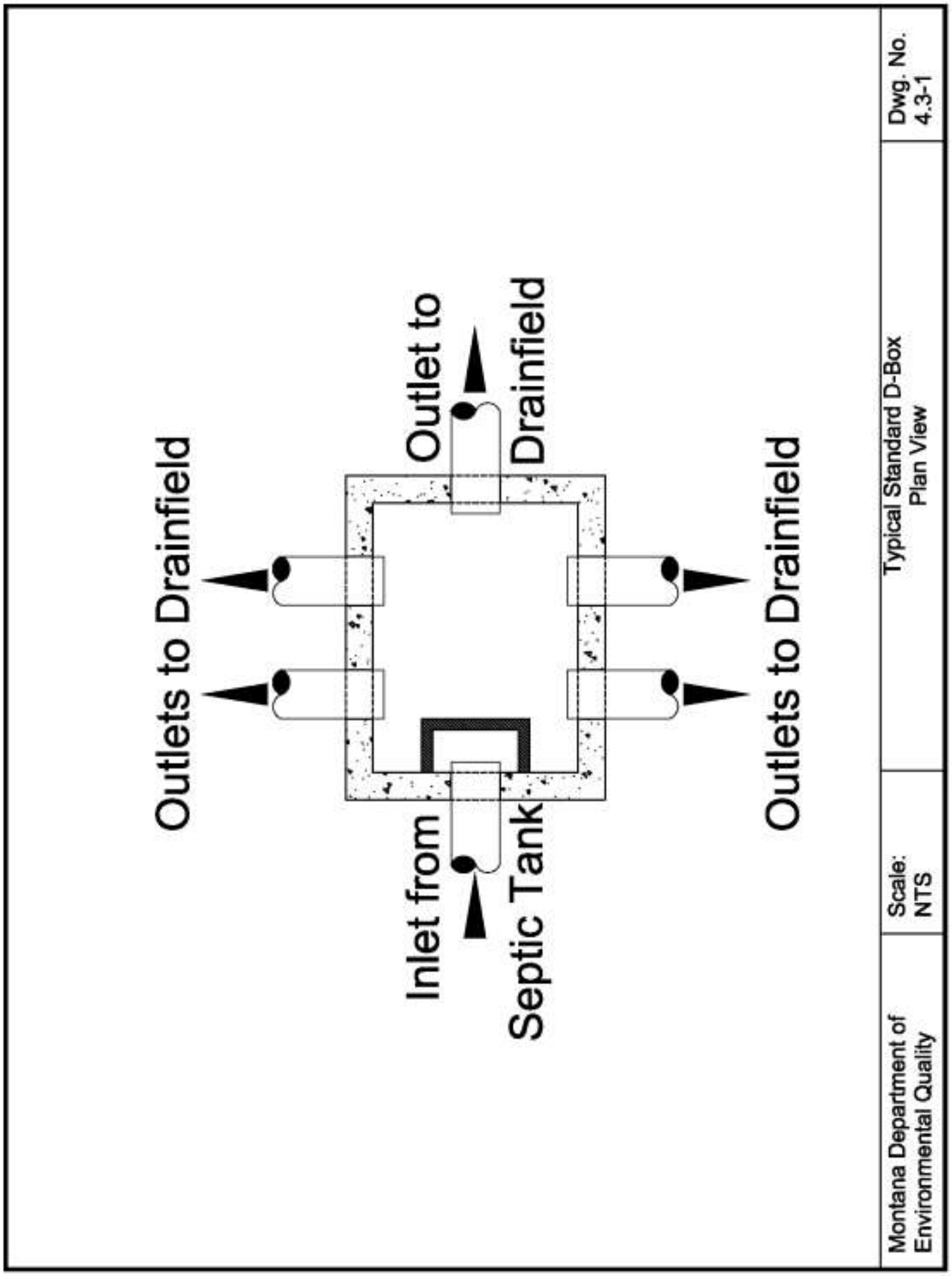
4.3.3.1. Distribution boxes must:

A. Be set level and bedded to prevent settling;
B. Use some flow control or baffling device to ensure equal distribution of effluent;

C. Be water tested for equal distribution;
D. Have each outlet serving an equal length of absorption trench;
E. If constructed using concrete, the concrete must meet the same requirements as concrete for septic tanks in Subsection 5.1.7.1. Minimum wall, floor, and lid thickness for concrete distribution boxes must be 2 inches; and
F. Have an access for inspection provided either through a riser or be marked with iron or a suitable, durable marker.

4.3.3.2. Drop boxes must:

A. Be set level and bedded to prevent settling;
B. If constructed using concrete, the concrete must meet the same requirements as concrete for septic tanks in Subsection 5.1.7.1. Minimum wall, floor, and lid thickness for concrete drop boxes must be 2 inches; and
C. Have an access for inspection provided either through a riser or be marked with iron or a suitable, durable marker.

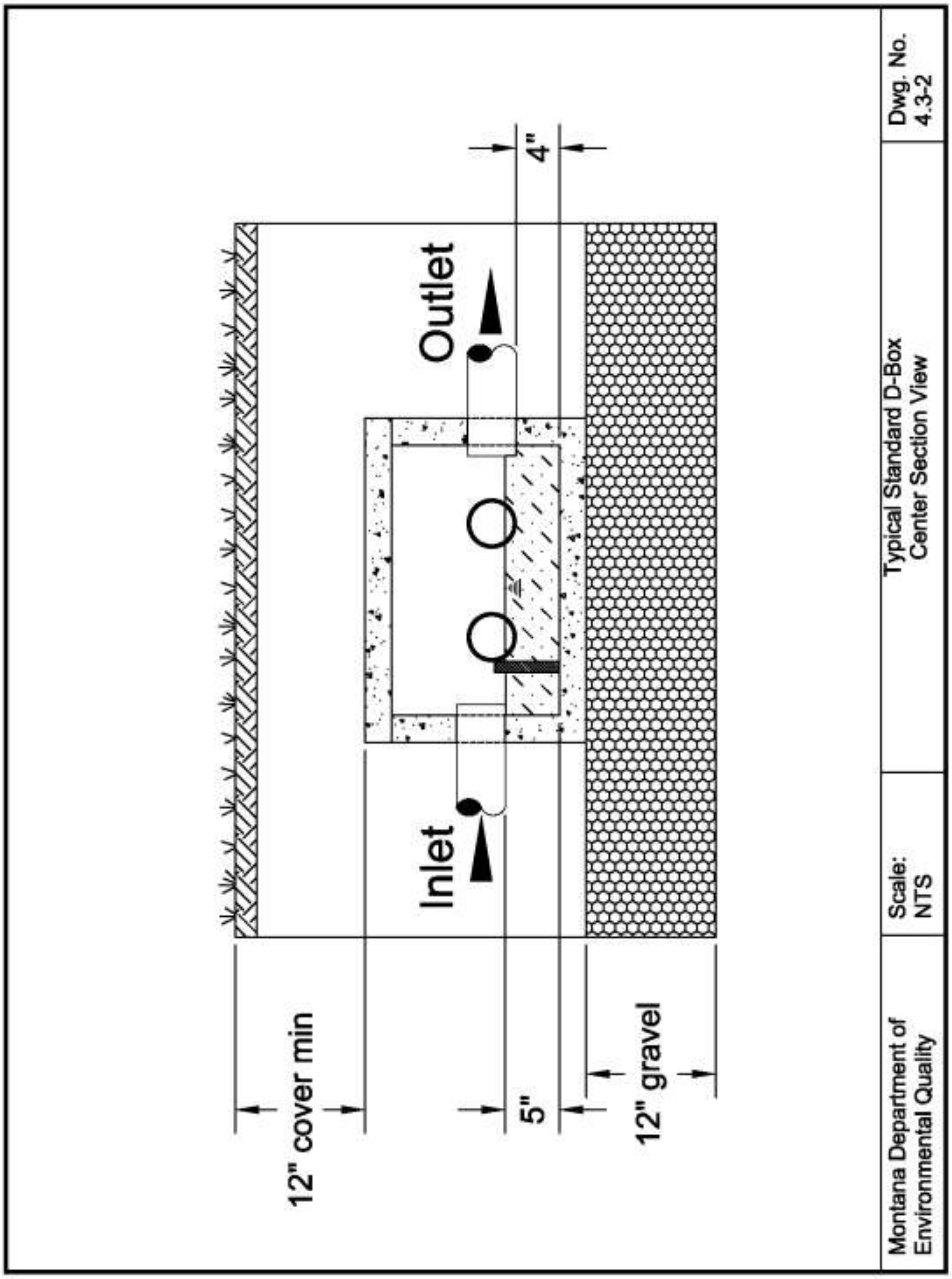


Montana Department of Environmental Quality

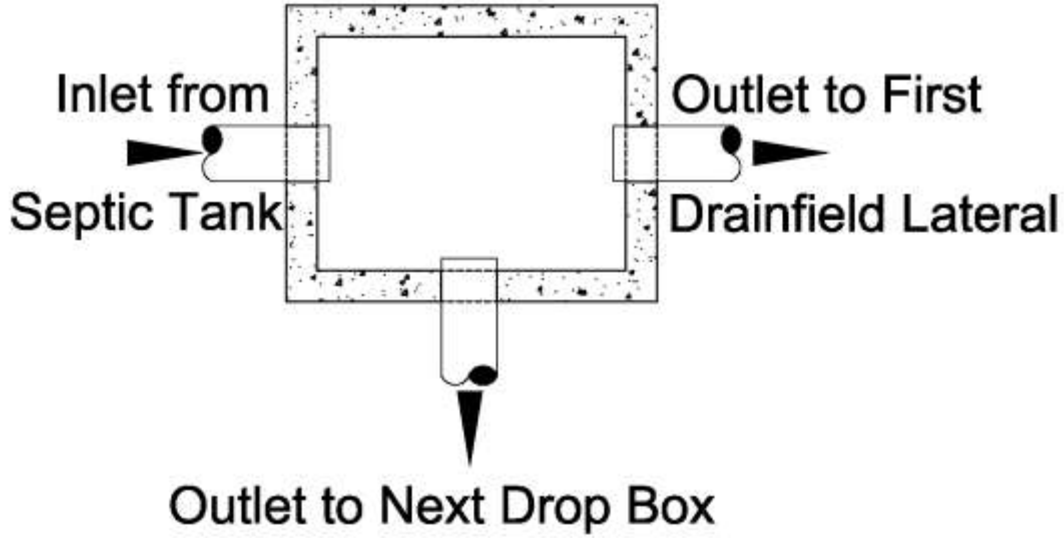
Scale: NTS

Typical Standard D-Box Plan View

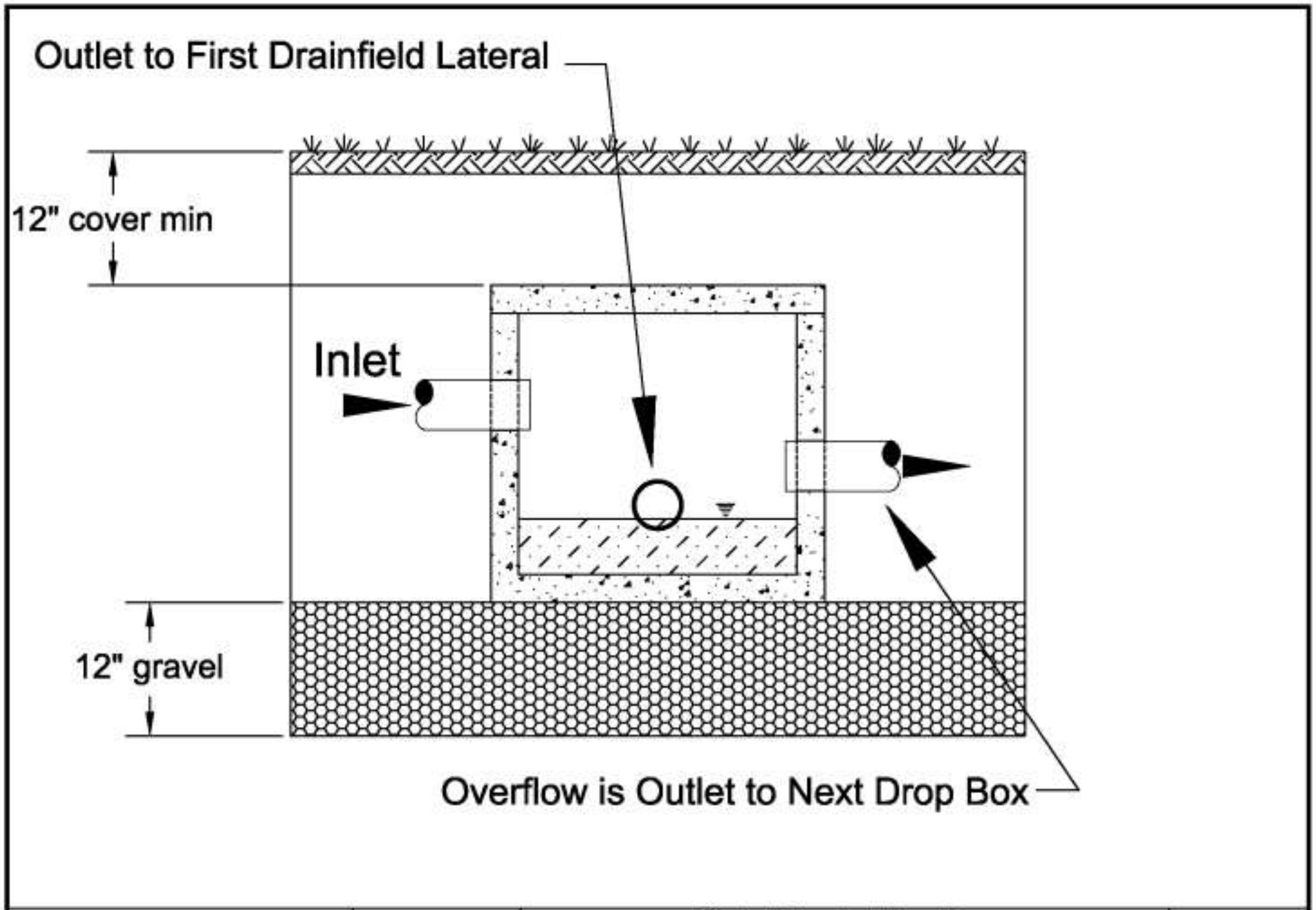
Dwg. No. 4.3-1



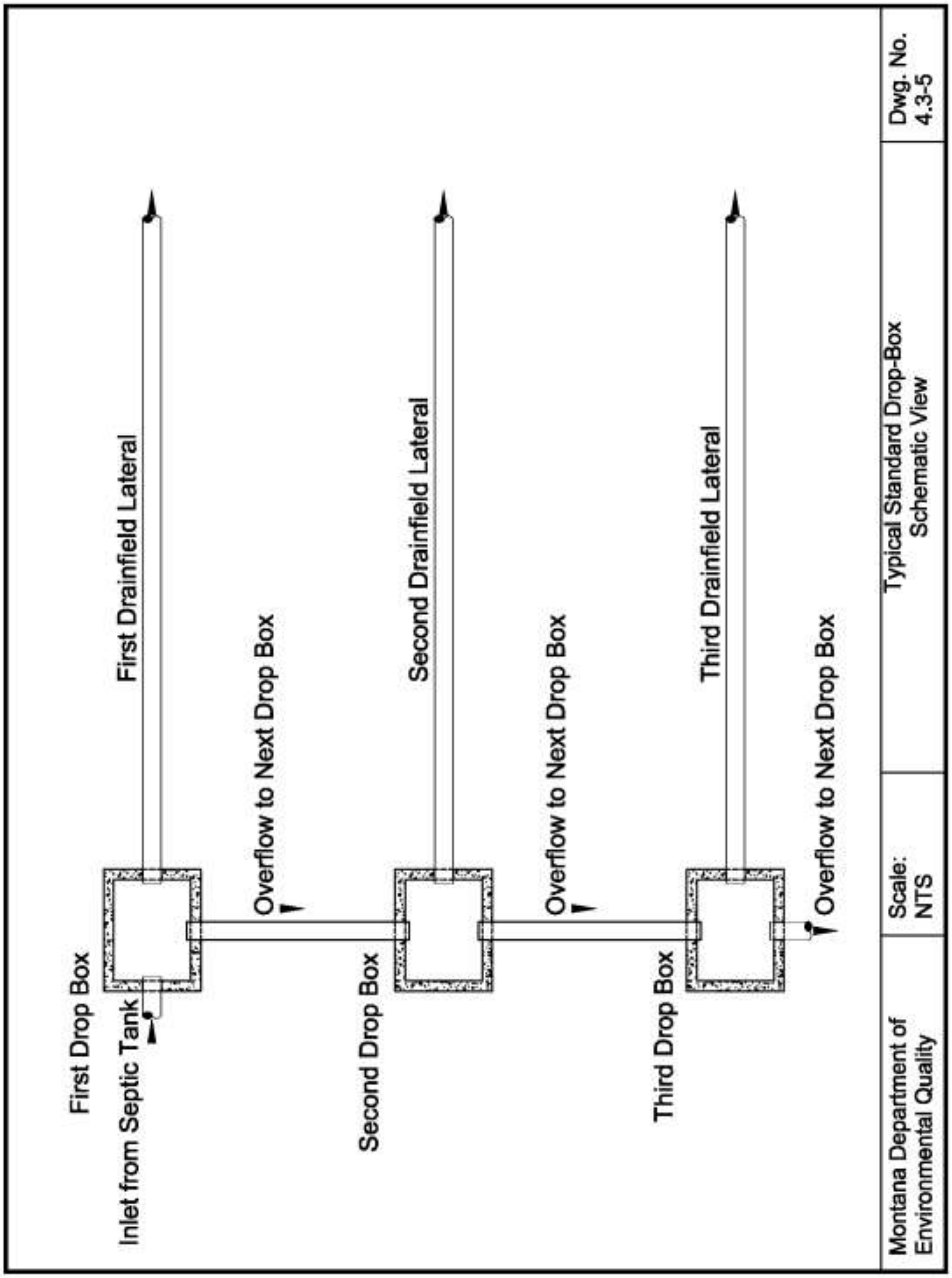
Typical Standard D-Box
Center Section View



Montana Department of Environmental Quality	Scale: NTS	Typical Standard Drop-Box Plan View	Dwg. No. 4.3-3



Montana Department of Environmental Quality	Scale: NTS	Typical Standard Drop-Box Center Section View	Dwg. No. 4.3-4


First Drop Box
Inlet from Septic Tank
First Drainfield Lateral
Overflow to Next Drop Box
Second Drop Box
Second Drainfield Lateral
Overflow to Next Drop Box
Third Drop Box
Third Drainfield Lateral
Overflow to Next Drop Box
Montana Department of Environmental Quality
Scale: NTS
Typical Standard Drop-Box Schematic View
Dwg. No. 4.3-5

5. PRIMARY TREATMENT

5.1. SEPTIC TANKS

5.1.1 General

All wastewater must discharge into a septic tank unless otherwise specifically provided in this Circular.

Roof, footing, garage, surface water drainage, and cooling water must be excluded from the septic tank.

The septic tank must be located where it is readily accessible for inspection and maintenance. The bottom of the septic tank should not be deeper than 12 feet from finished grade for ease of pumping and maintenance.

All septic tanks and access ports must have lids. The lids must be of durable construction and be secured with hex screws, lag bolts, locks, or other methods to prevent unauthorized access. Safety basket screens (child catchers) should be installed in all septic tanks.

5.1.2 Design

5.1.2.1. Liquid connection between compartments must consist of a single opening completely across the compartment wall or two or more openings equally spaced across the wall. The total area of openings must be at least three times the area of the inlet pipe.

5.1.2.2. A septic tank must provide an air space above the liquid level, which must be equal to, or greater than, 15 percent of its liquid capacity. Dose tanks do not need to meet the 15 percent air space requirement. Each compartment of the septic tank must be vented back to the inlet pipe.

5.1.2.3. Inspection ports measuring at least 8 inches in diameter must be provided above each inlet and outlet and marked with rebar. An access of at least 1.75 square feet in size must be provided for each compartment. Each access must be extended to within 12 inches of the finished ground surface. Access to the effluent filter must be large enough to maintain the filter and must be extended to the finished ground surface.

5.1.2.4. The nominal length of the septic tank must be at least twice the width (or diameter) of the tank. Dose tanks are excluded from these length, width, and depth requirements.

5.1.2.5. Septic tanks that have less than, or equal to, a 5,000-gallon liquid capacity must not use depths greater than 78 inches in computing tank capacity.

5.1.2.6. Septic tanks that have a greater than 5,000-gallon liquid capacity must calculate the maximum liquid depth by dividing the liquid length by a factor of 2.5.

5.1.3. Inlets

5.1.3.1. The inlet into the tank must be at least 4 inches in diameter and enter the tank 3 inches above the liquid level. The inlet connection must be watertight.

5.1.3.2. The inlet of the septic tank and each compartment must be submerged by means of a vented tee or baffle. Tees and baffles must extend below the liquid level to a depth where at least 10 percent of the tank's liquid volume is above the bottom of the tee or baffle.

5.1.3.3. Vented tees or baffles must extend above the liquid level a minimum of 7 inches.

5.1.3.4. Baffle tees must extend horizontally into the tank to the nearest edge of the riser access to facilitate baffle maintenance.

5.1.4. Outlets

5.1.4.1. Outlets must include an effluent filter complying with Section 5.1.5. A combination septic/dosing tank outlet is considered to be in the wall dividing the septic compartment(s) and the dosing compartment. Septic tanks aligned in series require an effluent filter only on the final outlet.

5.1.4.2. The outlet of the tank must be at least 4 inches in diameter. The outlet connection must be watertight.

5.1.4.3. Each compartment of the septic tank must be vented to the atmosphere.

5.1.5. Effluent Filters

5.1.5.1. Effluent filters must be used in all systems, unless the reviewing authority approves another filtering device such as a screened pump vault.

5.1.5.2. All septic tank effluent must pass through the effluent filter. No by-pass capability may be designed into the effluent filter. A high-water alarm should be installed to signal that the filter has clogged and needs maintenance.

5.1.5.3. Effluent filter inlets must be located below the liquid level at a depth where 30 to 40 percent of the tank's liquid volume is above the intake of the filter.

5.1.5.4. The effluent filter must be secured so that inadvertent movement does not take place during operation or maintenance. Filters must be readily accessible to the ground surface and the handle must extend to within 2 inches of the access riser lid to facilitate maintenance.

5.1.5.5. The effluent filter manufacturer must provide documentation that the filter meets the design standard for effluent filters in ANSI/NSF Standard 46.

5.1.5.6. The effluent filter manufacturer must provide installation and maintenance instructions with each filter. The installer must follow the manufacturer's instructions when installing the filter and must use the manufacturer's recommendations for sizing and application. The installer must provide the owner of the system with a copy of the maintenance instructions.

5.1.6. Sizing of Septic Tanks

5.1.6.1. Minimum Size Requirements

Multiple single compartment tanks may be connected in series to meet minimum capacity requirements. Dose tank or other tank volumes included in the design may not be included in the required septic tank minimum capacity. The reviewing authority may have additional maintenance requirements for tanks connected in series or those systems utilizing grinder pumps.

5.1.6.2. For Residential Flows

A. Residential septic tank capacity must be sized in accordance with the number of bedrooms as described below:

1. For 1 to 3 bedrooms, the minimum capacity is 1,000 gallons per living unit;
2. For 4 to 5 bedrooms, the minimum capacity is 1,500 gallons per living unit;
3. For 6 to 7 bedrooms, the minimum capacity is 2,000 gallons per living unit;
4. For 8 or more bedrooms, the minimum capacity is 2,000 gallons per living unit plus 250 gallons for each bedroom greater than 7 bedrooms (i.e., 8 bedrooms requires a 2,250 gallon tank, 9 bedrooms requires a 2,500 gallon tank).

B. When the number of living units on a single or common septic tank is between 2 and 9, the minimum capacity will be based on the number of living units and corresponding bedrooms as described in Subsection 5.1.6.2.A.

C. When the number of living units on a single or common septic tank is 10 or greater, the septic tank must have a capacity of at least 2.5 times the design flow.

5.1.6.3. For Nonresidential Flows

The minimum acceptable septic tank size is 1,000 gallons for any nonresidential system and must have a minimum tank capacity of 2.5 times the design flow.

5.1.7. Construction

5.1.7.1. Concrete Tanks (cast-in-place tanks and pre-cast tanks)

A. General Requirements

All concrete tanks must comply with Sections 1, 2, 3, 5, and 6 of ASTM C 1227-12 with the following additional requirements:

1. All concrete tanks must be manufactured with ASTM C 150-12 Type I, Type I-II or Type V cement and must be made with sulfate-resistant cement (tricalcium aluminates content of less than 8 percent).
2. All concrete tanks must be watertight. Tanks used for commercial facilities, multiple-user systems, public systems or those with a design flow of 700 gallons per day, or greater, must be tested in place for water tightness using a vacuum test or water pressure test. The reviewing authority or designer may require tanks intended for other uses to be tested. Tanks must be tested using one of the following methods:

   a. Vacuum testing: Seal the empty tank and apply a vacuum to 4 inches (100 mm) mercury. The tank is approved if 90 percent of vacuum is held for 2 minutes; or
   b. Water pressure testing: Seal the tank, fill with water, and let stand for at least 24 hours. Refill the tank. The tank is approvable if it holds water.

3. Repairs of all concrete tanks, when required, must be performed by the manufacturer in a manner ensuring that the repaired structure will conform to the requirements of this Circular.
4. All concrete tank sealants must be flexible, appropriate for use in septic tanks, and must conform to ASTM C 990-09.

B. Pre-cast Concrete Tank Requirements

A set of complete plans stamped by a professional engineer to certify compliance with this Circular must be on file with the tank manufacturer and made available to the reviewing authority upon request. These plans must show maximum depth of bury, all dimensions, capacities, reinforcing, structural calculations, and other such pertinent data for each tank model.

The pre-cast concrete tank manufacturer shall develop manufacturer's recommended installation instructions for each tank model. The manufacturer shall provide a copy of the stamped drawings along with the installation instructions to each tank purchaser.

All pre-cast concrete tanks must be clearly marked within 2 feet of the outlet with the name of the tank manufacturer, tank model, number of gallons, date of manufacture, and maximum depth of bury.

C. Cast-in-Place Concrete Tank Requirements, Certification, and As-builts

A complete set of plans stamped by a professional engineer to certify compliance with this Circular and ACI 318-11 must be provided to the reviewing authority. These plans must show maximum depth of bury, all dimensions, capacities, reinforcing, structural calculations, and other such pertinent data. The approved stamped plans must be given to the tank purchaser. As-built plans and a letter of certification, from a professional engineer, must be submitted to the reviewing authority within 90 days of construction of all cast-in-place concrete tanks.

5.1.7.2. Thermoplastic and Fiberglass Tanks

Thermoplastic and fiberglass septic tanks must be water tight and made of materials resistant to the corrosive environment found in septic tanks.

A set of complete plans stamped by a professional engineer to certify compliance with this Circular and IAPMO/ANSI Z1000-07 must be on file with the tank manufacturer and made available to the reviewing authority upon request. These plans must show maximum depth of bury, all dimensions, capacities, reinforcing, structural calculations, and other such pertinent data for each tank model.

The thermoplastic and fiberglass tank manufacturer shall develop manufacturer's recommended installation instructions for each tank model. The manufacturer shall provide a copy of the stamped drawings along with the installation instructions to each tank purchaser.

All thermoplastic and fiberglass tanks must be clearly marked near the outlet or on the top surface of the tank with the name of the tank manufacturer, tank model, number of gallons, date of manufacture, and maximum depth of bury.

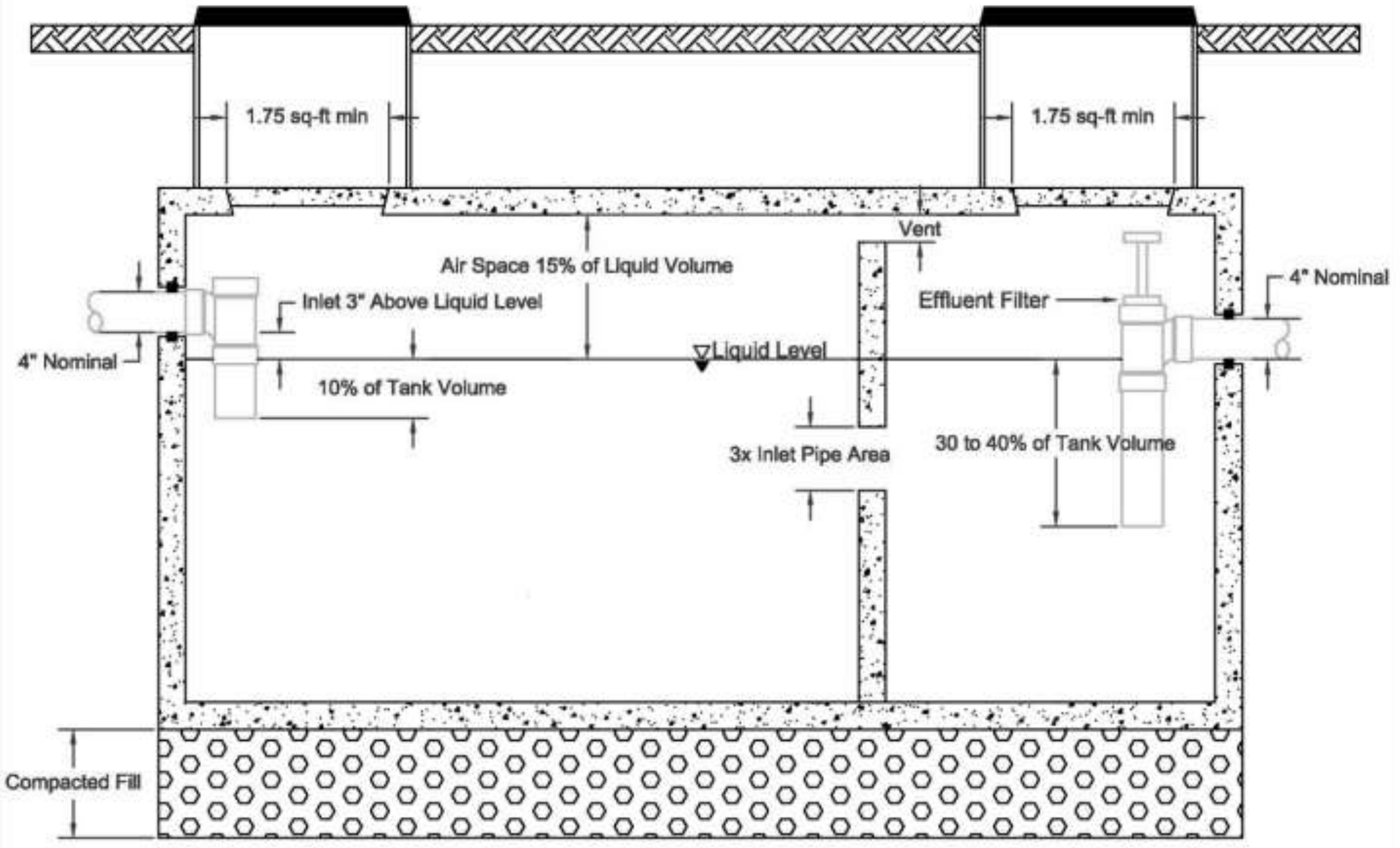
Tanks used for commercial facilities, multiple-user systems, public systems, or those with a design flow of 700 gpd or greater must be tested in place for water tightness. The reviewing authority may require tanks intended for other uses to be tested. For pressure testing a fiberglass or thermoplastic tank, all inlets, outlets, and access ports must be sealed and adequately secured. The tank must be charged with 5 pound-force per square inch gauge (psig) for a tank less than 12 feet in diameter or 3 psig for a tank 12 feet or larger in diameter. The tank pressure must be allowed to stabilize and the air supply must be disconnected. If there is any noticeable pressure drop in 1 hour, the tank must be rejected or repaired. After repair, the test must be repeated. Air must be carefully released through an appropriate valve mechanism.

5.1.8. Installation

All septic tanks must be installed per the manufacturer's recommendations.

5.1.9. Maintenance

Owners of septic systems should follow the septic tank maintenance recommendations published by Montana State University Extension Service, which are available through Montana County Extension Service offices located in each county. Two of these publications are *Septic Tank and Drainfield Operation* and *Maintenance and Septic System Inspection and Troubleshooting*. Those who own systems with siphons, pumps, or controls should carefully adhere to manufacturer's recommendations for operation and maintenance and seek guidance from the county extension service or local health department.



Montana Department of Environmental Quality	Scale: 3/4" = 1' - 0"	STANDARD SEPTIC TANK SECTION VIEW	Dwg. No. 5-1

6. SOIL ABSORPTION SYSTEMS

6.1. STANDARD ABSORPTION TRENCHES

6.1.1. General

The satisfactory operation of the wastewater treatment system is largely dependent upon wastewater quality, proper site selection, and the design and construction of absorption trenches.

All new and replacement absorption systems must be designed to accept and treat residential strength waste. High strength wastewater or water treatment waste residuals must comply with Subchapters 3.2 and 3.3 of this Circular.

6.1.2. Location

Absorption trenches must meet the location criteria in ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable.

All absorption trenches must meet the site requirements of Chapter 2.

6.1.3. Trench Design

6.1.3.1. The minimum area in any absorption trench system must be based upon the flow, as determined in Chapter 3 and sized by the soil type and percolation rate if percolation testing is required by the reviewing authority, whichever results in a larger absorption system, in accordance with Chapter 2, Section 6.1.4, and Appendix B. The reviewing authority may require a percolation test when the soils are variable or other conditions create the need to verify trench sizing.

6.1.3.2. An area that can be used as a replacement area for the original absorption trench system must be designated. Interim use of the area must be compatible with future absorption system use. The replacement area should be located separately from the primary area and must not be interlaced within the primary area.

6.1.3.3. Gravity-fed and gravity-dosed absorption trenches must be separated by at least 5 feet between trench walls. Pressure dosed absorption trenches must be separated by at least 4 feet between trench walls. Absorption trenches, utilizing proprietary design configurations, with effluent meeting NSF 40 criteria for 30 mg/L BOD_5 and 30 mg/L TSS, may have trench separation distances that meet manufacturer recommendations.

6.1.3.4. Gravity-fed and gravity-dosed absorption trenches must be at least 18 inches wide, but, for purposes of sizing, any width greater than 24 inches wide will not be considered. Systems utilizing pressure distribution may have absorption trenches 36 inches wide.

6.1.3.5. The bottom of the absorption trenches must be at least 24 inches and no more than 36 inches below the natural ground surface. There must be a minimum of 12 inches of soil or fill material above the drain rock.

6.1.3.6. Gravity-fed absorption trenches may not exceed 100 feet in length from where effluent is first applied to the soil. Gravity-fed absorption trenches may be connected through a manifold to accommodate serial configurations. If more than 500 lineal feet, or 1000 square feet, of absorption area, calculated before applying any reductions, is needed, then pressure distribution must be provided.

6.1.4. Sizing of the Absorption System

6.1.4.1. Application rates and absorption system length used for sizing onsite wastewater absorption systems can be determined using soil descriptions in accordance with Chapter 2, Appendix B, and the formula in Subsection 6.1.4.2. Comparison of the soil profile descriptions, at or near the depth of the infiltrative surface, percolation rate, if conducted, and USDA soils report must be submitted for review. If the submitted information shows a variable application rate, additional site-specific information may be required by the reviewing authority.

6.1.4.2. Absorption system sizing must be determined using the following formula:

The total square feet of the absorption system area is determined using the design wastewater flow rates from Chapter 3 (gpd) divided by the application rate in Section 2.1.7, Table 2.1-1 (gpd/ ft^2).

Total trench length is calculated by dividing the total square feet of the absorption system area by the trench width.

6.1.4.3. Systems that provide documentation or demonstrate, through a third independent party, that the unit is able to meet the testing criteria and performance requirements for NSF Standard No. 40 for Class 1 certification, or meet the testing requirements outlined in ARM 17.30.718 for 30 mg/L BOD_5 and 30 mg/L TSS, only, may utilize a reduced absorption area in accordance with the following criteria:

A. For subsurface absorption systems constructed in soils with percolation rates between 3 and 50 mpi, as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 50 percent;
B. For subsurface absorption systems constructed in soils with percolation rates between 51 and 120 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 25 percent.

A full-sized separate subsurface absorption replacement area, sized without reduction, must be designated for each site.

Further reductions in subsurface absorption system sizing, beyond those listed in this subsection, are not permissible.

6.1.5. Construction

6.1.5.1. Gravity-fed and gravity-dosed absorption field distribution pipes and trench bottoms must be level. Pressure-dosed distribution pipes in an absorption system or sand filter must be level, unless a hydraulic analysis indicates uniform distribution of effluent will occur with a sloped line.

6.1.5.2. When the trenches have been excavated, the sides and bottom must be raked to scarify any smeared soil surfaces. Construction equipment, unless needed to construct the system, should be kept off the area to be utilized for the absorption trench system to prevent undesirable compaction of the soils. Construction must not be initiated when the soil moisture content is high.

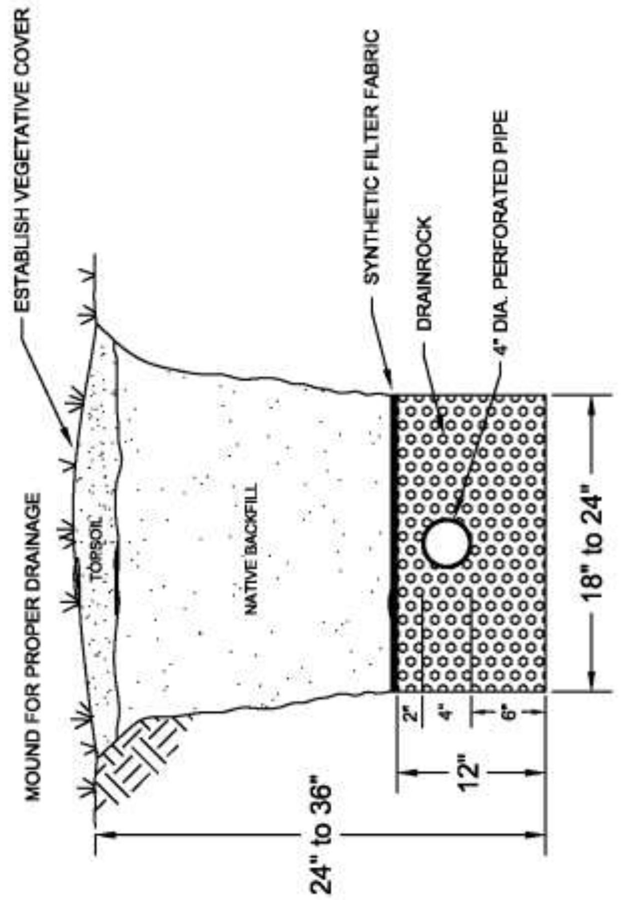
Note: If a sample of soil within the working depth can be easily rolled into the shape of a wire or ribbon, the soil moisture content is too high for construction purposes.

6.1.5.3. At least 6 inches of drain rock meeting the requirements of Section 1.2.25 must be placed in the bottom of the trench.

6.1.5.4. The distribution pipe must be covered with at least 2 inches of drain rock meeting the requirements of Section 1.2.25. An appropriate geotextile fabric, untreated building paper, or straw must be placed over the drain rock and covered with a minimum of 1 foot of soil or fill.

6.1.5.5. The ends of the distribution pipes must be capped or plugged.

6.1.5.6. Gravelless trenches and other absorption systems may be used in place of distribution pipe and drain rock in accordance with Subchapter 6.6.

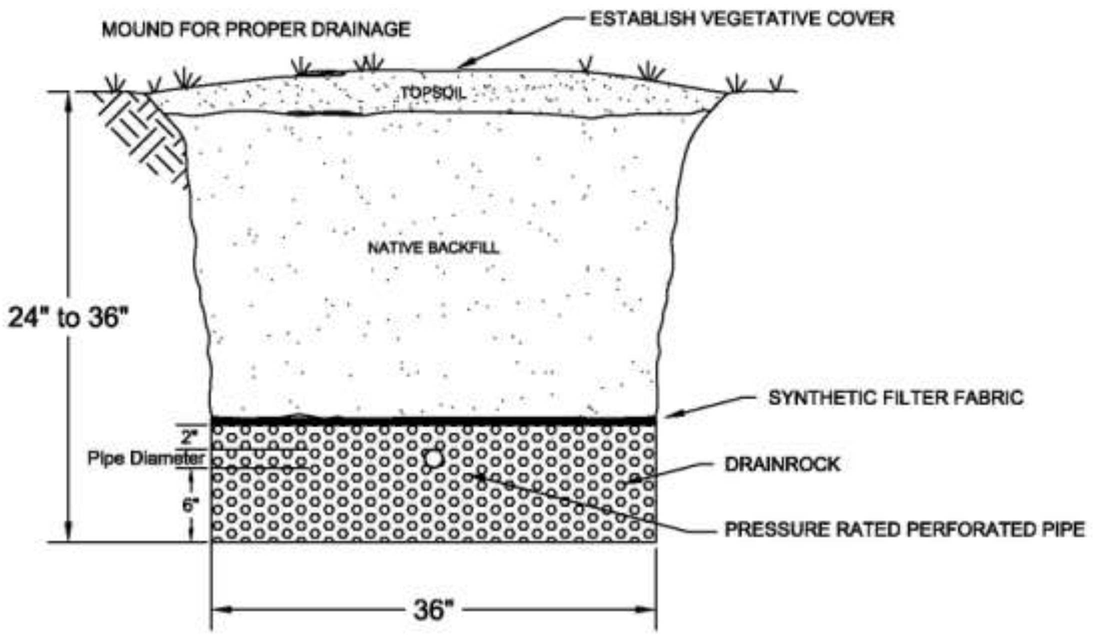


Montana Department of
Environmental Quality

Scale:
1" = 1' - 0"

Standard Absorption Trench
Gravity Fed

Dwg. No.
6.1-1



Montana Department of Environmental Quality	Scale: 1" = 1' - 0"	Standard Absorption Trench Pressure Dosed	Dwg. No. 6.1-2

6.2. SHALLOW-CAPPED ABSORPTION TRENCHES

6.2.1. General

A shallow-capped absorption trench is used to maintain a 4-foot natural soil separation between the bottom of the infiltrative surface and a limiting layer and/or to increase vertical separation distances in porous soils. Shallow-capped absorption trenches must meet the same requirements as a standard absorption trench, Subchapter 6.1, and, if applicable, gravelless and other absorption system methods, Subchapter 6.5, except where specifically modified in this subchapter.

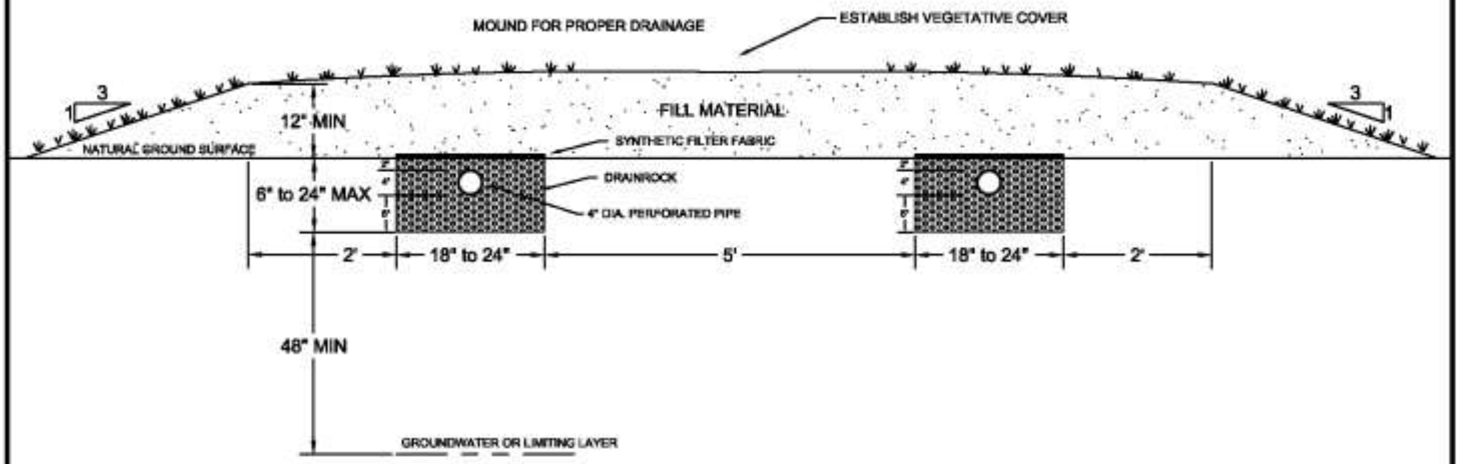
6.2.2. Design

Shallow-capped absorption trenches must be 6 to 24 inches below the natural ground.

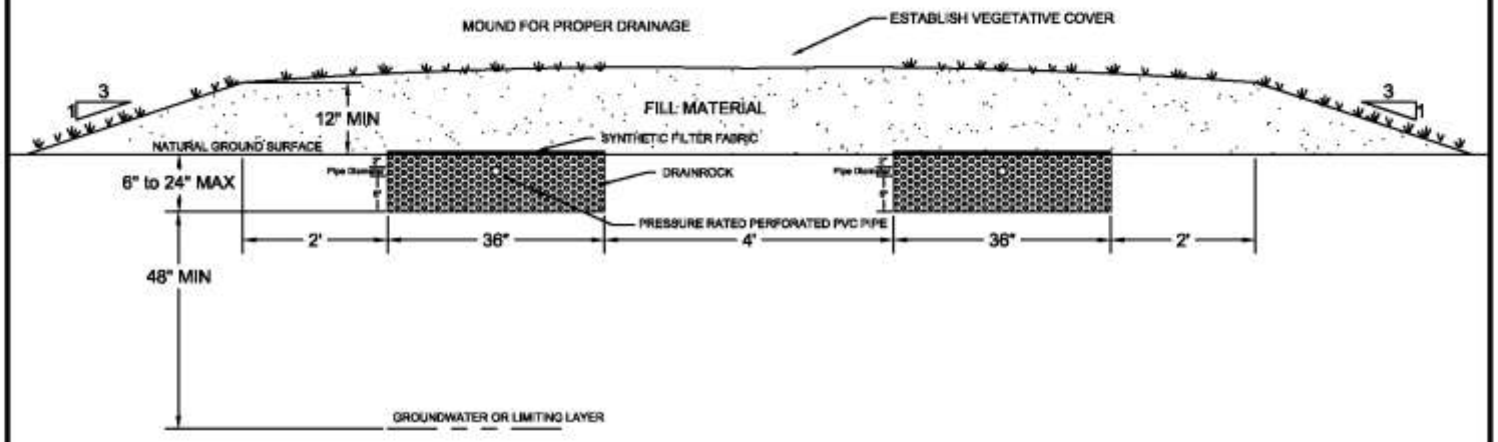
6.2.3. Construction

6.2.3.1. Shallow-capped absorption trench systems require a cap of topsoil material a minimum of 12 inches deep. This cap must be loamy sand or sandy loam and must extend 2 feet beyond the edges of the required absorption area before the sides are shaped to a 3 horizontal to 1 vertical or lesser slope. The cap must be sloped to provide positive drainage away from the center of the absorption system. The entire mound must be seeded, sodded, or otherwise provided with shallow-rooted vegetative cover to ensure stability of the installation.

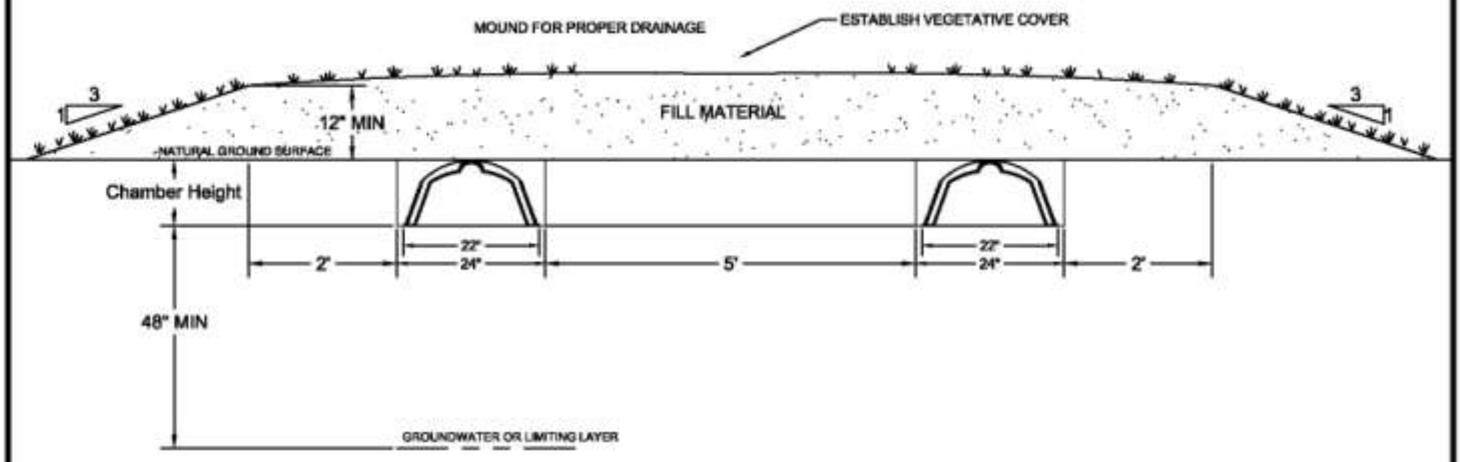
6.2.3.2. If gravelless or other absorption systems are used, depth of bury must be in accordance with manufacturer's recommendations but the top of the chamber or other manufactured distribution device must be no higher than the level of the natural ground.



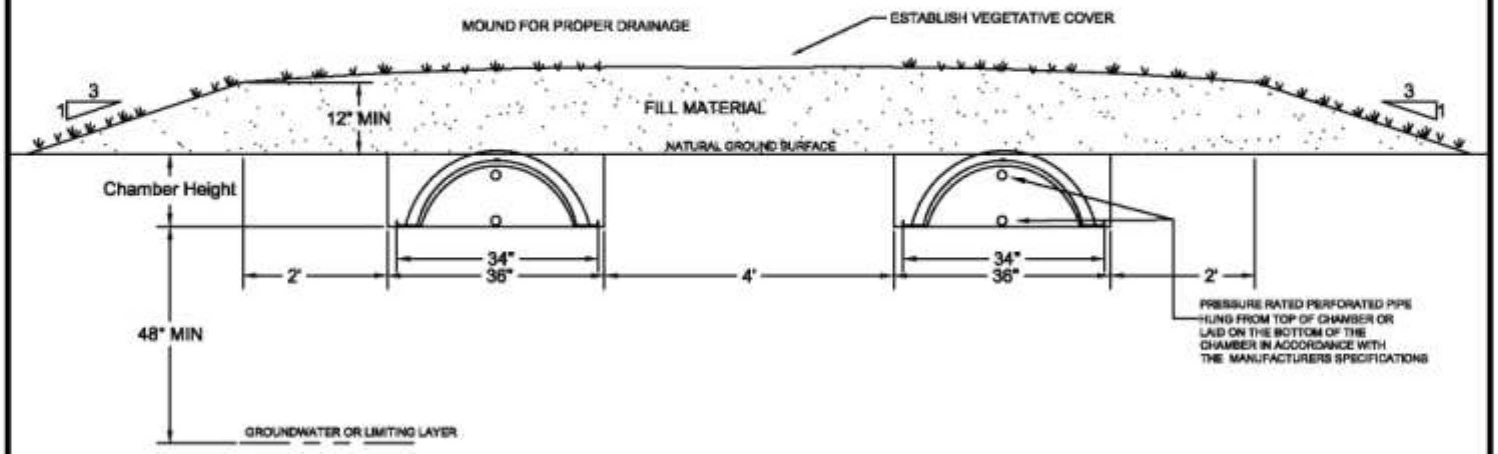
Montana Department of Environmental Quality	Scale: NTS	Shallow-Capped Absorption Trench Gravity Fed	Dwg. No. 6.2-1



Montana Department of Environmental Quality	Scale: NTS	Shallow-Capped Absorption Trench Pressure Dosed	Dwg. No. 6.2-2



Montana Department of Environmental Quality	Scale: NTS	Shallow-Capped Absorption Trench with Leaching Chambers Gravity Fed	Dwg. No. 6.2-3



Montana Department of Environmental Quality	Scale: NTS	Shallow-Capped Absorption Trench with Leaching Chambers Pressure Dosed	Dwg. No. 6.2-4

6.3. AT-GRADE ABSORPTION TRENCHES

6.3.1. General

At-grade systems may be used only for residential strength wastewater. At-grade systems must not be installed on land with a slope greater than 6 percent or where the percolation rate is slower than 40 mpi.

6.3.2. Effective Area

The effective area is that area which is available to accept effluent. Effective length of the absorption area is the actual length of the trench, which cannot exceed the length of the pipe by more than one-half the orifice spacing. The effective width is the actual width of the washed rock below the distribution pipe, not to exceed 3 feet for each pipe.

The effective area must be 1.5 times the area required for a standard absorption trench, as described in Section 6.1.4. Percolation tests must be conducted at a depth of not more than 12 inches below ground surface.

Pressure distribution is required for at-grade systems.

6.3.3. Construction

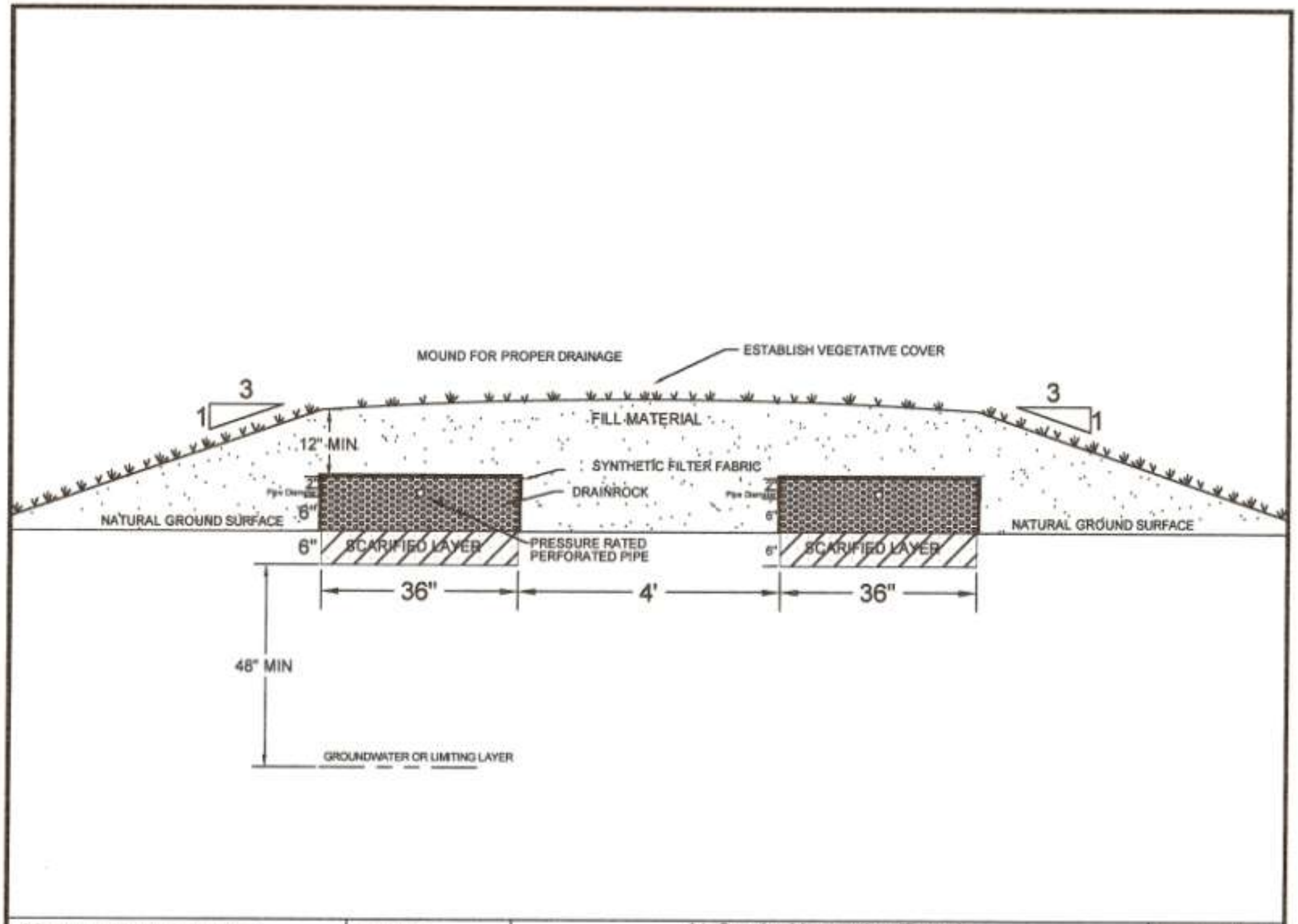
The ground surface where the system is to be placed must be plowed, scarified, or trenched less than 12 inches in depth. Trenching is preferred to plowing or scarifying to prevent horizontal migration of the effluent. There must be at least four feet of natural soil between the scarified layer and ground water or other limiting layer. The absorption trench is constructed by placing drain rock meeting the requirements of Section 1.2.25 on the scarified ground, with a minimum width of 24 inches at the bottom of the distribution pipe. A minimum of 6 inches of drain rock meeting the requirements of Section 1.2.25 must be placed under the distribution pipe and a minimum of 2 inches of drain rock meeting the requirements of Section 1.2.25 must be placed over the distribution pipe. If gravelless or other absorption systems are used, depth of bury must be in accordance with manufacturer's recommendations.

An appropriate geotextile fabric, untreated building paper, or straw must be placed over the drain rock and covered with approximately 1 foot of soil.

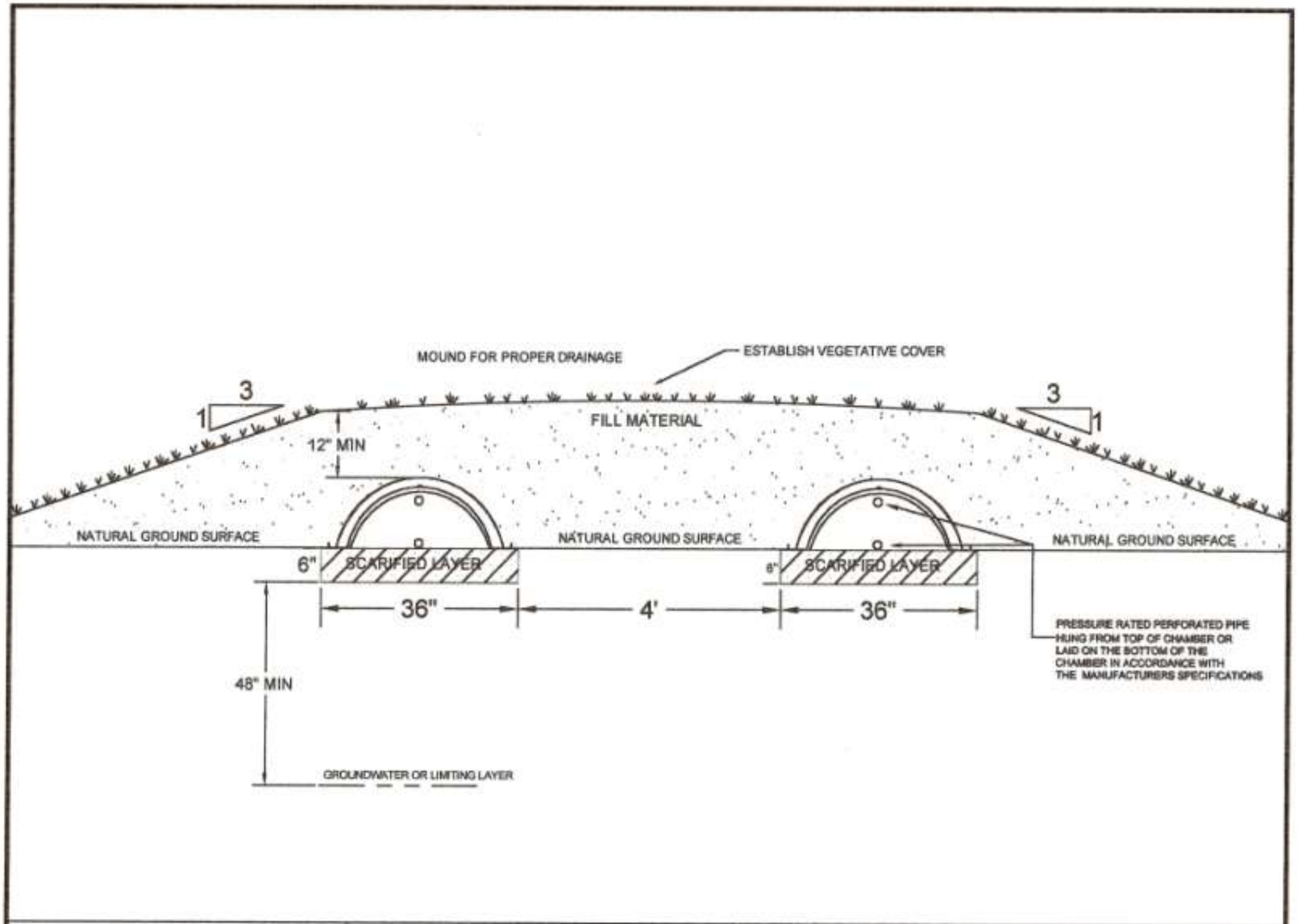
The fill over the distribution pipe must extend on all sides at least 5 feet beyond the edge of the aggregate below the distribution pipe.

Construction equipment which would cause undesirable compaction of the soils must not be moved across the plowed surface or the effluent disposal area. Construction and/or plowing must not be initiated when the soil moisture content is high.

Note: If a sample of soil within the working depth can be easily rolled into the shape of a wire or ribbon, the soil moisture content is too high for construction purposes.



Montana Department of Environmental Quality	Scale: 1/2" = 1' - 0"	At-Grade Absorption Trench Pressure Dosed	Dwg. No. 6.3-1



Montana Department of Environmental Quality	Scale: 1/2" = 1' - 0"	At-Grade Absorption Trench with Leaching Chambers Pressure Dosed	Dwg. No. 6.3-2

6.4. DEEP ABSORPTION TRENCHES

6.4.1. General

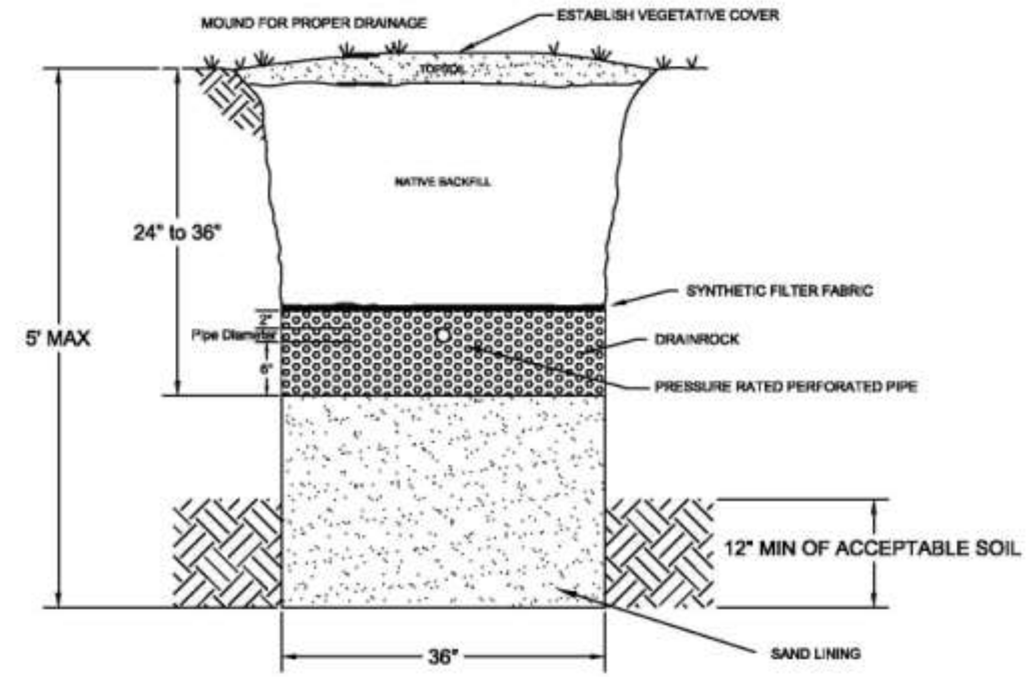
Deep absorption trenches are systems that have trenches excavated through a less permeable soil layer to allow effluent to infiltrate into a deeper and more permeable soil. The trench is then backfilled with a sandy soil to the depth of a standard absorption trench, 24 to 36 inches below natural ground surface. The bottom of the deep absorption trench must not be more than 5 feet below natural ground surface. Pressure distribution is required for all deep absorption trenches. Deep absorption trenches must meet the same requirements as a standard absorption trench as described in Subchapter 6.1, except where specifically modified in this chapter.

6.4.2. Site Evaluation

The site evaluation as outlined in Chapter 2 must also include soil profile descriptions of at least 2 soil observation pits excavated to a minimum depth of 4 feet below the proposed deep absorption trench bottom.

6.4.3. Construction

The deep trench must be excavated 1 foot into the acceptable soil and backfilled with medium sand, with no more than 3 percent finer than the No. 100 sieve, or other approved material to the level of a standard absorption trench. The system must be sized based on the most conservative application rate when comparing the deep trench infiltrative surface or the backfill sand.



Montana Department of Environmental Quality	Scale: 3/4" = 1' - 0"	Deep Absorption Trench Pressure Dosed	Dwg. No. 6.4-I

6.5. SAND-LINED ABSORPTION TRENCHES

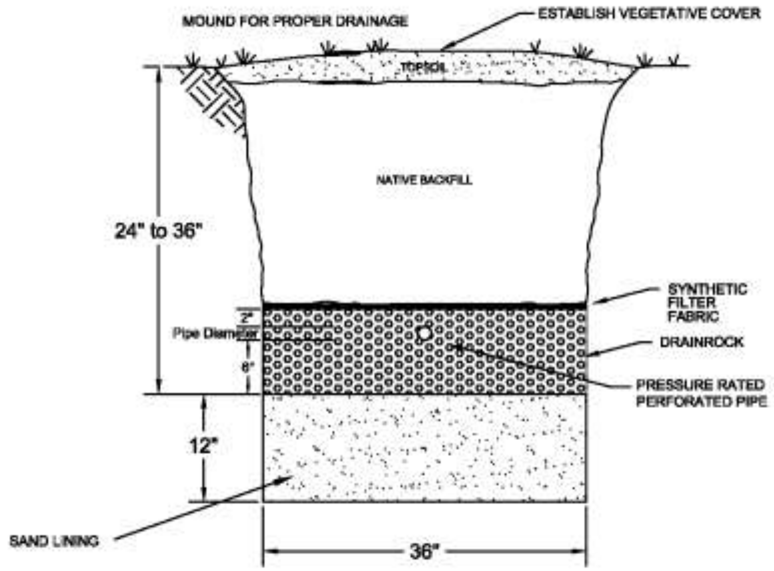
6.5.1. General

Sand-lined absorption trenches are used for rapid permeability situations. The trench below the drain rock is lined with sand to provide additional treatment. Sand-lined absorption trenches must meet the same requirements as a standard absorption trench as described in Subchapter 6.1, except where specifically modified in this chapter.

6.5.2. Design

Trenches must be lined with a minimum of 12 inches of fine to medium sand or loamy sand below the constructed absorption system. The system is to be sized in accordance with Section 6.1.4 using the most conservative application rate when comparing the natural soils and the sand used for lining the trench.

Pressure distribution must be provided for all sand-lined absorption trenches.



Montana Department of Environmental Quality	Scale: 3/4" = 1' - 0"	Sand Lined Absorption Trench Pressure Dosing Required	Dwg. No. 6.5-1

6.6. GRAVELLESS TRENCHES AND OTHER ABSORPTION METHODS

6.6.1. General

Gravelless trenches and other absorption systems include infiltration or leaching chambers and other wastewater distribution systems (single and multiple pipes, gravel substitutes, geo-composites, etc.). The purpose of these gravelless systems is to meet or exceed the characteristics, function, and performance of gravel in conventional gravel-filled absorption systems. Gravelless trenches and other absorption systems must meet the same requirements as a standard absorption trench as described in Subchapter 6.1, except where specifically modified in this chapter.

Gravelless trenches and other absorption systems may be used in lieu of pipe and drain rock for standard absorption trenches, deep absorption trenches, sand-lined absorption trenches, intermittent sand filters, recirculating sand filters, evapotranspiration systems, evapotranspiration absorption systems, sand mounds, and absorption beds.

Pressure dosed gravelless or other absorption systems must meet the design requirements of Subchapter 4.3.

Gravelless or other absorption systems must be installed according to the manufacturer's requirements and specifications. Specific absorption bed siting and minimum sizing requirements of this Circular override manufacturer's recommendations.

6.6.2. Leaching Chambers

6.6.2.1. Distribution Materials

A. Leaching chambers are chambers with an open bottom structurally designed to carry the earth loading.
B. Leaching chambers must be constructed of high-density polyolefin or other approved material and must comply with IAPMO PS 63-2005. Evidence that the chamber construction complies with these requirements must be made available to the reviewing authority upon request.

6.6.2.2. Design

The maximum trench width for leaching chambers is 36 inches. Pressure distribution must be provided for all trenches greater than 24 inches wide.

6.6.2.3. Construction

The total bottom area of the trench will be used to calculate the infiltration area. The absorption system size in square footage as described in Subchapter 6.1.4 may be reduced in size by 25 percent when using infiltration or leaching chambers. Chambers that are 15 inches in width will be equal to an 18-inch trench width, a 22-inch width chamber will be equal to a 24-inch trench width, and a 34-inch width chamber will be equal to a 36-inch trench width for calculating absorption system sizing. The size of the replacement absorption system must be large enough to accommodate a standard absorption system.

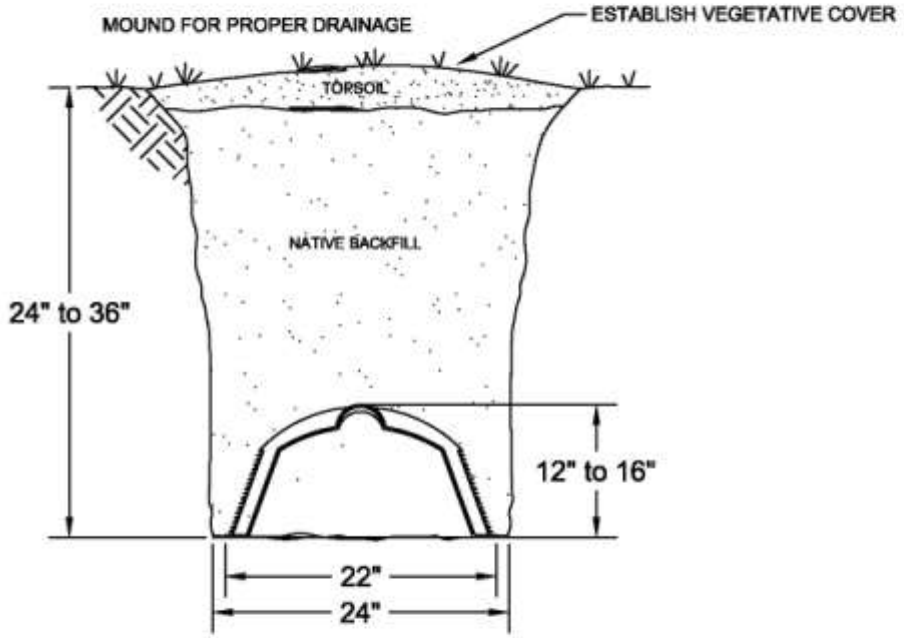
6.6.3. Other Absorption Systems

6.6.3.1. Other absorption systems must be able to meet or exceed the same system performance as conventional gravel-filled absorption systems with documentation presented by a third independent party.

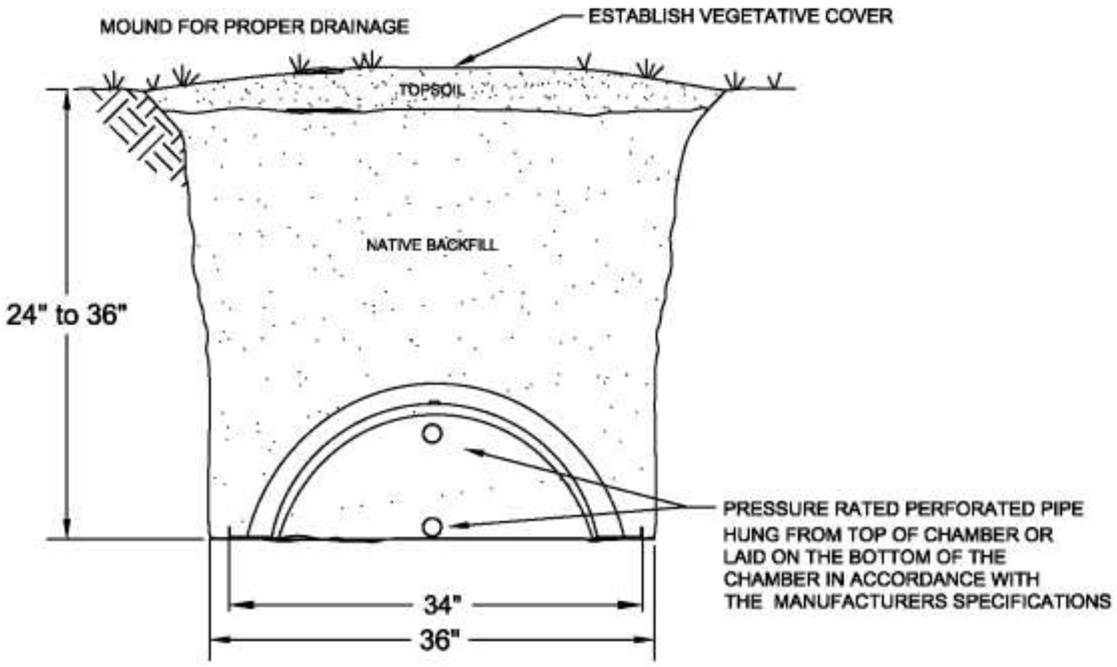
6.6.3.2. Other absorption systems must be able to handle the pertinent depth of bury.

6.6.3.3. All other absorption systems must be installed in accordance with manufacturer's recommendations, although specific proprietary designs which conflict with requirements of this Circular will require reviewing authority approval.

6.6.3.4. A reduction in other absorption system sizing may be allowed on a case-by-case basis as supported by documentation and justification submitted by the manufacturer to the reviewing authority for approval.



Montana Department of Environmental Quality	Scale: 1" = 1' - 0"	Leaching Chamber Absorption Trench Gravity Fed	Dwg. No. 6.6-1



Montana Department of Environmental Quality	Scale: 1" = 1' - 0"	Leaching Chamber Absorption Trench Pressure Dosed	Dwg. No. 6.6-2

6.7. ELEVATED SAND MOUNDS

6.7.1. General

Elevated sand mounds may be used to achieve separation distance between the treatment system and a limiting layer. Four feet of natural soil must be maintained between the modified site and the limiting layer.

Pressure distribution must be provided for all elevated sand mounds.

If an advanced wastewater treatment system is used prior to distribution in an elevated sand mound, or the distribution system meets the requirements of NSF 40 Class 1, as described in Subsection 6.1.4.3, the final absorption area may be downsized in accordance with the most conservative native soils found within 12 inches of the natural ground surface.

A. For subsurface absorption systems constructed in soils with percolation rates between 3 and 50 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 50 percent;

B. For subsurface absorption systems constructed in soils with percolation rates between 51 and 120 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 25 percent.

Gravelless trenches and other absorption systems installed in accordance with Subchapter 6.6 may be used in lieu of pipes and gravel, but no reduction in sizing will be permitted for the use of this technology.

6.7.2. Location

6.7.2.1. Elevated sand mounds must meet all of the site requirements of Chapter 2.

6.7.2.2. Elevated sand mounds must meet all minimum separation distances as stated in ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable. Separation distances must be measured from the outside of the mound where the topsoil fill meets the natural ground surface, or, if the design uses a lesser slope for landscaping purposes, where the toe of the mound would be if the 3:1 slope were used.

6.7.2.3. Elevated sand mounds must be constructed only upon undisturbed, naturally occurring soils.

6.7.2.4. Elevated sand mounds with a basal soil application rate of 0.4 to 0.8 gpd/ft^2, as described in Chapter 2 and Appendix B may not be installed on land with a slope greater than 12 percent.

Elevated sand mounds with a basal soil application rate of 0.3 to 0.2 gpd/ft^2, as described in Chapter 2 and Appendix B may not be installed on land with a slope greater than 6 percent.

The land area 25 feet from the toe of the infiltrative surface on the down gradient side of the elevated sand mound must not be disturbed.

6.7.2.5. A separate replacement area for the elevated sand mound may be required by the reviewing authority. Each replacement area must be sized in accordance with this chapter.

6.7.3. Design

6.7.3.1. *The Wisconsin Mound Soil Absorption System Siting, Design, and Construction Manual*, January 2000, is recommended as a procedural guideline in the design of elevated sand mounds. Where the requirements of the Manual differ from those of this Circular, the requirements of this Circular will govern.

6.7.3.2. The required basal area of the mound must be based upon the method described in Section 6.1.4 at a soil depth no greater than 12 inches.

6.7.3.3. The required bottom area of the bed must be based upon flows as determined in Chapter 3 with an application rate of 0.8 gpd/ft^2 before any reduction in bed size allowed in this Circular.

6.7.3.4. There must be a minimum total depth of 21 inches of sand fill above the natural soil surface and 12 inches of sand fill between the bottom of the absorption area and the natural soil surface. Sand must be washed free of silts and clays. The in-place fill material must meet one of the following specifications:

A. ASTM C-33-13 for fine aggregate, with a maximum of 2 percent passing the No. 100 sieve; or
B. Fit within the following particle size distribution:

Sieve	Particle Size (mm)	Percent Passing
3/8 in	9.50	100
No. 4	4.75	95 to 100
No. 8	2.36	80 to 100
No. 16	1.18	45 to 85
No. 30	0.60	20 to 60
No. 50	0.30	10 to 30
No. 100	0.15	0 to 2

C. Have an effective size (D10) of 0.15 mm to 0.30 mm with a Uniformity Coefficient (D60/D10) of 4 to 6, with a maximum of 3 percent passing the No. 100 sieve.

6.7.3.5. Drain rock meeting the requirements of Section 1.2.25 must be washed and range in size from 3/4 to 2.5 inches. It must be at least 9 inches deep and must be covered with an appropriate geotextile fabric, untreated building paper, or straw.

6.7.3.6. The distribution pipes must be installed parallel to the land contour, with spacing between pipes of at least 3 feet and no more than 5 feet. The length of a sand bed should be at least 3 times the width of a sand bed. Leaching chambers must be placed in accordance with the manufacturer's recommendations.

6.7.3.7. The area of sand fill must be sufficient to extend 2 feet beyond the edges of the required absorption area before the sides are shaped to a 3 horizontal to 1 vertical or lesser slope.

6.7.3.8. The mound must be covered with a minimum of 12 inches, at the center of the mound, and 6 inches, at the edge of the mound, of a suitable medium, such as sandy loam, loamy sand, or silt loam, to provide drainage and aeration.

6.7.4. Construction

6.7.4.1. The ground surface where a mound is to be placed must be plowed, scarified, or keyed into the natural ground 4 inches to 8 inches parallel to the land contour. This must be achieved by removing a portion of the topsoil with the plow throwing the soil up slope to provide a proper interface between the fill and natural soils. When mounds are keyed in, the removed soil must be replaced with the same sand as required for the rest of the mound, and this sand will not count as part of the required 21 inches of sand in the mound as described in Subsection 6.7.3.4. A minimum of 4 feet of natural soil from the bottom of the plowed surface, scarified surface, or key to the limiting layer must be maintained.

6.7.4.2. Construction equipment that would cause undesirable compaction of the soils must not be moved across the plowed surface or the effluent disposal area until a minimum of 6 inches of sand fill has been placed over the plowed area. Construction and/or plowing must not be initiated when the soil moisture content is high.

Note: If a sample of soil within the working depth can be easily rolled into the shape of a wire or ribbon, the soil moisture content is too high for construction purposes.

6.7.4.3. Aboveground vegetation must be closely cut and removed from the ground surface throughout the area to be utilized for the placement of the fill material. Tree stumps should be cut flush with the surface of the ground and roots should not be pulled. Trees may be left in place within the 3:1 side sloped portion of the fill.

6.7.4.4. The area surrounding the elevated sand mound must be graded to provide diversion of surface runoff waters.

6.7.4.5. Construction should be initiated immediately after preparation of the soil interface by placing the sand fill needed for the mound to a minimum depth of 21 inches above the plowed surface. This depth will permit excavation in the sand fill to accommodate the 9 inches of drain rock meeting the requirements of Section 1.2.25 necessary for the distribution piping. After hand leveling the absorption area, the drain rock should be placed and hand leveled. An observation port into the gravel is recommended but not required. An appropriate geotextile fabric, untreated building paper, or straw must be placed over the drain rock to separate the drain rock from the soil cover. After installation of the distribution system, the entire mound should be covered with 6 inches of a finer textured soil material, such as sandy loam to loam. A 4- to 6-inch layer of topsoil should then be added. The entire mound should be sloped to drain, either by providing a crown at the center or a uniform slope across the mound, with a minimum slope of 1 percent in either case. The entire mound must be seeded, sodded, or otherwise provided with shallow-rooted vegetative cover to ensure stability of the installation.

6.7.5. Certification and As-builts

Certification and as-built plans are required in accordance with Appendix D.

Sand Mound Material Specifications:

Sand must be washed free of silts and clays.

The in-place fill material must meet one of the following specifications:

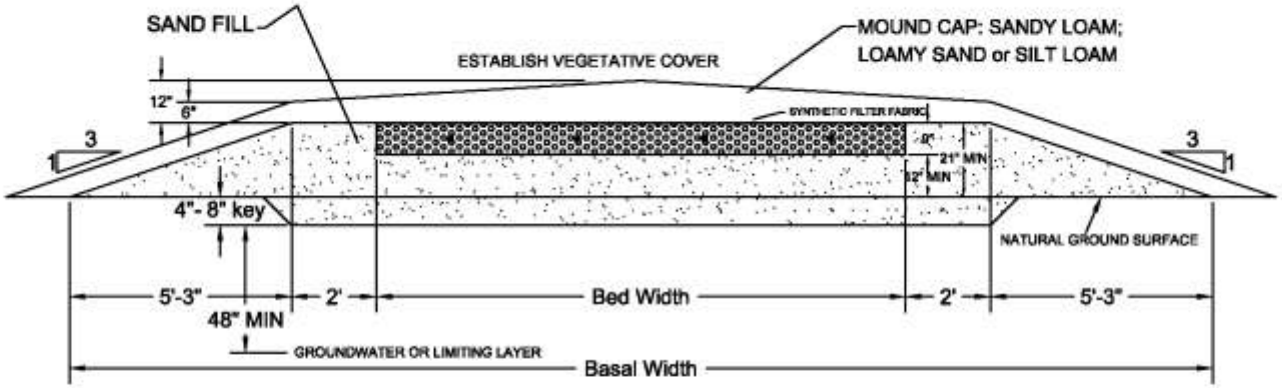
A. ASTM C-33 for fine aggregate, with a maximum of 2 percent passing the No. 100 sieve, or

B. Fit within the following particle size distribution:

Sieve	Particle Size (mm)	Percent Passing
3/8 in	9.50	100
No. 4	4.75	95 to 100
No. 8	2.36	80 to 100
No. 16	1.18	45 to 85
No. 30	0.60	20 to 60
No. 50	0.30	10 to 30
No. 100	0.15	0 to 2

C. Have an effective size (D10) of 0.15 mm to 0.30 mm with a Uniformity Coefficient (D60/D10) of 4 to 6, with a maximum of 3 percent passing the No. 100 sieve.

Drain rock must be washed and range in size from ¾ to 2-1/2 inches.



Montana Department of Environmental Quality	Scale: NTS	Elevated Sand Mound - Bed Design Section View	Dwg. No. 6.7-1

Sand Mound Material Specifications:

Sand must be washed free of silts and clays.

The in-place fill material must meet one of the following specifications:

A. ASTM C-33 for fine aggregate, with a maximum of 2 percent passing the No. 100 sieve, or

B. Fit within the following particle size distribution:

Sieve	Particle Size (mm)	Percent Passing
3/8 in	9.50	100
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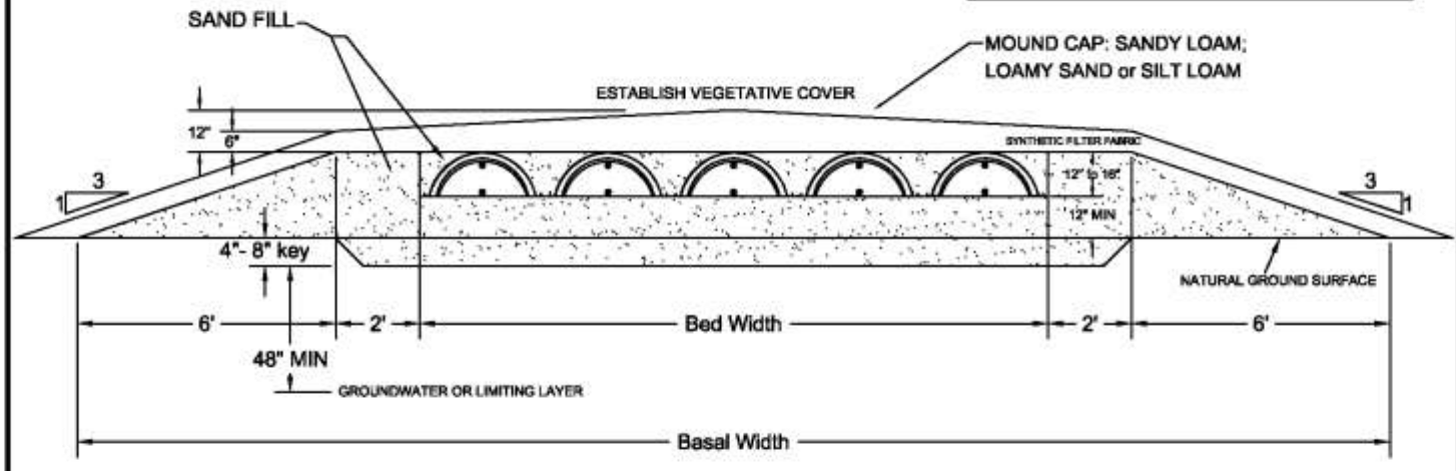
No. 16	1.18	45 to 85
No. 30	0.60	20 to 60
No. 50	0.30	10 to 30
No. 100	0.15	0 to 2

C. Have an effective size (D10) of 0.15 mm to 0.30 mm with a Uniformity Coefficient (D60/D10) of 4 to 6, with a maximum of 3 percent passing the No. 100 sieve.

Drain rock must be washed and range in size from ¾ to 2-1/2 inches.



Montana Department of Environmental Quality	Scale: NTS	Elevated Sand Mound - Leaching Chamber Trench Design Section View	Dwg. No. 6.7-2

6.8. EVAPOTRANSPIRATION ABSORPTION AND EVAPOTRANSPIRATION SYSTEMS

6.8.1. General

Evapotranspiration absorption (ETA) systems are used where slow percolation rates or soil conditions would preclude the use of a standard absorption system.

Percolation tests conducted in accordance with Appendix A, with at least a 24-hour presoak of the hole prior to the test or a double-ring infiltrometer procedure outlined in ASTM D5093-02 must be conducted for all ETA systems, at the depth of the bottom of the bed.

Evapotranspiration systems (ET) are used where slow percolation rates or soil conditions would preclude the use of a soil absorption system or where discharge to the receiving soils is undesirable.

The primary difference between the ETA and ET system is the inclusion of a liner in ET systems.

ETA and ET systems should be used in conjunction with wastewater flow reduction strategies.

6.8.2. Location

6.8.2.1. ETA and ET systems must meet all minimum separation distances as stated in ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable. Distances must be measured from the edge of the system.

6.8.2.2. ETA and ET systems must be level and must not be installed on land with a slope greater than 15 percent. Protective berms or drainage trenches must be installed to divert storm drainage and snow-melt run-off away from the system, if necessary.

6.8.3. Design

6.8.3.1. ETA and ET systems must not be deeper than 30 inches from the natural ground surface.

6.8.3.2. The fill material in the ETA and ET system must be washed coarse sand, drain rock meeting the requirements of Section 1.2.25, or other inert media approved by the reviewing authority. Information must be provided to document the void ratio used and, if available, the wicking characteristics of the material.

6.8.3.3. ETA and ET systems must be installed with the long dimension parallel to the land contour.

6.8.3.4. ET systems must include a watertight liner of at least 30-mil thickness to contain the effluent. Seams for a synthetic liner must be completely sealed in accordance with the manufacturer's recommendations and the liner must be keyed into the native soils at its edges.

6.8.3.5. A minimum of 2 inches of sand fill must be placed between the native soil surface and/or any projecting rocks and the liner.

6.8.3.6. Standard absorption trenches, gravelless trenches, other absorption systems, or distribution pipes may be used to distribute effluent in an ETA and ET system.

Standard absorption trenches, gravelless trenches and other absorption systems must be constructed in accordance with Subchapters 6.1 or 6.6 and this chapter. No reduction in absorption area sizing will be allowed for the use of gravelless or other trench technology in ETA or ET systems.

The spacing between standard absorption trenches, gravelless trenches, other trenches, or distribution pipes in an ETA or ET system must be a minimum of 6 feet and maximum of 8 feet measured on center.

Gravel trenches or leaching chambers are required for ET and ETA systems constructed with a sand media. These methods of distribution may be used, but are not required, for ET and ETA systems constructed with a gravel medium.

6.8.3.7. Soils with an initial percolation rate between 121 and 240 mpi, with a 24-hour presoak of the hole prior to the test, may use an ET or ETA system. All calculations must be submitted for review.

Soils with an initial percolation rate of 241 mpi or slower may use an ETA system if the percolation rate, determined in the field, using the ASTM D5093-02 double-ring infiltrometer procedure shows a rate between 121 and 240 mpi. All calculations must be submitted for review.

6.8.3.8. Calculated storage capacity must provide a factor of safety of at least 1.5 for storage loss over time caused by plugging of the voids due to evaporated salts and residuals wastewater flow rates.

6.8.3.9. Water balance sizing calculations for ETA and ET systems must be based on a one-year period. A water balance analysis may include pan evaporation data, precipitation for the wettest year in a 10-year period, soils absorption information from the site, transpiration, and other site-specific design information.

A. Pan evaporation information may be included in the water balance where it can be adequately demonstrated. Very few locations exist where data has been tabulated in Montana and calculations must address site-specific pan evaporation conditions.

B. The design must show that total water lost through evaporation and absorption equals or exceeds the total water gained through precipitation and effluent discharge. Precipitation information used must be for the wettest year in a 10-year period. Storage capacity must be built into the system to accommodate months with low evaporation.

C. Transpiration may be included in the water balance where it can be adequately demonstrated.

D. Other site-specific design information such as shade, area topography, or manmade structures must be considered.

6.8.4. Construction

6.8.4.1. Construction of an ET system must be initiated immediately after preparation of the liner.

6.8.4.2. Excavation for ETA systems may proceed only when the moisture content is below the soil's plastic limit. If a sample of soil taken at the depth of the proposed bottom of the system forms a ribbon, instead of crumbling, when one attempts to roll it between the hands, the soil is too wet to excavate.

6.8.4.3. ETA construction must be completed in such a manner to prevent compaction.

The fill material must be covered completely with an appropriate geotextile fabric, untreated building paper, or 2 inches of straw to prevent the soil cover from entering the media.

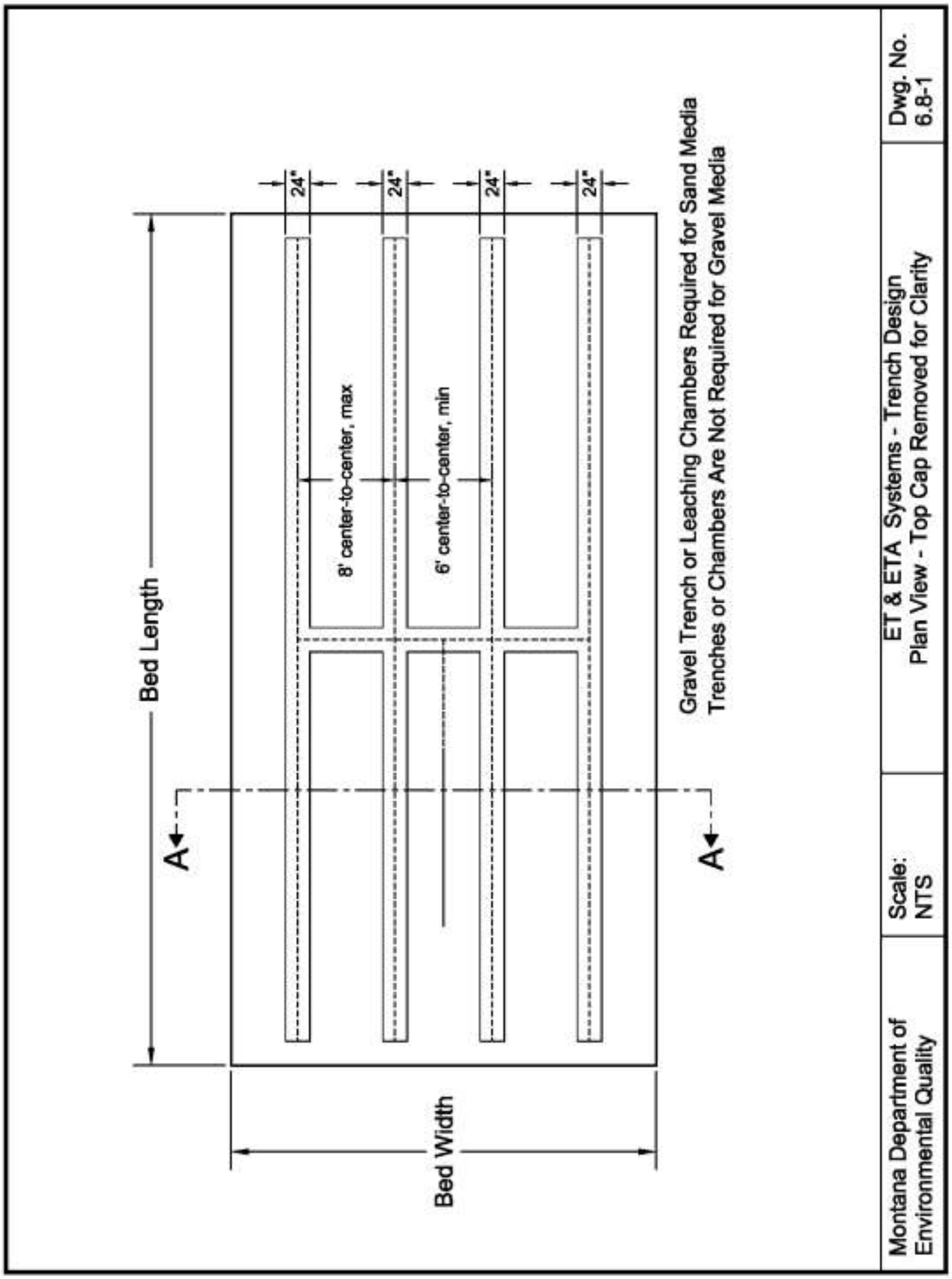
6.8.4.4. A 4-inch diameter standing check pipe with both ends capped (only the bottom cap should be glued) must be installed. Several 1/8-inch to 1/4-inch diameter holes should be drilled in the bottom half of the pipe and covered with a filter cloth sock. The check pipe should be anchored in fill material to prevent the pipe from being pulled out of the system.

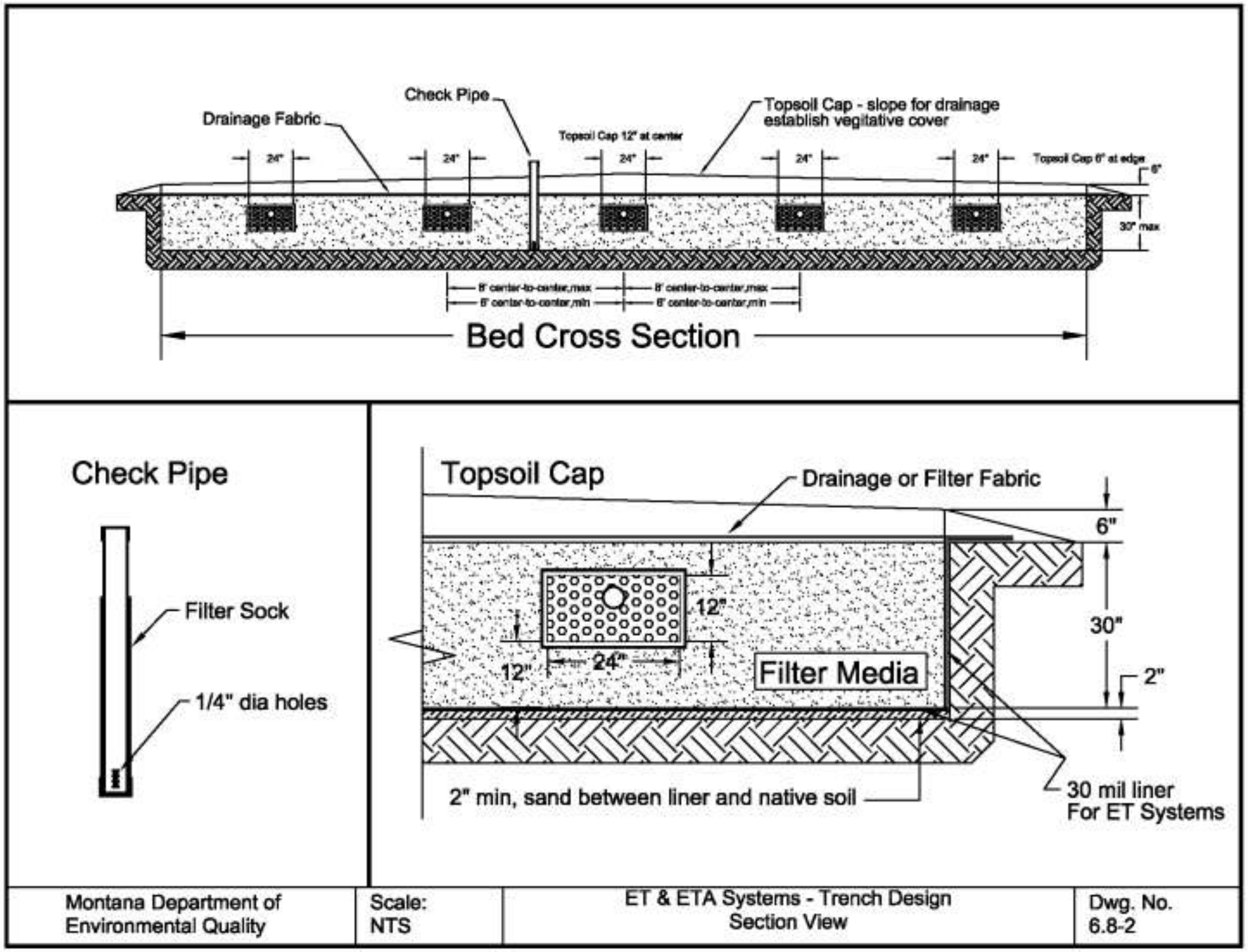
6.8.4.5. The ETA and ET system must be covered with a minimum of 12 inches at the center of the system and 6 inches at the edge of the system of a suitable medium, such as sandy loam, loamy sand, or silt loam to provide drainage and aeration. These depths are measured after settling.

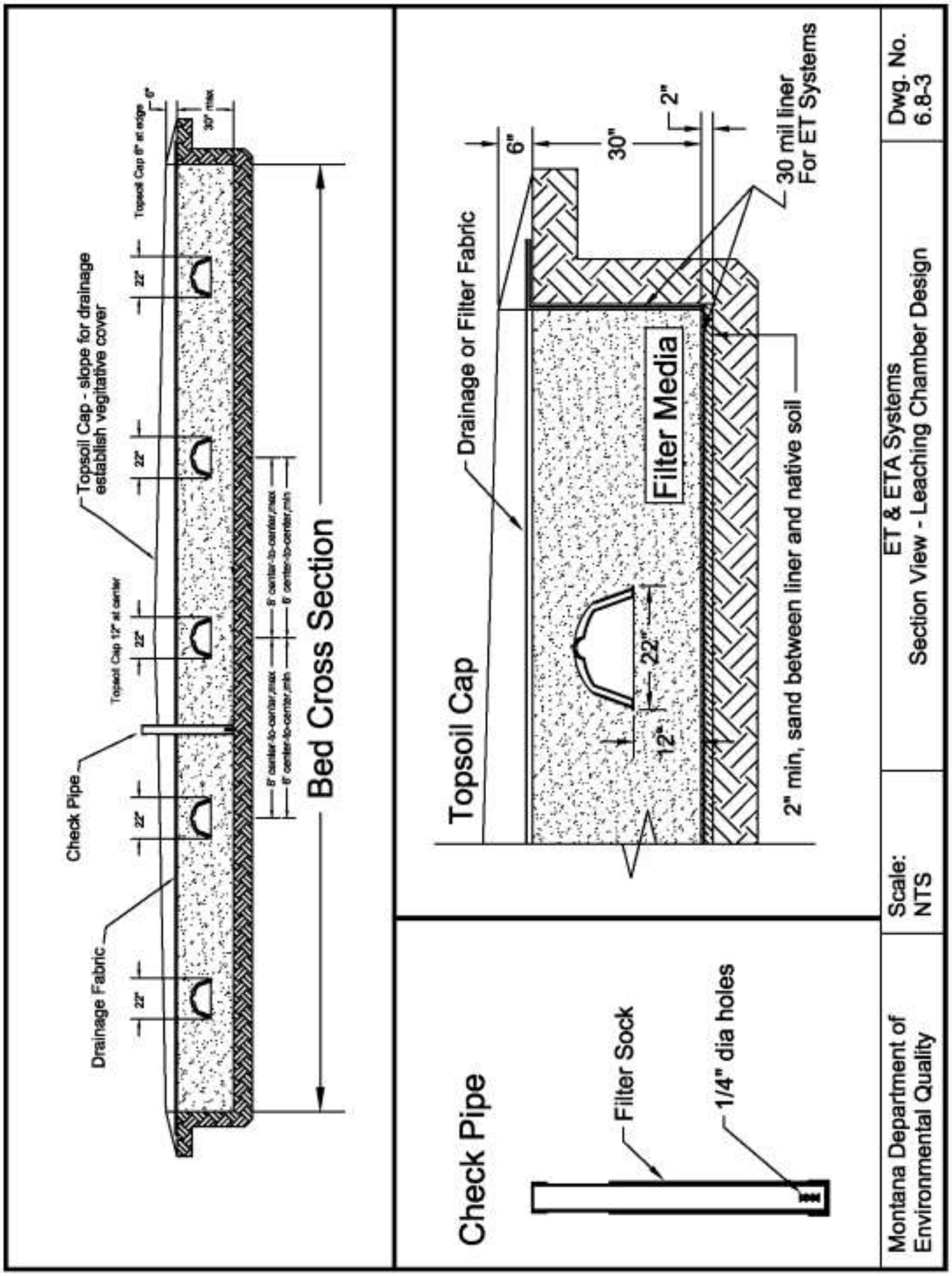
The topsoil cap must be immediately vegetated after construction with sod or other appropriate method.

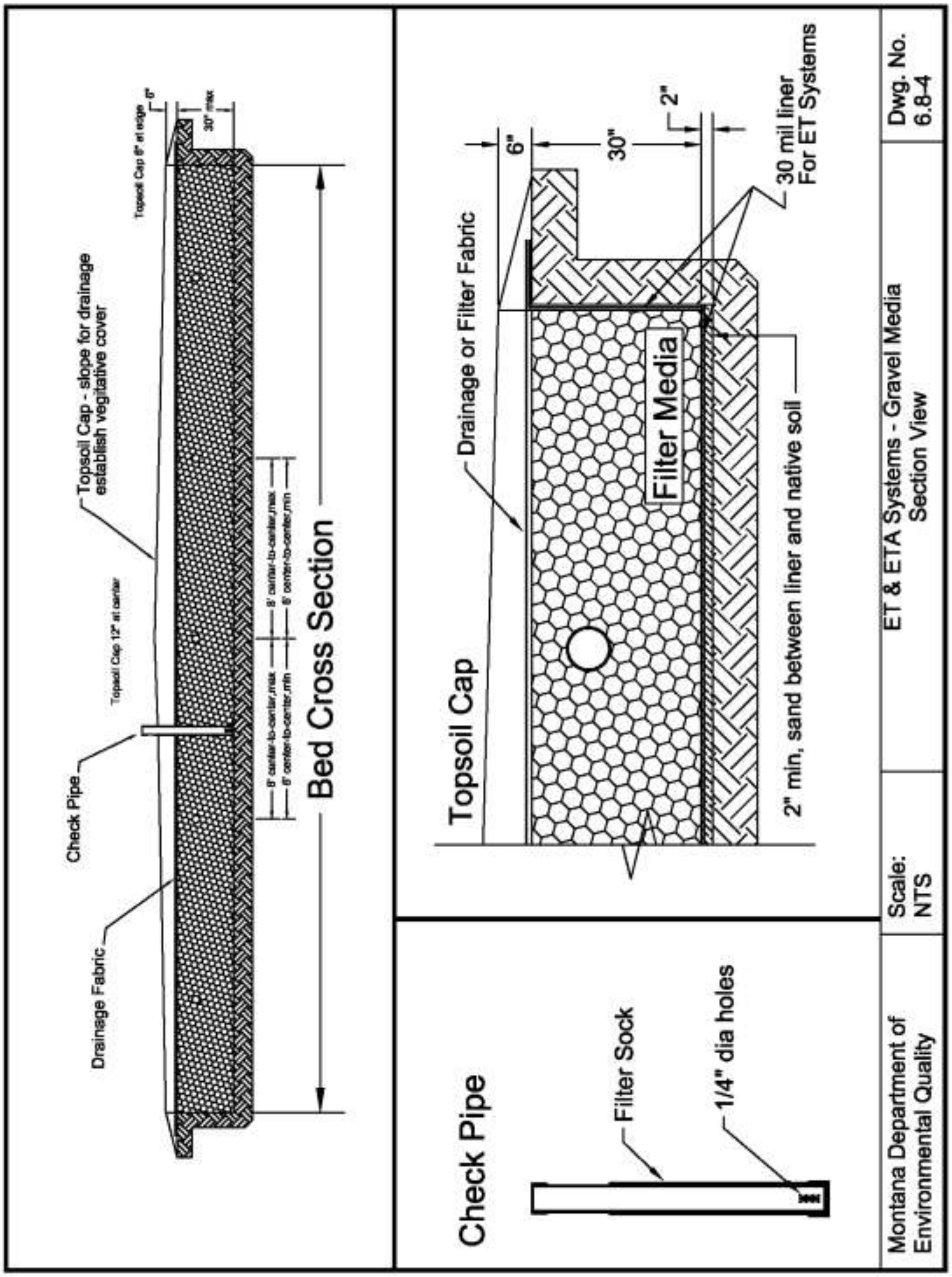
6.8.5. Operation and Maintenance, Certification, and As-builts

A detailed set of plans, specifications, and an operation and maintenance plan are required. The operation and maintenance plan must meet the requirements in Appendix D. Certification and as-built plans are required in accordance with Appendix D.


Bed Length
Bed Width
A
A
24"
24"
24"
24"
8' center-to-center, max
6' center-to-center, min
Gravel Trench or Leaching Chambers Required for Sand Media
Trenches or Chambers Are Not Required for Gravel Media
Montana Department of
Environmental Quality
Scale:
NTS
ET & ETA Systems - Trench Design
Plan View - Top Cap Removed for Clarity
Dwg. No.
6.8-1


Check Pipe
Drainage Fabric
Topsoil Cap 12" at center
Topsoil Cap - slope for drainage
establish vegitative cover
24"
24"
24"
24"
24"
Topsoil Cap 6" at edge
6"
30" max
8' center-to-center,max
6' center-to-center,min
8' center-to-center,max
6' center-to-center,min
Bed Cross Section
Check Pipe
Filter Sock
1/4" dia holes
Topsoil Cap
Drainage or Filter Fabric
6"
12"
30"
12"
24"
Filter Media
2"
2" min, sand between liner and native soil
30 mil liner
For ET Systems
Montana Department of
Environmental Quality
Scale:
NTS
ET & ETA Systems - Trench Design
Section View
Dwg. No.
6.8-2


Drainage Fabric
Check Pipe
Topsoil Cap 12" at center
Topsoil Cap - slope for drainage establish vegitative cover
Topsoil Cap 6" at edge
6"
30" max
22"
22"
22"
22"
22"
8' center-to-center,max
6' center-to-center,min
8' center-to-center,max
6' center-to-center,min
Bed Cross Section
Topsoil Cap
Drainage or Filter Fabric
6"
30"
2"
30 mil liner
For ET Systems
Filter Media
22"
12"
2" min, sand between liner and native soil
Check Pipe
Filter Sock
1/4" dia holes
Montana Department of
Environmental Quality
Scale:
NTS
ET & ETA Systems
Section View - Leaching Chamber Design
Dwg. No.
6.8-3


Topsoil Cap 6" at edge
6"
30" max
Topsoil Cap - slope for drainage
establish vegitative cover
Topsoil Cap 12" at center
Check Pipe
Drainage Fabric
8' center-to-center,max
6' center-to-center,min
8' center-to-center,max
6' center-to-center,min
Bed Cross Section
Drainage or Filter Fabric
6"
30"
2"
30 mil liner
For ET Systems
Topsoil Cap
Filter Media
2" min, sand between liner and native soil
Check Pipe
Filter Sock
1/4" dia holes
Montana Department of
Environmental Quality
Scale:
NTS
ET & ETA Systems - Gravel Media
Section View
Dwg. No.
6.8-4

6.9. SUBSURFACE DRIP

6.9.1. General

Subsurface drip systems are an efficient method for dispersal of wastewater and/or gray water into the soil in small volume doses throughout the day. Uniformly spaced drip emitters in flexible polyethylene tubing control the rate of wastewater discharge and are available in either turbulent flow or pressure compensating configurations.

Each emitter's pressure compensating feature controls discharge at a nearly constant rate along the entire drip line lateral's length over a wide range of pressures. Typically, the drip line is installed directly into the soil without aggregate or other media. Pumps fill and pressurize the drip line sufficiently to achieve uniform distribution.

Monitoring system function and performance along with effluent metering is essential to proper operation. The subsurface drip system is typically operated by an integrated controller programmed to activate the pumps to dose the drip line at appropriate intervals and duration. The controller must be programmable to perform a forward flush of the drip line and back flushing of a filter. The controller should also store operating data for documenting system performance and diagnosing system malfunctions.

6.9.2. Location

Subsurface drip systems must meet the site evaluation criteria of Chapter 2.

Subsurface drip systems must meet the location criteria in ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable. The subsurface drip system may not be located where vehicles will cross the drip lines. Potable water lines may not pass under or through any part of the dispersal system.

Each submittal must address how the service provider can access the subsurface drip system for maintenance and how property use can be controlled to prevent unauthorized access to components.

6.9.3. Design

6.9.3.1. Wastewater Quantity and Quality Characterization

The quantity of expected wastewater or gray water shall be estimated using the guidelines outlined in Chapter 3 or Subchapter 6.10.

6.9.3.2. Materials

All subsurface drip system materials must be warranted by the manufacturer for use with sewage and be resistant to plugging from solids, bacterial slime, and root intrusion.

Fittings used to join the drip line to the distribution line and for flushing the manifolds must be installed in accordance with manufacturer's recommendations. Either compression or barb fittings may be specified, depending on the manufacturer's recommendations and system operating pressure.

6.9.3.3. System Components

A. Primary Treatment

All subsurface drip systems must include a septic tank in compliance with Chapter 5.

B. Advanced Wastewater Treatment System

An advanced wastewater treatment system is required prior to final subsurface disposal in compliance with Chapter 7.

C. Dosing System

Pressure distribution must be provided.

All subsurface drip systems must operate at pressures indicated in the manufacturer's specifications. These operating pressures are typically between 15 to 45 psi.

Timed dosing is required. A minimum number of 12 equally spaced doses per day are required. A method to track and verify dosing volumes and times, such as a digital control panel, pump elapsed time meters (ETMs), event counters, etc., must be provided.

D. Pumps/System Flushing

Pump selection must take into account the operating volume and pressure for the drip dispersal field when calculating the total dynamic head required for filter flushing and/or back flushing, field dosing, and drip line flushing. All disposal and flushing parameters must fall within the operational range of the pump selected.

All subsurface drip systems must include means to backwash the filters and flush drip lines and manifolds.

Filter backwash and drip line flushing must be automatic. Filter backwash and drip line flushing must be accomplished according to manufacturer's recommendations to prevent damage to the drip line and maintain product warranty.

Filter backwash and drip line flushing debris must be returned to the septic tank or the primary treatment tank.

Hose bibs are not allowed for use as a flushing component, to prevent cross contamination of potable water supply.

Field flushing velocity must be designed at the distal end of each drip line lateral connection. This velocity must be the same as required by the drip line manufacturer.

The flush return volume may not exceed the hydraulic capacity of the pretreatment unit.

E. Supply and Return Manifolds

Both supply and return manifolds are required on all subsurface drip systems.

F. Component Design and Construction

All piping, valves, fittings, level control switches, and all other components must be designed and manufactured to resist the corrosive effects of wastewater and common household chemicals.

G. Drip Line/Dispersal Line

Drip line tubing is typically a flexible polyethylene (PE) available in several diameters with a nominal 1/2 inch as the typical size in wastewater applications.

The drip line must be color coded purple by the manufacturer to be easily recognized as suitable for subsurface drip dispersal.

The drip line must be warranted fully by the manufacturer for protection against root intrusion for a minimum period of 10 years.

Drip lines should always be installed as level as possible on the contour line.

Drip lines must be installed to facilitate positive drainage back to the manifold. No standing water may pool within the system. Subsurface drip systems located on sloped sites must be designed and installed to prevent drainage to lower elevated components (drip lines, tanks, valve boxes, etc.).

Minimum installation depth for drip lines and manifolds is 8 inches beneath grade. Site specific characteristics and land use practices may require a deeper depth of installation.

Drip lines should be installed on 2-foot centers.

H. Emitters

Emitter size and type must be specifically designed for use in a subsurface drip system.

All subsurface drip systems must be equipped with self-cleaning, pressure compensating, or turbulent flow emitters.

Emitters should be installed on 2-foot intervals along the drip line with an effective subsurface infiltrative area of 4 square feet. This spacing may be altered for specific reuse systems per both the manufacturer's recommendations and the reviewing authority's approval. Spacing of emitters closer than 2 feet does not change the required subsurface infiltrative area.

The discharge rate of emitters may not vary by more than 10 percent over the entire drip line lateral in order to ensure that the effluent is uniformly distributed over the disposal area.

I. Filters

Designers shall specify the filter that is recommended by the drip line manufacturer.

All filters used must be resistant to corrosion. The manufacturer shall warrant the filters for wastewater use.

All filters must be sized to operate at a flow rate at least equal to the maximum design discharge rate of the system. Filter backwash must be included in calculating the maximum discharge rate, where applicable.

Filters may either require backwashing in accordance with manufacturer's recommendations or may be the continuously self-cleaning type.

All subsurface drip system filters must be readily accessible for inspection and servicing.

J. Flow Meter

Flow meters or some other means to monitor flow must be installed in a readily accessible location for reading and servicing. Flow meters must be warranted by the manufacturer for use with wastewater and must be accurate within the expected flow range of the installed system.

K. Electronic control panel

A controller capable of timed dosing and automatic line/filter flushing is required.

L. Air/Vacuum Relief Valve(s)

Air/vacuum relief valve(s) must be installed at the high point(s) of each supply or return manifold. All valves must be installed in a valve box with access to grade and include a gravel sump. They must have constant venting to the atmosphere.

M. Control Valves

Valves must be readily accessible for inspection and/or service, such as in a valve box with access to grade.

Control valves used for system flushing and zone distribution must operate automatically.

Pressure regulators are recommended for all subsurface drip systems.

Pressure gauge access points (Schrader valves or equal) are required at appropriate locations on system networks utilizing turbulent flow emitters to verify design and operational performance. Pressure gauge access points are recommended to be installed on all systems.

6.9.3.4. Sizing

Subsurface drip systems must be sized in accordance with soil descriptions of Chapter 2 and Appendix B. Unless otherwise approved by the reviewing authority, the effective width of the absorption area will be 2 feet per drip line.

No reduction in absorption field size will be granted for advanced wastewater treatment systems.

6.9.3.5 All subsurface drip systems must be designed to remain free flowing during freezing conditions. The reviewing authority may direct the timing for installation of the subsurface drip system to correspond to favorable weather conditions.

6.9.4 Construction

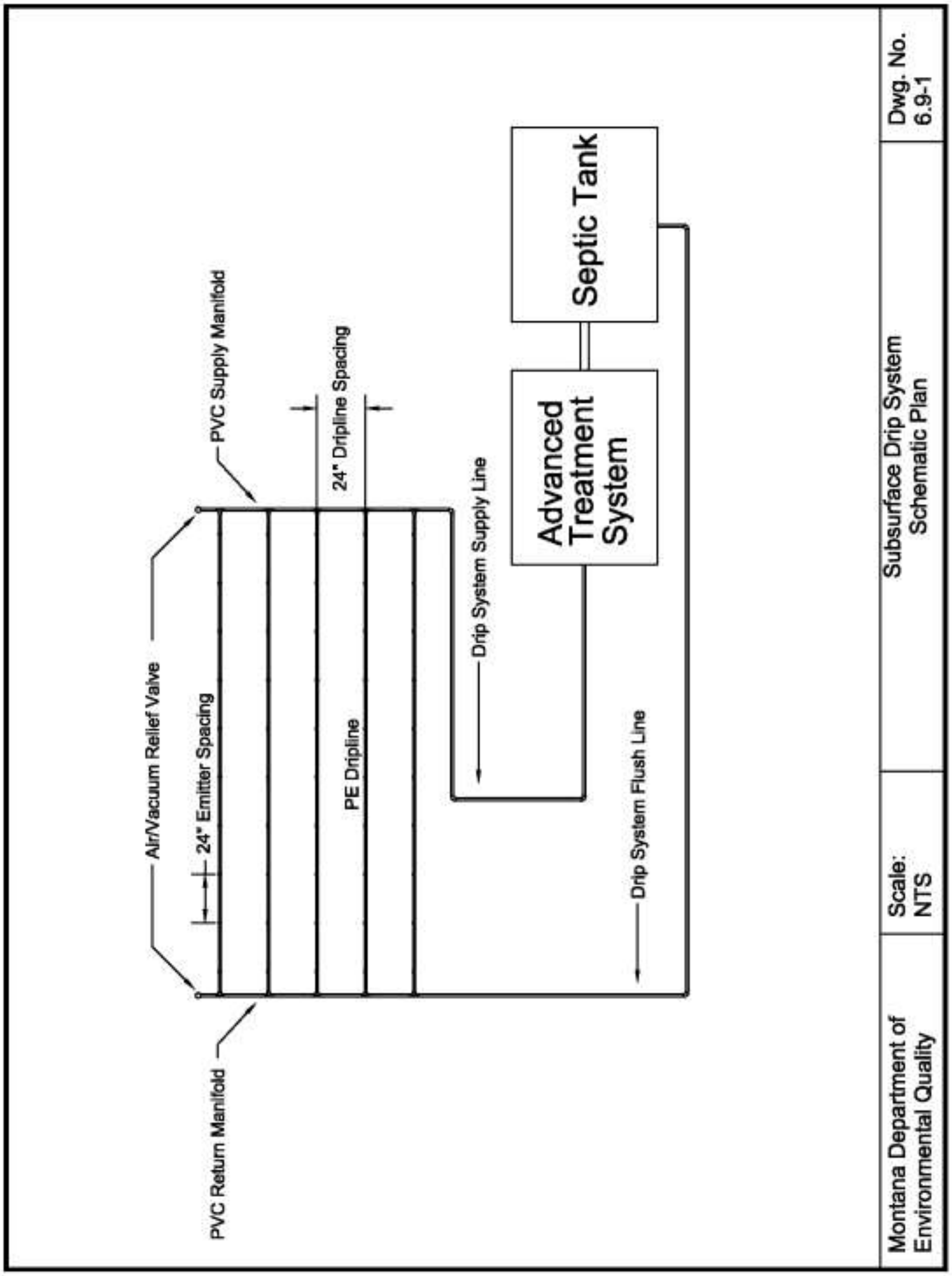
Installation instructions and recommendations vary by manufacturer. Installation knowledge and skill may be product-specific. Installers are responsible for obtaining proper training before attempting to install subsurface drip systems.

A ground cover (turf or other appropriate landscaping) must be planted over the dispersal field after installation to prevent erosion. Selection of the ground cover type and subsequent maintenance requirements must not compromise the integrity of the disposal area.

In addition to these standards, all systems must be constructed in accordance with manufacturer's recommendations.

6.9.5 Operation and Maintenance

A detailed set of plans and specifications and an operation and maintenance plan are required for all components of the system. The operation and maintenance plan must meet the requirements outlined in Appendix D.


PVC Return Manifold
Air/Vacuum Relief Valve
24" Emitter Spacing
PVC Supply Manifold
24" Dripline Spacing
PE Dripline
Drip System Supply Line
Drip System Flush Line
Advanced Treatment System
Septic Tank
Montana Department of Environmental Quality
Scale: NTS
Subsurface Drip System Schematic Plan
Dwg. No. 6.9-1

6.10 GRAY WATER IRRIGATION SYSTEMS

6.10.1. General

Gray water is untreated wastewater collected from bath tubs, showers, lavatory sinks, clothes washing machines, and laundry tubs. Gray water systems used in conjunction with a waste segregation system may also use wastewater collected from kitchens. Gray water can be contaminated with organic matter, suspended solids, or microorganisms that are potentially pathogenic. In general, treatment and disposal of gray water is subject to all applicable provisions in this Circular, except that gray water may be used for irrigation as provided in this chapter.

Gray water reuse within a building or residence, for uses such as toilet flushing, is permitted without review, provided that the gray water is ultimately disposed of by means of an approved wastewater treatment system that meets all applicable requirements of this Circular.

Gray water irrigation systems that meet the requirements of this chapter are not subject to the other chapters in this Circular, except as specifically referenced in this chapter.

6.10.2. Location

Gray water irrigation systems must meet the location criteria for gray water reuse set out in ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable.

6.10.3. Design

6.10.3.1. The collection, storage, and distribution portions of a gray water irrigation system must be designed in accordance with this chapter. The reviewing authority may allow the use of other designs and material pursuant to the review of manufacturer's information and data to substantiate the proposed alternative.

6.10.3.2. Except for lots with waste segregation systems, lots with gray water irrigation systems must be served by an existing approved alternate wastewater treatment system that is adequate to treat both the gray water and the other wastewater from the lot. Lots with waste segregation systems must have an alternate approved waste water treatment system for treating gray water, although the system need not be installed if gray water irrigation is conducted pursuant to this chapter.

6.10.3.3. Gray water from kitchen sources may be used for irrigation only where a waste segregation system is used.

6.10.3.4. All effluent from sources that are not gray water must be disposed of in an approved wastewater system.

6.10.3.5. The reviewing authority may require sampling data to ensure that the strength of gray water used for irrigation does not exceed typical residential strength parameters.

6.10.3.6. Gray water irrigation systems must use subsurface dispersal. All systems must be a minimum of 6 inches below the ground surface. Ponding or water surfacing may not occur at any gray water irrigation location.

6.10.3.7. Gray water irrigation system designs may be augmented with potable water. If potable water is used to augment gray water for irrigation within the same distribution network, a method of backflow prevention for the potable water source must be included that is consistent with the requirements of ARM Title 17, Chapter 38, subchapter 3.

6.10.3.8. All gray water irrigation system piping and appurtenances must be easily identifiable as non-potable through the use of purple piping and continuous marking at a minimum of 4-foot intervals. Tanks, pumps, and other equipment must also be labeled as "non-potable" using a permanent label placed in a conspicuous location.

6.10.3.9. If a gray water irrigation system is proposed for a lot served by a public wastewater system, the reviewing authority may not approve the gray water system unless the managing entity of the public system provides a letter of approval.

6.10.3.10. Gray water design flow rates must be estimated as follows:

A. Estimated Residential Flow Rates:

To determine total flow rate for the gray water irrigation system, the number of occupants must be multiplied by the estimated flow shown in this subsection, Table 6.10-1.

Table 6.10-1

Number of occupants per residential living unit:		
	1st bedroom	2
	each additional bedroom	1
Flow for each occupant is:		
	showers, tubs, wash basins	25 gpd
	laundry	15 gpd
	kitchen	10 gpd

B. Estimated Nonresidential Flow Rates:

Nonresidential flow rates must be substantiated by the system designer in order to be approved by the reviewing authority.

6.10.3.11. Gray water irrigation systems must have a minimum absorption area based on soil types as described in accordance with Chapter 2 and Appendix B and Section

6.1.4.

6.10.3.12. Gray water irrigation systems that are not designed to prevent freezing must be used in conjunction with a supplemental year-round method for wastewater treatment and disposal that meets applicable state and local requirements.

6.10.3.13. When a supplemental year-round system is used, gray water irrigation systems must include a three-way diverter valve to easily direct gray water to the year-round wastewater treatment system when needed. A backflow prevention device must be installed to prevent black water from entering the gray water irrigation system.

6.10.3.14. The year-round wastewater treatment system must be sized to accept and treat the total flow from the gray water irrigation system together with any other effluent in the system.

6.10.3.15. A gray water irrigation system may not adversely impact the functioning of the year-round wastewater treatment system.

6.10.3.16. Gray water systems may be installed in fill.

6.10.4. Collection and Distribution

6.10.4.1. Hose bib or hose-type attachments, including frost-free hydrants, may not be present on a gray water irrigation system.

6.10.4.2. The design must include appropriate valves or other methods to isolate the surge tank, irrigation zones, and connection to a wastewater treatment system.

6.10.4.3. Surge tanks may be incorporated into a gray water irrigation system design. Surge tanks allow for uniform distribution of the gray water despite variable flow from the source. If a gray water irrigation system contains a surge tank, the tank must meet the following requirements:

A. Surge tanks used for the storage and distribution of gray water must be designed by the manufacturer for use with wastewater;
B. Surge tanks must be easily accessible for maintenance with a locking gasketed access opening or approved equivalent;
C. Surge tanks must be covered;
D. The minimum capacity of the surge tank must be 50 gallons;
E. Surge tanks may be installed either inside or outside a building, above or below ground;
F. Aboveground surge tanks must be installed on a level, 3-inch concrete slab or equivalent, and must be anchored to prevent overturning;
G. Below ground surge tanks must be installed in dry, level, well-compacted soil. Buoyancy of the surge tank must be prevented with appropriate construction where high ground water exists;

H. Surge tanks must be equipped with an overflow pipe of the same diameter as the gray water influent pipe. The overflow must be permanently connected to an approved wastewater treatment system. This connection should be made to the building sewer, or septic tank, if any. The overflow drain may not be equipped with a shutoff valve. For waste segregation systems without an approved alternate wastewater treatment system installed, the overflow from the surge tank must be connected to a second surge tank. The second surge tank must also connect to the gray water irrigation system;

I. Above ground surge tanks must be equipped with an emergency drain of the same diameter as the gray water influent pipe. The emergency drain must be permanently connected to an approved wastewater treatment system. This connection should be made to the building drain, building sewer, or septic tank, if any;

J. The surge tank must include a method of backflow prevention that complies with ARM Title 17, Chapter 38, subchapter 3;

K. Surge tanks must include vents to the atmosphere; and

L. If storage time within the collection system is going to exceed 24 hours, appropriate treatment for odor control may be necessary.

6.10.4.4. All gray water irrigation systems should include a filter to prevent the buildup of solids and to ensure proper system functioning. If no filter is included in the design, at least 3 valved irrigation zones must be designated. Each irrigation zone must have the required length of trench to accommodate the entire gray water flow per day with automatic valves to rotate the distribution of gray water between irrigation zones.

6.10.4.5. Gravity fed absorption trenches may not exceed 100 feet in length.

6.10.4.6. All pressure dosed gray water irrigation systems must meet the following minimum requirements:

A. Surge tanks must provide sufficient access to allow maintenance of the tank and pump. Surge tanks using a siphon should have a dose counter installed to check for continued function of the siphon;

B. High-water alarms must be provided for all surge tanks utilizing pumps;

C. The minimum dose volume must be equal to the drained volume of the discharge line and manifold plus a volume equal to at least 2 times the lateral volume;

D. The duration of each discharge should not exceed 15 minutes to promote uniform distribution and soil absorption;

E. The reserve volume of the dosing system surge tank must be at least equivalent to 25 percent of the design flow. This reserve volume is computed from the high-level alarm;

F. Cleanouts must be provided at the end of every lateral. Cleanouts must be within 6 inches of finished grade and should be made with either a long sweep elbow or 2 45-degree bends; and

G. Dosed irrigation systems should be field-tested to verify uniform distribution.

6.10.5. Operation and Maintenance, Certification, and As-builts

6.10.5.1. Property owners are responsible for proper operation and maintenance of their gray water irrigation systems. Gray water systems that include kitchen wastewater may have increased maintenance requirements.

6.10.5.2. All public gray water irrigation systems must submit a detailed set of plans, specifications, and an operation and maintenance plan to the reviewing authority in accordance with Appendix D. Certification and as-built plans are required in accordance with Appendix D.

6.11. ABSORPTION BEDS

6.11.1. General

Absorption beds may be used as replacement wastewater treatment systems in existing lots where standard absorption trenches cannot be utilized. Absorption beds may be used as replacement for previously approved seepage pits. Absorption beds may not be used on new lots without an existing wastewater treatment system that has been in continuous use and that was permitted by the reviewing authority.

Absorption beds must meet the same requirements as standard absorption trenches as described in Subchapter 6.1, except where specifically modified in this chapter.

Rapid infiltration basins designed for effluent disposal rather than subsurface treatment must be designed in accordance with DEQ-2.

6.11.2. Design

6.11.2.1. Absorption beds must be more than 3 feet wide, and must be at least 2 feet in depth, unless a limiting condition requires a lesser depth, but in no case may the bed be less than 1 foot in depth.

6.11.2.2. Pressure distribution must be provided for all absorption beds with a minimum of 2 distribution pipes installed per system.

6.11.2.3. Distribution piping should be separated by a minimum of 30 inches and a maximum of 48 inches and 18 to 30 inches from the edge of the excavation.

6.11.2.4. Absorption bed sizing is determined by flows described in Chapter 3, the application rates in Chapter 2, along with the procedure described in Section 6.1.4 or by using the maximum area available. Absorption beds shall not be installed with soils that have percolation rates greater than 60 mpi.

6.11.3. Construction

6.11.3.1. Absorption beds may be constructed in accordance with Chapter 2 but must not be constructed on unstabilized fill.

6.11.3.2. The excavation must be filled with a minimum of 6 inches of washed rock or 6 inches of ASTM C-33-13 sand.

6.11.3.3. Distribution piping should be covered by 2 inches of drain rock meeting the requirements of Section 1.2.25.

6.11.3.4 Distribution piping must be installed to ensure uniform distribution of effluent.

6.11.3.5 Drain rock must be covered with an appropriate geotextile fabric, untreated building paper, or straw at least 4 inches in depth.

6.11.3.6 Backfill for beds should be loam type soils that do not form an impervious seal. High clay or silt content soils may not be used for backfill.

6.11.4. Gravelless or other absorption systems may be used in absorption beds. Gravelless or other absorption systems must be installed in accordance with Subchapter 6.6 and this subchapter. No reduction in sizing will be allowed for the use of gravelless or other systems in absorption beds.

7. ADVANCED WASTEWATER TREATMENT SYSTEMS

7.1. RECIRCULATING MEDIA TRICKLING FILTERS

7.1.1. General

These systems utilize aerobic, attached-growth treatment processes to biologically oxidize organic material and convert ammonia to nitrate (nitrification). A trickling filter consists of a bed of highly permeable medium to which a bio-film adheres in an unsaturated environment. Wastewater is applied to the top of the bed and trickles through the media. Microorganisms in the bio-film degrade organic material and may also nitrify the wastewater. An under-drain system collects the treated wastewater and any sloughed solids and transports it to a settling tank from which it is recirculated and trickled back through the media.

Due to the reduced amount of BOD_5 and TSS produced by this technology, the absorption system used for final disposal may be reduced, except where specifically prohibited in this Circular, for the following soil types:

A. For subsurface absorption systems constructed in soils with percolation rates between 3 and 50 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 50 percent;
B. For subsurface absorption systems constructed in soils with percolation rates between 51 and 120 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 25 percent.

The reviewing authority may request data from the recirculating trickling media filter to demonstrate performance criteria.

A separate subsurface absorption replacement area, sized without reductions, must be designated for each site using a recirculating trickling media filter.

Classification of a recirculating media trickling filter as a Level 1a, Level 1b, or Level 2 system for nutrient reduction, under ARM 17.30.718, must be made under separate application. The reviewing authority may impose additional design requirements for systems with extremely low BOD_5 levels to ensure adequate treatment of effluent in the soil.

7.1.2. Design

7.1.2.1. The design criteria must include, but not necessarily be limited to, primary treatment, filter size, filter media, organic loading, hydraulic loading, dosing rate, and recirculation rate. The level of treatment provided by the recirculating media trickling filter must be provided.

7.1.2.2. Recirculating media trickling filter systems must have a means of primary and secondary settling. Additional components such as pump chambers, pumps, controls, recirculation valves, etc. may be used as required.

7.1.2.3. Filter media must be resistant to spalling or flaking, and must be relatively insoluble in wastewater. The type, size, depth, volume, and clogging potential of the medium used must be based on published criteria and proven through monitoring and testing in accordance with Appendix D.

7.1.2.4. The vessel containing the media must be watertight and corrosion resistant.

7.1.2.5. Waste effluent must be distributed uniformly across the design surface area of the filter.

7.1.2.6. The means of aerating the media must be described.

7.1.2.7. The method of recirculation and recirculation rate must be discussed and justified to show adequate functioning of the system. The recirculation tank must meet the same material and construction specifications as a septic tank. The reviewing authority may require systems with large surge flows to have recirculation tank size based on the estimated or actual surge flow volume.

7.1.2.8. All recirculating trickling systems must operate in a manner such that, if a component of the system fails and treatment diminishes or ceases, untreated effluent will not be discharged to the absorption system. Systems must be equipped with adequate alarms.

7.1.3. A detailed set of plans and specifications and an operation and maintenance plan are required. The operation and maintenance plan must meet the requirements in Appendix D.

7.1.4. Gravelless or other absorption systems constructed in accordance with the requirements of Subchapter 6.6 may be used in lieu of a standard absorption trench. The use of gravelless trenches and other absorption systems will not qualify for any additional reduction beyond that listed in Section 7.1.1.

7.2. INTERMITTENT SAND FILTERS

7.2.1. General

The design criteria must include, but not necessarily be limited to, the type of usage, primary treatment, filter media, filtration rate, and dosage rate.

The wastewater strength discharged to the filter must not exceed residential strength wastewater. Intermittent sand filters must discharge to a subsurface absorption system.

Due to the reduced amount of BOD_5 and TSS produced by intermittent sand filters, the absorption system used for final disposal may be reduced for the following soil types except where specifically addressed in this Circular:

A. For subsurface absorption systems constructed in soils with percolation rates between 3 and 50 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 50 percent;
B. For subsurface absorption systems constructed in soils with percolation rates between 51 and 120 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 25 percent.

A separate subsurface absorption replacement area, sized without reductions, must be designated for each site using an intermittent sand filter.

Intermittent sand filters classified as Level 1a, Level 1b, or Level 2 systems, as defined in ARM 17.30.718, may have additional requirements beyond those listed in this Circular.

7.2.2. Design

7.2.2.1. The minimum area in any subsurface sand filter must be based upon flow rates as determined in Chapter 3.

7.2.2.2. The application rate for intermittent sand filters may not exceed 1.0 gpd/ft^2. This must be computed by dividing the effluent flow rate by the area, in square feet, of the filter.

7.2.2.3. A minimum of one 4-inch in diameter collection line must be provided at the bottom of the intermittent sand filter. The upper end of the collection line(s) must be provided with a 90-degree elbow turned up, a pipe to the surface of the filter, and a removable cap. The collection(s) line may be level. The bottom of the filter may be level or sloped to the collection line(s).

7.2.2.4. Distribution lines must be level and must be horizontally spaced a maximum of 3 feet apart, center-to-center. Orifices must be placed such that that there is at least one orifice for each 4 square feet of sand surface area. All intermittent sand filter dosing must be controlled by a programmable timer. The minimum depth of filter media must be 24 inches.

7.2.2.5. A watertight, 30-mil PVC liner, or equivalent, must be used to line the sand filter.

7.2.2.6. There must be a minimum of 2 inches of sand fill between the natural soil surface and/or any projecting rocks and the liner.

7.2.2.7. Washed drain rock meeting the requirements of Section 1.2.25 must be placed in the bottom of the system to provide a minimum depth of 8 inches in all places and to provide a minimum of 4 inches of material over the top of the collection lines.

7.2.2.8. The drain rock must be covered with a 3-inch thick layer of 1/4-inch to 1-inch washed gravel.

7.2.2.9. A minimum of 24 inches of filter sand media must be placed above the 1/4-inch to 1-inch washed gravel.

7.2.2.10. A layer of 1/4-inch to 1-inch washed gravel must be placed over the sand media, with at least 3 inches placed over the distribution lines and 3 inches placed under the distribution lines. The distribution pipes must be installed in the center of this layer, and all parts of the distribution system must drain between cycles.

7.2.2.11. An appropriate geotextile fabric, untreated building paper, or straw must be used to separate the top layer of washed gravel containing the distribution lines and the sand media to keep silt from moving into the sand while allowing air and water to pass through the fabric.

7.2.2.12. The intermittent sand filter must be backfilled with 6 inches at the edges to 8 inches at the center of a suitable medium, such as sandy loam or loamy sand that is then planted with sod or other shallow-rooted vegetative cover.

7.2.2.13. Monitoring pipes to detect filter clogging must be installed. A means for sampling effluent quality must be provided.

7.2.3. Pressure distribution in accordance with Subsection 4.2.3.3, except Subsection 4.2.3.3.D, must be provided for all sand filters.

7.2.4. The dose volume must not exceed 0.25 gallons per dose per orifice. The dose frequency must not exceed 1 dose per hour per zone. The dose tank must include a minimum surge volume of 1/2 the daily flow for individual or shared systems. For multiple-user and public systems, the applicant must demonstrate that a smaller surge volume is adequate. The surge volume is the liquid storage capacity between the "timer-on" float and the "timer-override" float. The "timer-override" float and the "high-water alarm" float may be combined. Note that the surge volume defined here is not the same as the reserve storage volume defined in Chapter 4.

7.2.5. Materials

7.2.5.1. Washed drain rock meeting the requirements of Section 1.2.25 must be a minimum of 1 inch in diameter to prevent clogging.

7.2.5.2. Washed gravel measuring 1/4-inch to 3/4 inch in diameter must meet the following gradation:

Sieve	**Particle Size (mm)**	**Percent Passing**
1 inch	25	100
3/4 inch	19	50 to 100
3/8 inch	9.5	30 to 80
No. 4	4.75	0 to 10
No. 8	2.36	0 to 2
No. 16	1.18	0 to 1

7.2.5.3. The filter media must be washed and free of clay or silt and contain the following criteria in place:

Sieve	**Particle Size (mm)**	**Percent Passing**
3/8 in	9.50	100
No. 4	4.75	95 to 100
No. 8	2.36	80 to 100
No. 16	1.18	45 to 85
No. 30	0.60	15 to 60
No. 50	0.30	3 to 10
No. 100	0.15	0 to 2

7.2.5.4. The intermittent sand filter must be covered by a suitable medium, such as sandy loam or loamy sand, to provide drainage and aeration. The material must be seeded, sodded, or otherwise provided with shallow-rooted vegetative cover to ensure stability of the installation.

7.2.6. Operation and Maintenance, Certification, and As-builts

A detailed set of plans, specifications, and an operation and maintenance plan are required. The operation and maintenance plan must meet the requirements in Appendix D. Certification and as-built plans are required in accordance with Appendix D.

7.2.7. Gravelless trenches and other absorption systems, constructed in accordance with the requirements of Subchapter 6.6, may be used in lieu of a standard absorption trench. The use of gravelless trenches and other absorption systems will not qualify for any additional reduction beyond that listed in Section 7.2.1.

7.3. RECIRCULATING SAND FILTERS

7.3.1. General

The design criteria must include, but not necessarily be limited to, the type of usage, primary treatment, filter media, filtration rate, and dosage rate. The wastewater strength discharged to the sand filter must not exceed residential strength wastewater. Recirculating sand filters must discharge to a subsurface absorption system.

Due to the reduced amount of BOD_5 and TSS produced by recirculating sand filters, the absorption system used for final disposal may be reduced for the following soil types except where specifically addressed in this Circular:

A. For subsurface absorption systems, constructed in soils with percolation rates between 3 and 50 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 50 percent;
B. For subsurface absorption systems constructed in soils with percolation rates between 51 and 120 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 25 percent.

A separate subsurface absorption replacement area, sized without reductions, must be designated for each site using a recirculating sand filter.

Recirculating sand filters classified as Level 1a, Level 1b, or Level 2 systems, as defined in ARM 17.30.718, may have additional requirements beyond those listed in this Circular.

7.3.2. Design

7.3.2.1. A watertight, 30-mil PVC liner, or equivalent must be used to line the sand filter. There must be a minimum of 2 inches of sand fill between the soil surface and/or any projecting rocks and the liner.

7.3.2.2. Entrance and exit points resulting in liner penetration must be water tight.

7.3.2.3. Drain rock meeting the requirements of Section 1.2.25 must be placed in the bottom of the filter, providing a minimum depth of 6 inches in all places and providing a minimum of 2 inches of material over the top of the collection lines. The drain rock must be covered with a 3-inch layer of 1/4-inch to 3/4-inch washed gravel meeting the gradation chart in Subsection 7.2.5.2. Drain rock for the under-drain lines must meet the requirements for a standard absorption system, except it must be a minimum of 1 inch in diameter to prevent clogging.

7.3.2.4. The depth of filter media must be at least 24 inches. The media must have a Uniformity Coefficient of 2 or less, must be washed, and must meet the following gradation:

Sieve	Particle Size (mm)	Percent Passing
1/2 in	12.5	100
3/8 in	9.50	50 to 95
No. 4	4.75	0 to 15
No. 8	2.36	0 to 1.6

7.3.2.5. The filter media must be covered with a layer of 3/4- to 1.5-inch washed gravel at least 6 inches thick. The distribution pipes must be installed in the center of this layer, and all parts of the distribution system must drain between cycles.

7.3.2.6. For sizing the filter, the application rate must not exceed 5 gallons per day per square foot of filter area. This must be computed by dividing the effluent flow rate, not considering the amount of recirculation, by the area, in square feet, of the filter.

7.3.2.7. The liquid capacity of the recirculation tank must be at least 1.5 times the daily design wastewater flow. The recirculation tank must meet the same material and construction specifications as a septic tank. The minimum liquid level in the recirculation tank must be at least 80 percent of the daily flow at all times during the 24-hour daily cycle. The reviewing authority may require systems with large surge flows to have recirculation tank size based on the estimated or actual surge flow volume.

7.3.2.8. The filter-effluent line passing through the recirculation tank must be provided with a control device that directs the flow of the filter effluent. The filter effluent will be returned to the recirculation tank for recycling or be discharged to the subsurface absorption system, depending upon the liquid level in the recirculation tank. The recirculation pump(s) must be located at the opposite end of the recirculation tank from the filter return line and the tank inlet(s).

7.3.2.9. The system must be designed with a minimum recirculation ratio of not less than four. Each orifice must be dosed at least every 30 minutes, and the maximum dose volume must be 2 gallons per orifice per dose. All recirculating sand-filter dosing must be controlled with a programmable timer.

7.3.2.10. A minimum of 1 4-inch in diameter collection line must be provided. The upper end of the collection line(s) must be provided with a sweep to the surface which includes a 90-degree elbow turned up, a pipe to the surface of the filter, and a removable cap. The collection line(s) may be level. The bottom of the filter may be level or sloped to the collection line(s)

7.3.2.11. Distribution lines must be level and must be horizontally spaced a maximum of 3 feet apart, center-to-center. Orifices must be placed such that there is at least one orifice for each 4 square feet of filter media surface area.

7.3.2.12. The effluent must be discharged in such a manner as to provide uniform distribution in accordance with Subsection 4.2.3.3, except for Subsection

4.2.3.3.D.

7.3.2.13. The distribution line must be designed for freezing conditions. The plans and engineering report will specify how this is accomplished.

7.3.2.14. Topsoil or other oxygen-limiting materials must not be placed over the filter.

7.3.3. Operation and Maintenance, Certification, and As-builts

A detailed set of plans, specifications, and an operation and maintenance plan are required. The operation and maintenance plan must meet the requirements in Appendix D. Certification and as-built plans are required in accordance with Appendix D.

7.3.4. Gravelless trenches and other absorption systems, constructed in accordance with the requirements of Subchapter 6.6, may be used in lieu of a standard absorption trench. The use of gravelless trenches and other absorption systems will not qualify for any additional reduction beyond that listed in Section 7.3.1.

7.4. AEROBIC WASTEWATER TREATMENT UNITS

7.4.1. General

Aerobic treatment units (ATUs) are concrete tanks or other containers of various configurations that provide for aerobic biodegradation or decomposition of the wastewater components in a saturated environment by bringing the wastewater in contact with air by some mechanical means. ATUs are exclusively proprietary products representing a wide variety of designs, materials, and methods of assembly.

Classification of ATUs as Level 1a, Level 1b, or Level 2 systems for nutrient reduction, under ARM 17.30.718, must be made under separate application.

All ATUs must discharge to a subsurface wastewater treatment system. This treatment system must be sized in accordance with Chapters 2~~,~~ and 3~~,~~ and Section 6.1.4. Aerobic treatment devices must demonstrate compliance with the testing criteria and performance requirements for NSF Standard No. 40 for Class 1 certification. This compliance may be demonstrated either through NSF, through a third independent party using comparable protocol, or through the testing requirements outlined in ARM 17.30.718 for 30 mg/L BOD_5 and 30 mg/L TSS only. ATUs may apply the following sizing reduction to the subsurface absorption area:

A. For subsurface absorption systems constructed in soils with percolation rates between 3 and 50 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 50 percent;

B. For subsurface absorption systems constructed in soils with percolation rates between 51 and 120 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 25 percent.

A separate subsurface absorption replacement area, sized without reductions, must be designated for each site using an ATU.

7.4.2. An adequate form of positive filtration will be required between the treatment device and the disposal component to prevent excessive solids from being carried over into the disposal component during periods of bulking.

7.4.3. ATU systems must provide primary treatment for wastewater through a septic tank that meets all of the requirements of Chapter 5. Designs for the use of an external trash rack will be evaluated on a case-by-case basis.

7.4.4. Access ports

7.4.4.1. Ground level access ports must be sized and located to facilitate installation, removal, sampling, examination, maintenance, and servicing of components or compartments that require routine maintenance or inspection.

7.4.4.2. Access ports must be protected against unauthorized intrusion. Acceptable protective measures include, but are not limited to, padlocks or covers that can be removed only with tools.

7.4.5. Failure sensing and signaling equipment

7.4.5.1. The ATU must possess a mechanism or process capable of detecting:

A. failure of electrical and mechanical components that are critical to the treatment process; and,
B. high liquid level conditions above the normal operation specifications.

7.4.5.2. The ATU must possess a mechanism or process capable of notifying the system owner of failure identified by the failure sensing components. The mechanism must deliver a visible and audible signal.

7.4.6. Installation

ATUs must be installed according to the manufacturer's instructions.

7.4.7. Sampling ports

7.4.7.1. A sampling port must be designed, constructed, and installed to provide easy access for collecting a water sample from the effluent stream. The sampling port may be located within the ATU or other system component, such as a pump chamber, provided that the wastewater stream being sampled is representative of the effluent stream from the ATU.

For ATUs using effluent disinfection to meet the fecal coliform criteria, the sampling port must be located downstream of the disinfection component, including the contact chamber if chemical disinfection is used, so that samples will accurately reflect disinfection performance.

7.4.7.2. Sampling ports must be protected against unauthorized intrusion, as described in Subsection 7.4.4.2.

7.4.8. Operation and Maintenance, Certification, and As-builts

A detailed set of plans, specifications, and an operation and maintenance plan are required. The operation and maintenance plan must meet the requirements outlined in Appendix D. Certification and as-built plans are required in accordance with Appendix D.

7.5. CHEMICAL NUTRIENT REDUCTION SYSTEMS

7.5.1. General

Chemical nutrient reduction systems are used to provide advanced treatment of septic tank effluent. The monitoring frequency must be sufficient to establish the treatment efficiency and response to varying wastewater flows, strengths, and climatic conditions. The reviewing authority will consider the complexity and maintenance required of the system, the stability of the processes, and the monitoring data in determining the adequacy, level of maintenance, and monitoring frequency of the system.

A means of securing continuous maintenance and operation of the system must be approved by the reviewing authority.

7.5.2. Design

Specific design criteria will not be outlined in this document due to the various alternatives and design complexity involved. The EPA manual, *On-Site Wastewater Treatment Systems Manual* (February 2002), pages TFS-41 to 52, will be used as a guideline for the design of these systems.

7.5.3. Operation and Maintenance, Certification, and As-builts

A detailed set of plans, specifications, and an operation and maintenance plan are required. The operation and maintenance plan must meet the requirements outlined in Appendix D. Certification and as-built plans are required in accordance with Appendix D.

7.6. ALTERNATIVE ADVANCED TREATMENT SYSTEMS

7.6.1. General

Alternative advanced treatment systems will be evaluated by the reviewing authority on a case-by-case basis.

7.6.2. Design

Specific design criteria will not be outlined in this document due to the various alternatives and design complexity involved.

Those systems that provide documentation or demonstrate through a third independent party that the unit is able to meet the testing criteria and performance requirements for NSF Standard No. 40 for Class 1 certification or meet the testing requirements outlined in ARM 17.30.718 for 30 mg/L BOD_5 and 30 mg/L TSS only may apply the following sizing reduction to the subsurface absorption area:

A. For subsurface absorption systems constructed in soils with percolation rates between 3 and 50 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 50 percent;
B. For subsurface absorption systems constructed in soils with percolation rates between 51 and 120 mpi as described in Chapter 2 and Appendix B, the final absorption area may be reduced by 25 percent.

A separate subsurface absorption replacement area, sized without reductions, must be designated for each site using an alternative advanced treatment system.

7.6.3. Classification as a Level 1a, Level 1b, or Level 2 system for nutrient reduction, under ARM 17.30.718, must be made under separate application. Additional design requirements may apply.

7.6.4. Operation and Maintenance, Certification, and As-builts

A detailed set of plans, specifications, and an operation and maintenance plan are required. The operation and maintenance plan must meet the requirements outlined in Appendix D. Certification and as-built plans are required in accordance with Appendix D.

8. MISCELLANEOUS

8.1. HOLDING TANKS

8.1.1. General

Holding tanks are used to hold wastewater until pumping occurs by a licensed septic tank pumping service and wastewater is disposed at an approved location. They are used for storage and do not, as part of their normal operation, dispose of or treat the wastewater**.**

8.1.2. Holding tanks are septic tanks that have no standard outlets and are modified to provide full time access for pumping.

8.1.3. Holding tanks must have a minimum capacity of 1,000 gallons. Larger tank capacity may be required by the reviewing authority.

8.1.4. Holding tanks must meet the construction standards for septic tanks in Chapter 5, except that no outlet opening shall be cast in the tank walls.

8.1.5. Holding tanks must have an audible or visual warning alarm that signals when the tank level has reached 75 percent of capacity. The tank must be pumped as soon as possible after the alarm is triggered and before the tank reaches 100 percent capacity.

8.1.6. Holding tanks installed where the seasonal ground water table may reach any portion of the tank must be evaluated for buoyancy by a qualified individual and flotation prevented. The tanks must be a single pour (seamless) tank design, and must be waterproofed against infiltration.

8.1.7. Holding tanks must meet the separation distances and other applicable requirements in ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable.

8.2. SEALED (VAULT) PIT PRIVY

8.2.1. General

A sealed pit privy is an underground vault for the temporary storage of non-water-carried wastewater. The vault must be pumped periodically and the wastewater disposed of at a treatment site.

8.2.2. Construction

8.2.2.1. The vault must be watertight, constructed of durable material, and not subject to excessive corrosion, decay, frost damage, or cracking.

8.2.2.2. The vault may be used in a floodplain or high ground water area provided that the floor surface is 1 foot above the floodplain elevation and the weight of the structure is adequate to prevent the vault from floating during high ground water or a flood even when the vault is empty. The vault must be evaluated for buoyancy by a qualified individual and flotation prevented.

8.2.2.3. The access or pumping port should be located outside of any structure and should have a minimum diameter of 8 inches. This access must have a tight, locking lid.

8.2.2.4. The vault may be a modified septic tank with the inlet and outlet opening sealed. The toilet structure over the tank vault must meet construction standards for a pit privy, as described in Section 8.3.2.

8.2.3. Maintenance and Operation

The vault must be pumped prior to reaching the maximum capacity of the tank by a licensed septic tank pumper and wastewater is disposed of at an approved location.

8.3. UNSEALED PIT PRIVY

8.3.1. General

A pit privy is a building containing a stool, urinal, or seat over an excavation in natural soil for the disposal of undiluted black wastes (toilet wastes). Pit privies may only serve structures that have no pumping fixtures or running water (piped water supply). Pit privies must meet the location requirements of ARM Title 17, Chapter 36, subchapter 3 or 9, as applicable.

8.3.2. Construction

8.3.2.1. Pit privies must be located to exclude surface water.

8.3.2.2. Pit privy buildings must be constructed with openings no greater than 1/16 inch to prohibit access of insects.

8.3.2.3. The pit must be vented with a screened flu or vent stack having a cross-sectional area of at least 7 inches per seat and extending at least 12 inches above the roof of the building.

8.3.2.4. The pit privy must be constructed on a level site with the base of the building being at least 6 inches above the natural ground surface as measured 18 inches from the sides of the building.

8.3.2.5. The bottom of the pit should be between 3 feet and 6 feet below the original ground surface.

8.3.3. Abandoning Pit Privies

8.3.3.1. A pit privy should be abandoned when the waste comes within 16 inches of the ground surface.

8.3.3.2. A pit privy building should be either dismantled or moved to cover a new pit.

8.3.3.3. The abandoned pit must be filled with soil, free of rock, with sufficient fill material to allow for 12 inches or more of settling.

8.4. SEEPAGE PITS

8.4.1. General

Seepage pits may be used for replacement systems only. Seepage pits are excavations in which a subsurface concrete ring(s) is placed in drain rock to receive effluent from the septic tank.

8.4.2. Design

8.4.2.1. Seepage pits must be sized according to the permeability of the vertical stratum where wastewater will contact the soils.

8.4.2.2. A seepage pit that is excavated to a 4-foot depth and a 5-foot diameter must be equivalent to 50 square feet of absorption area.

8.4.2.3. A seepage pit must have a concrete ring with a minimum diameter of 3 feet and a minimum height of 3.5 feet. Concrete rings may be stacked to provide for additional absorption area.

8.4.2.4. The seepage pit must have 6 inches of drain rock meeting the requirements of Section 1.2.25 placed in the bottom of the excavation for bedding.

8.4.2.5. The concrete ring must have a minimum of 1 foot of drain rock meeting the requirements of Section 1.2.25 placed on the outside of the ring. A concrete lid shall be installed on each concrete ring or on the top-most concrete ring if stacked.

8.4.2.6. Schedule 40 piping, or equivalent strength, must be used to connect the septic tank or the distribution box to the concrete ring(s).

8.4.2.7. Drain rock must be covered with an appropriate geotextile fabric, untreated building paper, or straw at least 5 inches in depth.

8.4.2.8. Effluent distribution to multiple seepage pits must use a distribution box.

8.4.2.9. Seepage pits must not be installed in soils that have percolation rates greater than 60 mpi.

8.5. WASTE SEGREGATION

8.5.1. General

Waste segregation systems consist of dry disposal for human waste, such as various biological or composting and incinerator type systems, with separate disposal for gray water.

8.5.2. Location

A complete layout must be provided showing the location of the absorption system and the location of a replacement site with adequate area for a full-size system, if waste segregation is not used, or an alternate approved wastewater treatment system for future development needs.

8.5.3. Design

This Circular addresses the specific requirements relating to the use of composting and incinerating toilets. The reviewing authority may allow the use of other designs and materials pursuant to the review of manufacturer's information and data to substantiate the proposed alternative.

8.5.3.1. Composting Toilets

A. An applicant for a composting toilet must have documentation, or demonstrate through a third independent party, that the unit is able to meet the testing criteria and performance requirements for NSF Standard 41.

B. All materials used must be durable, easily cleanable, and impervious to strong acid or alkaline solutions and corrosive environments.

C. Composting toilets must be used in accordance with the manufacturer's recommendation to serve the anticipated number of persons.

D. The composting unit must be constructed to separate the solid fraction from the liquid fraction and produce a stable humus material with less than 200 most probable number (MPN) per gram of fecal coliform.

E. Bulking agents may be added to provide spaces for aeration and microbial colonization.

F. When operated at the design rated capacity, the device must be capable of accommodating full- or part-time usage.

G. Continuous forced ventilation to the outside (e.g. electric fan or wind-driven turbo vent) of the storage or treatment chamber must be provided. Ventilation components must be independent of other household venting systems. Venting connections must not be made to room vents or to chimneys. All vents must be designed to prevent flies and other insects from entering the treatment chamber. Vent conduits and pipes must be adequately insulated to prevent the formation of interior-condensed vapors.

H. Components in which biological activity is intended to occur must be insulated, heated, or otherwise protected from low temperature conditions.

In order to maintain the stored wastes at temperatures conducive to aerobic biological decomposition, it is recommended that the components maintain a temperature range of 20° C - 55° C (68° F - 130° F). The device must be capable of maintaining wastes within a moisture range of 40 percent to 75 percent.

I. The device must be designed to prevent the deposition of inadequately treated waste near the clean-out port. The solid end product (i.e. waste humus) must be stabilized to meet NSF criteria prior to removal at the clean-out port.
J. Any liquid overflow must be discharged to a disposal field designed and approved in accordance with this Circular.
K. The contents of a composting toilet shall be removed and disposed of in compliance with 40 CFR Part 503 and Title 75, Chapter 10, MCA.
L. The owner of a composting toilet shall maintain the waste disposal system.

8.5.3.2. Incinerating Toilets

A. Incinerating toilets may be electric or gas-fired.
B. An applicant for an incinerating toilet must have documentation, or demonstrate through a third independent party, that the unit is able to meet the testing criteria and performance requirements for NSF Standard 41.
C. Incinerating toilets must be used in accordance with the manufacturer's recommendation to serve the anticipated number of persons.
D. All gas-fired incinerating toilets must be plumbed and installed as per the manufacture's recommendation and local requirements.
E. An anti-foaming agent may be added to incinerating toilets to prevent boil-over of liquid waste.
F. When operated at the design rated capacity, the device must be capable of accommodating full- or part-time usage.
G. The contents of an incinerating toilet must be removed and disposed of in compliance with 40 CFR Part 503 and Title 75, Chapter 10, part 2, MCA.
H. Vapor and products of combustion must be vented. Ventilation components must be independent of other household venting systems.
I. Incinerating toilets must be installed and operated in accordance with local air pollution requirements.
J. The owner of an incinerating toilet shall maintain the waste disposal system.

8.6. EXPERIMENTAL SYSTEMS

8.6.1. General

Treatment systems not listed in this Circular may receive a waiver for use as experimental systems. Experimental systems may be considered only under the following conditions:

8.6.1.1. The applicant shall provide adequate information to the reviewing authority that ensures the system will effectively treat the wastewater in a manner that will prevent ground water contamination and will meet all of the requirements of ARM Title 17, Chapter 36, subchapter 9.

8.6.1.2. The applicant shall include a complete description of a scientific evaluation process to be carried out by a scientific, educational, governmental, or engineering organization.

8.6.1.3. The applicant shall provide for any funding necessary to provide adequate design, installation, monitoring, and maintenance.

8.6.1.4. A professional engineer, sanitarian, or other professional, acceptable to the reviewing authority, shall design the system.

8.6.2. Reviewing Authority

The reviewing authority may place any requirements or restrictions it deems necessary on an experimental system. All requirements for conventional systems must apply to experimental systems, except those specifically exempted by waiver. Applicants shall provide for inspections to be made by persons acceptable to the reviewing authority. Monitoring and inspections must be conducted as required by the reviewing authority. The monitoring and inspection results must be submitted to the reviewing authority. The reviewing authority may require that a redundant system (i.e., a system that meets the requirements of another chapter of this Circular) be installed in parallel with the experimental system.

8.6.3. Seller's Disclosure

Any person who sells a property containing an experimental system shall disclose all permit, monitoring, and maintenance requirements to the buyer.

8.6.4. Maintenance and Operation

8.6.4.1. Continuous maintenance and operation must be provided for the life of the system by a management entity acceptable to the reviewing authority. The type of entity required and the degree of management must be commensurate with the complexity of the system and the site conditions.

8.6.4.2. The management entity shall be responsible for monitoring the operation of the system.

8.6.4.3. Frequent inspections, as determined by the reviewing authority, of the mechanical equipment must be provided during the first 90-day start-up period.

8.6.4.4. The routine inspection schedule must be quarterly at a minimum.

8.6.4.5. Records, both of maintenance and performance, must be kept and made available to the reviewing authority upon request.

8.6.4.6. All manufacturers of experimental systems shall provide an operation and maintenance plan in accordance with Appendix D.

APPENDIX A - PERCOLATION TEST PROCEDURE

Properly conducted percolation tests may be needed to determine absorption system site suitability and to size the absorption system. If needed, percolation tests must be conducted within the boundary of the proposed absorption system. The percolation test must be completed by a qualified site evaluator approved by the reviewing authority. Some system designs may dictate different test procedures than those outlined below. Please see applicable chapters for further requirements.

Procedures outlined in ASTM D5093-02, Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring, may be required in addition to those listed below.

Test Hole Preparation

1. Dig or bore holes 6 to 10 inches in diameter with vertical sides. The depth of the holes must be at the approximate depth of the proposed absorption trenches, typically 24 inches below ground. If the hole is larger than 6 to 8 inches, place a piece of 4-inch diameter, perforated pipe inside the hole, and fill the space between the pipe and the walls of the hole with drain rock. It is recommended that a sketch or photograph of the hole be provided to the reviewing authority.

2. Roughen or scratch the bottoms and sides of the holes to provide natural unsmeared surfaces. Remove loose material. Place about 2 inches of 3/4-inch washed gravel in the bottom of holes to prevent scouring during water addition.

3. Establish a reference point for measurements in or above each hole.

Soaking

1. Fill holes with clear water to a level of at least 12 inches above the gravel.

2. If the soil is coarser than sandy clay loam and the first 12 inches of water seeps away in 60 minutes or less, add 12 inches of water a second time. If the second filling seeps away in 60 minutes or less, the percolation test should be run immediately in accordance with the sandy soil test. If both the first and second fillings have percolation rates faster than 3 mpi, the test may be stopped.

3. If either the soil is sandy clay loam or finer, or the first 12 inches or the second 12 inches does not seep away in 60 minutes, the percolation test must be run in accordance with the test for other soils. In these other soils, maintain at least 12 inches of water in the hole for at least 4 hours to presoak the hole.

Sandy Soils Test (percolation rate of 10 mpi or faster)

This test is applicable to sandy soils only (percolation rate of 10 mpi or faster). Add water to provide a depth of 6 inches above gravel. Measure water level drop at least four times, in equally spaced intervals, in a 1-hour time period. Measure to nearest 1/4 inch. Refill to 6-inch depth after each measurement. Do not exceed 6-inch depth of water. Use final water-level drop to calculate rate.

Other Soils Test (percolation rate slower than 10 mpi)

This test is applicable to other soils (percolation rate slower than 10 mpi). Remove loose material on top of gravel. Add water to provide a depth of 6 inches above gravel. Measure water levels for a minimum of 1 hour. A minimum of 4 measurements must be taken. The test must continue until 2 successive readings yield percolation rates that do not vary by more than 15 percent, or until measurements have been taken for 4 hours. Do not exceed 6-inch depth of water. Use final water-level drop to calculate rate.

Records

Record the following information on the attached form and include as part of the application:

- Date(s) of test(s)
- Location, diameter, and depth of each test hole,
- Time of day that each soak period began and ended
- Time of day for beginning and end of each water-level drop interval
- Each water-level drop measurement
- Calculated percolation rate
- Name and signature of person performing test
- Name of owner or project name.

Rate Calculation

Percolation Rate = Time interval in minutes/water-level drop in inches.

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
PERCOLATION TEST FORM

Owner Name ____

Project Name ____

Lot of Tract Number __________________________ Test Number __________________

Diameter of Test Hole _________________________ Depth of Test Hole _____________

Date and Time Soak Period Began ________________ Ended _______________________

Date Test Began ____

Distance of the reference point above the bottom of the hole ____________________________

Test Results

Start Time of Day	End Time of Day	Time Interval (minutes)	Initial Distance Below Reference Point	Final Distance Below Reference Point	Drop in Water Level (inches)	Percolation Rate (mpi)

I certify that this percolation test was done by a qualified site evaluator in accordance with DEQ-4 Section 1.2.68 and Appendix A.

______________________________ ______________________________ ______________
Name (printed) Signature Date

____
Company

APPENDIX B - SOILS AND SITE CHARACTERIZATION

Accurate description of soil types must be based on information within Appendix B for evaluating the soils in the area of the proposed absorption system to determine if suitable conditions for wastewater treatment and disposal exist. Appendix B provides guidance for reporting soil characteristics using terminology generally accepted by the field of soil science. Application rate for wastewater treatment and disposal is based on soil characteristics using this terminology and the relative proportions of sand, silt and clay within a soil matrix.

Soil Texture

Soil texture refers to the weight proportion of the separates for particles less than 2 mm. Field criteria for estimating soil texture must be chosen to fit the soils of the area. Sand particles feel gritty and can be seen individually with the naked eye. Silt particles cannot be seen individually without magnification. They have a smooth feel to the fingers when dry or wet. In some places, clay soils are sticky, in others, they are not. Soils dominated by montmorillonite clays, for example, feel different than soils that contain similar amounts of micaceous or kaolinitic clay. The reviewing authority may require that field estimates of soil texture be checked against laboratory determinations and adjusted as necessary when soil texture cannot be identified.

Definitions of the soil texture classes according to distribution of size classes of mineral particles less than 2 mm in diameter are as follows:

Sands: 85 percent or more sand and the percentage of silt plus 1.5 times the percentage of clay is 15 or less.

> Coarse sand: 25 percent or more very coarse and coarse sand and less than 50 percent any other single grade of sand.
>
> Sand: 25 percent or more very coarse, coarse, and medium sand, but less than 25 percent very coarse and coarse sand, and less than 50 percent either fine sand or very fine sand.
>
> Fine sand: 50 percent or more fine sand, or less than 25 percent very coarse, coarse, and medium sand, and less than 50 percent very fine sand.
>
> Very fine sand: 50 percent or more very fine sand.

Loamy sands: At the upper limit, 85 to 90 percent sand and the percentage of silt, plus 1.5 times the percentage of clay, is 15 or more. -At the lower limit, 70 to 85 percent sand and the percentage of silt, plus twice the percentage of clay, is 30 or less.

> Loamy coarse sand: 25 percent or more very coarse and coarse sand and less than 50 percent any other single grade of sand.
>
> Loamy sand: 25 percent or more very coarse, coarse, and medium sand, but less than 25 percent very coarse and coarse sand, and less than 50 percent either fine sand or very fine sand.

Loamy fine sand: 50 percent or more fine sand or less than 50 percent very fine sand and less than 25 percent very coarse, coarse, and medium sand.

Loamy very fine sand: 50 percent or more very fine sand.

Sandy loams: 20 percent or less clay and 52 percent or more sand and the percentage of silt, plus twice the percentage of clay, exceeds 30, or less than 7 percent clay, less than 50 percent silt, and between 43 and 52 percent sand.

Coarse sandy loam: 25 percent or more very coarse and coarse sand and less than 50 percent any other single grade of sand.

Sandy loam: 30 percent or more very coarse, coarse, and medium sand, ~~(~~but less than 25 percent very coarse and coarse sand~~)~~, and less than 30 percent either fine sand or very fine sand.

Fine sandy loam: 30 percent or more fine sand and less than 30 percent, or between 15 to 30 percent very coarse, coarse, and medium sand, or more than 40 percent fine and very fine sand, at least half of which is fine sand, and less than 15 percent very coarse, coarse, and medium sand.

Very fine sandy loam: 30 percent or more very fine sand or more than 40 percent fine and very fine sand, at least half of which is very fine sand, and less than 15 percent very coarse, coarse, and medium sand.

Loam: 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Silt loam: 50 percent or more silt and 12 to 27 percent clay or 50 to 80 percent silt and less than 12 percent clay.

Silt: 80 percent or more silt and less than 12 percent clay.

Sandy clay loam: 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

Clay loam: 27 to 40 percent clay and 20 to 45 percent sand.

Silty clay loam: 27 to 40 percent clay and less than 20 percent sand.

Sandy clay: 35 percent or more clay and 45 percent or more sand.

Silty clay: 40 percent or more clay and 40 percent or more silt.

Clay: 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Necessarily, these verbal definitions are somewhat complicated. The texture triangle is used to resolve problems related to word definitions. The eight distinctions in the sand and loamy sand groups provide refinement greater than can be consistently determined by field techniques. Only those distinctions that are significant and that can be consistently made in the field should be applied.

Particle Size Distribution

Particle size distribution (fine earth or less than 2 mm) is determined in the field mainly by feel. The content of rock fragments is determined by estimating the proportion of the soil volume that they occupy.

Soil

The United States Department of Agriculture uses the following size separates for the <2 mm mineral material:

Very coarse sand: 2.0 – 1.0 mm
Coarse sand: 1.0 – 0.5 mm
Medium sand: 0.5 – 0.25 mm
Fine sand: 0.25 – 0.10 mm
Very fine sand: 0.10 – 0.05 mm
Silt: 0.05 – 0.002 mm
Clay: <0.002 mm

The texture classes are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. Subclasses of sand are subdivided into coarse sand, sand, fine sand, and very fine sand. Subclasses of loamy sands and sandy loams that are based on sand size are named similarly.

Rock Fragments

Rock fragments are unattached pieces of rock 2 mm in diameter, or larger, that are strongly cemented or more resistant to rupture. Rock fragments include all sizes that have horizontal dimensions less than the size of a pedon.

Rock fragments are described by size, shape, and, for some, the kind of rock. The classes are pebbles, cobbles, channers, flagstones, stones, and boulders. If a size or range of sizes predominates, the class is modified as, for example: "fine pebbles," "cobbles 100 to 150 mm in diameter," and "channers 25 to 50 mm in length."

Gravel is a collection of pebbles that have diameters ranging from 2 to 75 mm. The terms "pebble" and "cobble" are usually restricted to rounded or subrounded fragments. However, they can be used to describe angular fragments if they are not flat. Words like chert, limestone, and shale refer to a kind of rock, not a piece of rock. The upper size of gravel is 3 inches (75 mm). The 5-mm and 20-mm divisions for the separation of fine, medium, and coarse gravel coincide with the sizes of openings in the "number 4" screen (4.76 mm) and the "3/4-inch" screen (19.05 mm) used in engineering.

The 75-mm (3-inch) limit separates gravel from cobbles. The 250-mm (10-inch) limit separates cobbles from stones and the 600-mm (24-inch) limit separates stones from boulders. The 150-mm (channers) and the 380-mm (flagstones) limits for thin, flat fragments follow conventions used for many years to provide class limits for plate-shaped and crudely spherical rock fragments that have about the same soil use implications as the 250-mm limit for spherical shapes.

Rock Fragments in Soil

The adjectival form of a class name of rock fragments (Appendix B, Table B-1) is used as a modifier of the textural class name: "gravelly loam," and "stony loam." The following classes, based on volume percentages, are used:

> Less than 15 percent: No adjectival or modifying terms are used in writing for contrast with soils having less than 15 percent pebbles, cobbles, or flagstones. The adjective "slightly" may be used, however, to recognize those soils used for special purposes.
>
> 15 to 35 percent: The adjectival term of the dominant kind of rock fragment is used as a modifier of the textural terms: "gravelly loam," "channery loam," and "cobbly loam."
>
> 35 to 60 percent: The adjectival term of the dominant kind of rock fragment is used with the word "very" as a modifier of the textural term: "very gravelly loam" and "very flaggy loam."

More than 60 percent: If enough fine earth is present to determine the textural class (approximately 10 percent or more by volume), the adjectival term of the dominant kind of rock fragment is used with the word "extremely" as a modifier of the textural term: "extremely gravelly loam," and "extremely bouldery loam." If there is too little fine earth to determine the textural class (less than about 10 percent by volume), the terms "gravel," "cobbles," "stones," or "boulders" are used as appropriate.

The class limits apply to the volume of the layer occupied by all pieces of rock larger than 2 mm. The soil generally contains fragments smaller or larger than those identified in the term. For example, a stony loam usually contains pebbles, but "gravelly" is not mentioned in the name. The use of a term for larger pieces of rock, such as boulders does not imply that the pieces are entirely within a given soil layer. A simple boulder may extend through several layers.

Table B-1
Terms for Rock Fragments

Shape and size	Noun	Adjective
Spherical, cubelike, or equiaxial:		
2-75 mm diameter	Pebbles	Gravelly
2-5 mm diameter	Fine	Fine gravelly
5-20 mm diameter	Medium	Medium gravelly
20-75 mm diameter	Coarse	Coarse gravelly
75-250 mm diameter	Cobbles	Cobbly
250-600 mm diameter	Stones	Stony
> 600 mm diameter	Boulders	Bouldery
Flat:		
2-150 mm long	Channers	Channery
150-380 mm long	Flagstones	Flaggy
380-600 mm long	Stones	Stony
> 600 mm long	Boulders	Bouldery

Table B-2
Classes of Surface Stones and Boulders in Terms of Cover and Spacing

Class	Percentage of surface covered	Distance in meters between stones or boulders if the diameter is:			Name
		0.25m	0.6m	1.2m	
1	0.01 - 0.1	>8	>20	>37	Stony or bouldery
2	0.1 - 3.0	1 - 8	3 - 20	6 - 37	Very stony or very bouldery
3	3.0 - 15	0.5 - 1	1 - 3	2 - 6	Extremely stony or extremely bouldery
4	15 - 50	0.3 - 0.5	0.5 - 1	1 - 2	Rubbly
5	50 - 90	<0.3	<0.05 - 1	<1	Very rubbly

Soil Color

Elements of soil color descriptions are the color name, the Munsell notation, the water state, and the physical state: "brown (10YR 5/3), dry, crushed, and smoothed."

Physical state is recorded as broken, rubbed, crushed, or crushed and smoothed. The term "crushed" usually applies to dry samples and "rubbed" to moist samples. If unspecified, the surface is broken. The color of the soil is recorded for a surface broken through a ped, if a ped can be broken as a unit.

The color value of most soil material becomes lower after moistening. Consequently, the water state of a sample is always given. The water state is either "moist" or "dry." The dry state for color determinations is air-dry and should be made at the point where the color does not change with additional drying. Color in the moist state is determined on moderately moist or very moist soil material and should be made at the point where the color does not change with additional moistening. The soil should not be moistened to the extent that glistening takes place, as color determinations of wet soil may be in error because of the light reflection of water films.

Munsell notation is obtained by comparison with a Munsell system color chart. The most commonly used chart includes only about 1/5 of the entire range of hues. It consists of about 250 different colored papers, or chips, systematically arranged on hue cards according to their Munsell notations.

The Munsell color system uses 3 elements of color – hue, value, and chroma – to make up a color notation. The notation is recorded in the form: hue, value/chroma – for example, 5Y 6/3.

Hue is a measure of the chromatic composition of light that reaches the eye. The Munsell system is based on five principle hues: red (R), yellow (Y), green (G), blue (B), and purple (P). Five intermediate hues representing midpoints between each pair of principle hues complete the 10 major hue names used to describe the notation. The intermediate hues are yellow-red (YR), green-yellow (GY), blue-green (BG), purple-blue (PB), and red-purple (RP).

Value indicates the degree of lightness or darkness of a color in relation to a neutral gray scale. On a neutral gray (achromatic) scale, value extends from pure black (0/) to pure white (10/). The value notation is a measure of the amount of light that reaches the eye under standard lighting conditions.

Chroma is the relative purity or strength of the spectral color. Chroma indicates the degree of saturation of neutral gray by the spectral color. The scales of chroma for soils extend from /0 to a chroma of /8 as the strongest expression of color used for soils.

Conditions for Measuring Color

The quality and intensity of the light affect the amount and quality of the light reflected from the sample to the eye. The moisture content of the sample and the roughness of its surface affect the light reflected. The visual impression of color from the standard color chips is accurate only under standard conditions of light intensity and quality. Color determination may be inaccurate early in the morning or late in the evening. When the sun is low in the sky or the atmosphere is smoky, the light reaching the sample and the light reflected is redder. Even though the same kind of light reaches the color standard and the sample, the reading of sample color at these times is commonly one or more intervals of hue redder than at midday. Colors also appear different in the subdued light of a cloudy day than in bright sunlight. If artificial light is used, as for color determinations in an office, the light source used must be as near the white light of midday as possible. With practice, compensation can be made for the differences, unless the light is so subdued that the distinctions between color chips are not apparent. The intensity of incidental light is especially critical when matching soil to chips of low chroma and low value.

Roughness of the reflecting surface affects the amount of reflected light, especially if the incidental light falls at an acute angle. The incidental light should be as nearly as possible at a right angle. For crushed samples, the surface is smoothed and the state is recorded as "dry, crushed, and smoothed."

Recording Guidelines

Uncertainty exists under field conditions. Measurements of color are reproducible by different individuals within 2.5 units of hue (1 card) and 1 unit of value and chroma.

Dominant color is the color that occupies the greatest volume of the layer. Dominant color (or colors) is always given first among those of a multicolored layer. It is judged on the basis of colors of a broken sample. For only 2 colors, the dominant color makes up more than 50 percent of the volume. For 3 or more colors, the dominant color makes up more of the volume of the layer than any other color, although it may occupy less than 50 percent.

Mottling refers to repetitive color changes that cannot be associated with compositional properties of the soil. Redoximorphic features are a type of mottling that is associated with wetness. A color pattern that can be related to the proximity to a ped surface of other organizational or compositional feature is not mottling. Mottle description follows the dominant color. Mottles are described by quantity, contrast, color, and other attributes in that order.

Quantity is indicated by three areal percentage classes of the observed surface:

Few: less than 2 percent
Common: 2 to 20 percent
Many: more than 20 percent

The notations must clearly indicate to which colors the terms for quantity apply.

Size refers to dimensions as seen on a plane surface. If the length of a mottle is not more than 2 or 3 times the width, the dimension recorded is the greater of the 2. If the mottle is long and narrow, as a band of color at the periphery of a ped, the dimension recorded is the smaller of the 2 and the shape and location are also described. Three size classes are used:

Fine: smaller than 5 mm
Medium: 5 to 15 mm

Coarse: larger than 15 mm

Contrast refers to the degree of visual distinction that is evident between associated colors:

Faint: Evident only on close examination, faint mottles commonly have the same hue as the color to which they are compared and differ by no more than 1 unit of chroma or 2 units of value. Some faint mottles of similar but low chroma and value differ by 2.5 units (one card) of hue.

Distinct: Readily seen but contrast only moderately with the color to which they are compared. Distinct mottles commonly have the same hue as the color at which they are compared, but differ by 2 to 4 units of chroma or 3 to 4 units of value, or differ from the color to which they are compared by 2 units (1 card) of hue, but by no more than 1 unit of chroma or 2 units of value.

Prominent: Contrast strongly with the color to which they are compared. Prominent mottles are commonly the most obvious color feature of the section described. Prominent mottles that have medium chroma and value commonly differ from the color to which they are compared by at least 5 units (two pages) of hue, if chroma and value are the same, at least 4 units of value or chroma, if the hue is the same, or at least 2 units of chroma or 2 units of value, if hue differs by 2.5 units (one card).

Contrast is often not a simple comparison of one color with another, but is a visual impression of the prominence of the one color against a background, commonly involving several colors.

Soil Structure

Soil structure refers to units composed of primary particles. The cohesion within these units is greater than the adhesion among units. As a consequence, under stress, the soil mass tends to rupture along predetermined planes or zones. Three planes or zones, in turn, form the boundary. A structural unit that is the consequence of soil development is called a ped. The surfaces of peds persist through cycles of wetting and drying in place. Commonly, the surface of the ped and its interior differ as to composition or organization, or both, because of soil development.

Some soils lack structure and are referred to as structureless. In structureless layers or horizons, no units are observable in place or after the soil has been gently disturbed, such as by tapping a space containing a slice of soil against a hard surface or by dropping a large fragment on the ground. When structureless soils are ruptured, soil fragments, single grains, or both, result. Structureless soil material may be either single grain or massive. Soil material of single grains lacks structure. In addition, it is loose. On rupture, more than 50 percent of the mass consists of discrete mineral particles.

Some soils have simple structure, each unit being an entity without component smaller units. Others have compound structure, in which large units are composed of smaller units separated by persistent planes of weakness.

In soils that have structure, the shape, size, and grade (distinctness) of the units are described.

Field terminology for soil structure consists of separate sets of terms designating each of the 3 properties, which by combination form the names for structure.

Shape

Several basic shapes of structural units are recognized in soils:

> *Platy:* The units are flat and platelike. They are generally oriented horizontally. A special form, lenticular platy structure, is recognized for plates that are thickest in the middle and thin toward the edges.
>
> *Prismatic*: The individual units are bounded by flat to rounded vertical faces. Units are distinctly longer vertically and the faces are typically casts or molds of adjoining units. Vertices are angular or subrounded. The tops of prisms are somewhat indistinct and normally flat.
>
> *Columnar:* The units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns, in contrast to those prisms, are very distinct and normally rounded.
>
> *Blocky:* The units are block like or polyhedral. They are bounded by flat or slightly rounded surfaces that are casts of the faces of surrounding peds. Typically, blocky structural units are nearly equidimensional but grade to prisms and to plates. The structure is described as angular blocky if the faces intersect at relatively sharp angles. The structure is described as subangular blocky if the faces are a mixture of rounded and plane faces and the corners are mostly rounded.
>
> *Granular*: The units are approximately spherical or polyhedral and are bounded by curved or very irregular faces that are not casts of adjoining peds.

Size

Five classes are employed: very fine, fine, medium, coarse, and very coarse. The size limits differ according to the shape of the units. The size limit classes are given in Appendix B, Table B-3. The size limits refer to the smallest dimension of plates, prisms, and columns.

Table B-3
Size Classes of Soil Structure

	Shape of Structure			
Size Classes	Platy[1] mm	Prismatic & Columnar mm	Blocky mm	Granular mm
Very Fine	<1	<10	<5	<1
Fine	1 – 2	10 – 20	5 – 10	1 – 2
Medium	2 – 5	20 – 50	10 – 20	2 – 5
Coarse	5 – 10	50 – 100	20 – 50	5 – 10
Very Coarse	>10	>100	>50	>10

[1] In describing plates, "thin" is used instead of "fine" and "thick" instead of "coarse."

Grade

Grade describes the distinctness of units. Criteria are the ease of separation into discrete units and the proportion of units that hold together when the soil is handled. Three classes are used:

> *Weak*: The units are barely observable in place. When gently disturbed, the soil material parts into a mixture of whole and broken units and much material that exhibits no planes of weakness. Faces that indicate persistence through wet-dry-wet cycles are evident if the soil is handled carefully. Distinguishing structurelessness from weak structure is sometimes difficult. Weakly expressed structural units in virtually all soil materials have surfaces that differ in some way from the interiors.
>
> *Moderate:* The units are well formed and evident in undisturbed soil. When disturbed, the soil material parts into a mixture of mostly whole units, some broken units, and material that is not in units. Peds part from adjoining peds to reveal nearly entire faces that have properties distinct from those of fractured surfaces.
>
> *Strong:* The units are distinct in undisturbed soil. They separate cleanly when the soil is disturbed. When removed, the soil material separates mainly into whole units. Peds have distinctive surface properties.

Three terms for soil structure are combined in order (1) grade, (2) size, (3) shape. "Strong fine granular structure" is used to describe a soil that separates almost entirely into discrete units that are loosely packed, roughly spherical, and mostly between 1 and 2 mm in diameter.

Compound Structure

Smaller structural units may be held together to form larger units. Grade, size, and shape are given for both, and the relationship of one set to the other is indicated: "strong medium blocks within moderate coarse prisms" or "moderate coarse prismatic structure parting to strong medium blocky."

Concentrations

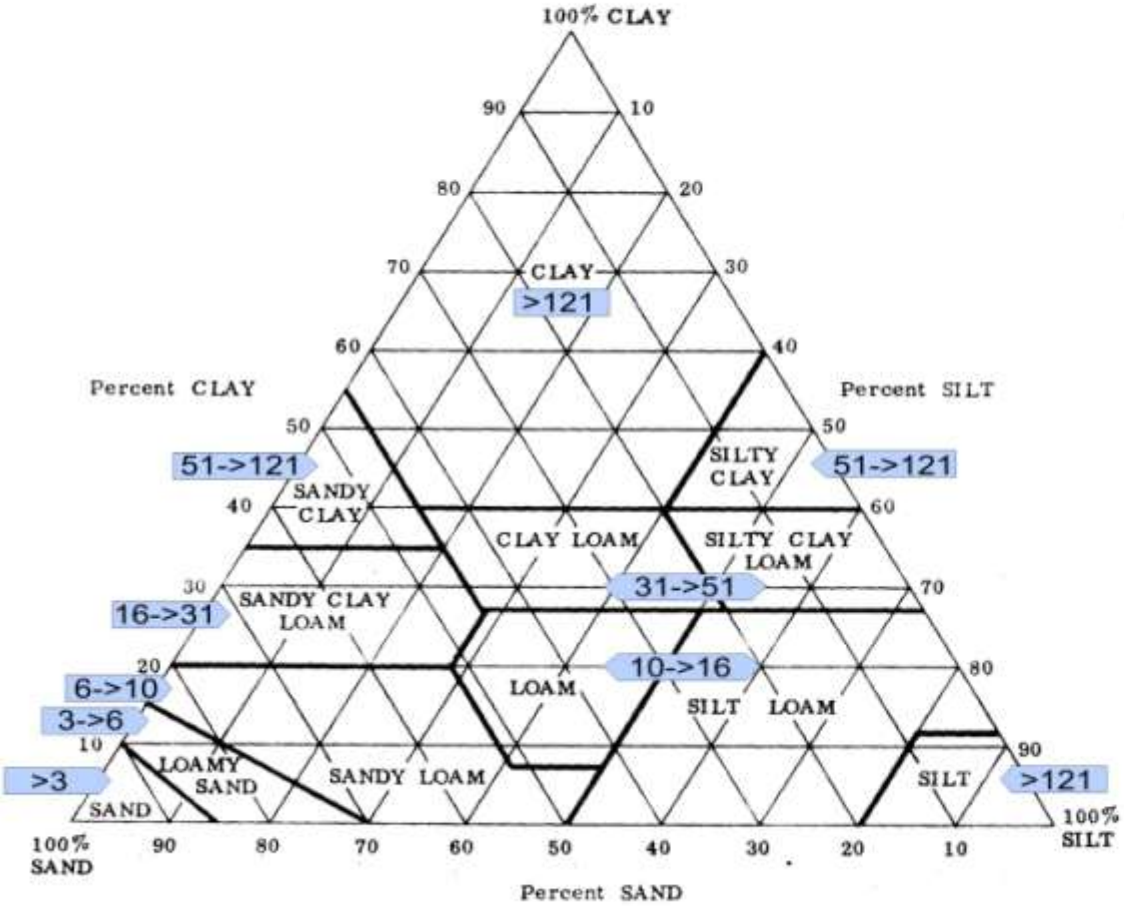
The features discussed here are identifiable bodies within the soil that were formed by pedogenesis. Some of these bodies are thin and sheetlike, some are nearly equidimensional, and others have irregular shapes. They may contrast sharply with the surrounding material in strength, composition, or internal organization. Masses are non-cemented concentrations of substances that commonly cannot be removed from the soil as a discrete unit. Most accumulations consist of calcium carbonate, fine crystals of gypsum or more soluble salts, or iron and manganese oxides. Except for very unusual conditions, masses have formed in place.

Nodules and concretions are cemented bodies that can be removed from the soil intact. Composition ranges from material dominantly like that of the surrounding soil to nearly pure chemical substances entirely different from the surrounding material.

Concretions are distinguished from nodules on the basis of internal organization. Concretions have crude internal symmetry organized around a point, a line, or a plane. Nodules lack evident, orderly internal organization.

Textural Triangle

Soil Percolation Rate min/in



APPENDIX C - GROUND WATER OBSERVATION WELL INSTALLATION AND MEASURING PROCEDURES

Observation Schedule

Observation must be done during the time when ground water levels are highest. This is typically during spring runoff or during the irrigation period, but may also be at some other time during the year. Observation must be done weekly or more frequently during the appropriate periods of suspected high ground water. Observation must include at least two weeks of observation prior to and after the ground water peak, otherwise the reviewing authority may reject the results. The applicant is encouraged to consult with the state and/or county before installing wells. The monitoring of the observation well must be completed by a qualified site evaluator as defined in Section 1.2.68 approved by the reviewing authority.

Surface water levels may be indicative of the ground water levels that may peak several weeks after spring runoff and irrigation seasons.

Local conditions may indicate that there is more than one geologic horizon that can become seasonally saturated. This may require observation wells to be installed at different horizons. The well should be placed in, but not extended through, the horizon that is to be monitored.

The reviewing authority may refuse to accept seasonal high ground water data when the total precipitation for the previous year, defined as May 1 of the previous year to April 30 of the current year, of April 1 snowpack equivalent, measured at the nearest officially recognized observation station, is more than 25 percent below the 30-year historical average. This is based upon the definition of drought conditions created by the National Drought Mitigation Center. The reviewing authority may consider soil morphology and data from nearby ground water observation sites with similar soil, geology, and proximity to streams or irrigation ditches, if available, to determine maximum ground water elevation during periods of drought.

Where to Install

The observation well(s) must be installed within 25 feet of the proposed absorption trench and on the same elevation. The reviewing authority may require the placement of the well(s) in an exact location. Additional observation wells may be required if the recommended observation sites show ground water higher than 6 feet below the ground surface.

Installation Process

The observation well must be installed vertically into a dug or drilled hole.

A slotted water well pipe should be used that is 2 to 4 inches in diameter and 10 feet long.

A. Slotted pipe (PVC is the most common material) with slot sizes between 40 and 100 (i.e. slot widths between 0.04 and 0.10 inches wide) is suggested. Slots should be horizontal and spaced at intervals less than or equal to 0.5 inches.
B. Check with the reviewing authority to determine if an alternate well material is

acceptable.

The pipe should be perforated from 1 foot below the ground surface to 8 feet below the ground surface unless multiple horizons exist.

The casing must be unperforated 1 foot below the ground surface to the top of the observation well. The well must extend at least 2 feet above the ground surface.

The top of the observation well must be sealed with a watertight cap.

The area around the well must be backfilled with native material to 1 foot below the ground surface.

The observation well must be sealed in such a manner that prevents surface runoff from running along the outside of the well casing. The well should be sealed from 1 foot below the ground surface to slightly above grade to allow for subsidence and to maintain a positive ground slope away from well casing. The material used to seal the well can be either fine-grained material or bentonite.

Each observation well should be flagged to facilitate locating the well and labeled with the lot number, location, and subdivision name.

Measuring Procedures

Lower a measuring tape or stick to the water level and measure the distance from the water level to the top of the pipe (see example on next page). Water levels should be measured to the nearest inch. A plunking device or electronic water sensor can also be used. Data should be submitted in a similar form to that of the example.

Measure the distance from the top of the pipe to the natural ground surface (B distance) (see example). Then measure the distance from the top of the pipe to the water level (A distance) (see example). Subtract B from A. This value equals the actual separation between the water table and the natural ground surface.

Decommissioning

The applicant should consult with the reviewing authority before decommissioning observation wells.

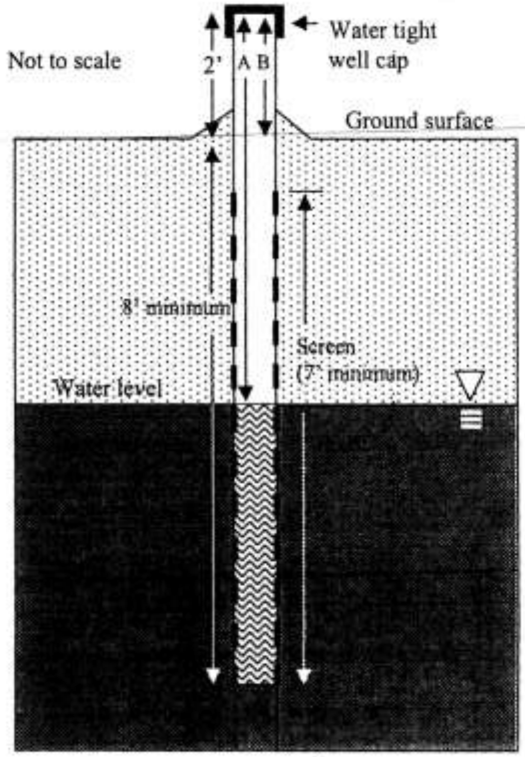
Ground Water Observation Results
Monitored By:
Location :
Section __________ Township_________ Range______ Lot #______
Observation Well # ________

Other Location Information:

Date	Time	A (inches)	B (inches)	A-B (inches)

A= Distance to top of casing to the ground water level in pipe (inches).
Note: If the observation pipe is dry, enter the total depth measured and "dry" in this column.
B= Distance from top of casing to the natural ground surface (inches).

Ground Water Observation Well Design



APPENDIX D - OPERATION AND MAINTENANCE PLAN

Continued service and maintenance of the wastewater system must be addressed for the life of the system by an approved operation and maintenance plan.

The owner of the residence or facility is responsible for assuring proper operation and providing timely maintenance of the system. A copy of the approved operation and maintenance plan must be given to the local health department for their files. Some health departments may require that this document be presented in electronic format. If observations reveal a system failure, absorption trench failure, or history of effluent ponding within the absorption trench, the owner of the system must take appropriate action. Notification to the local health department and, if appropriate, the service provider must be made within two business days if any unit of the system fails to function properly.

The reviewing authority will consider the complexity and maintenance required of the system along with the stability of the processes in determining the adequacy, level of maintenance, and monitoring frequency of the system. The monitoring frequency should be sufficient to establish the treatment efficiency and response to varying wastewater flows, strengths, and climatic condition.

The operation and maintenance plan must include: an owner's manual, a system installation manual, an operation and maintenance manual, and as-built plans with the name of the designer and installer.

Certification and As-builts
The following wastewater treatment systems require certification and as-builts:

Public Wastewater Systems, regardless of type, in accordance with ARM 17.38.101
Cut, Fill, and Artificially Drained Systems
Drainfields that serve 10 or More Living Units
High Strength Wastewater Treatment Systems
Alternative Wastewater Collection Systems
Raw Wastewater Pumping Stations
Elevated Sand Mounds
Evapotranspiration Absorption and Evapotranspiration Systems
Gray Water Irrigation Systems
Intermittent Sand Filters
Recirculating Sand Filters
Aerobic Wastewater Treatment Units
Chemical Nutrient Reduction Systems
Alternate Advanced Treatment Systems

The wastewater system owner may not commence or continue the operation of the wastewater systems listed above, or any portion of such system, prior to certifying by letter to the reviewing authority that the system, or portion of the system constructed, altered, or extended to that date, was completed in accordance with plans and specifications approved by the reviewing authority. Within 90 days after the completion of construction, alteration, or extension of the wastewater systems listed above, or any portion of such system, a complete set of certified "as-built" drawings must be signed and submitted to the reviewing authority.

Owner's Manual

A comprehensive owner's manual must be submitted to the reviewing authority and include:

A. A clear statement providing examples of the types of waste that can be effectively treated by the system;
B. Requirements for periodic removal of residuals from the system. The septic tank, grease trap, or other settling tanks should be pumped as specified by the manufacturer;
C. A course of action to be applied if the system will be used intermittently or if extended periods of non-use are anticipated;
D. The name and telephone number of a service representative, pumpers, and the local health department to be contacted in the event that the system experiences a problem; and
E. Description of the initial and extended service policies.

Installation Manual

A comprehensive installation manual must be submitted to the reviewing authority and include:

A. A numbered parts list of system components with accompanying illustrations, photographs, or prints in which the components are respectively identified;

B. Design, construction, and material specifications for the system's components;

C. Schematic drawings of the system's electrical components;

D. A process overview explaining the function of each component and a description of how the entire system functions when all components are properly assembled and connected;

E. A clear description of installation requirements for, but not limited to, plumbing, electrical power, ventilation, air intake protection, bedding, hydrostatic displacement protection (floating in high ground water conditions), watertightness, slope, and miscellaneous fittings and appurtenances;

F. A sequential installation procedure from the residence out to the effluent discharge connection; and

G. A detailed start-up procedure.

Operations and Maintenance Manual

Comprehensive instruction in the operation and maintenance of the system must be provided to the reviewing authority and must include:

A. Maintenance procedures and schedules for all components;

B. Requirements and recommended procedures for periodic removal of residuals from the system;

C. A detailed procedure for visually evaluating function of system components; and

D. Safety concerns that may need to be addressed.

As-built Plans

A comprehensive set of as-built plans must be submitted to the reviewing authority and include the name of the designer and installer. As-builts will be added to the operation and maintenance plan after initial approval and construction of the system.

Proprietary and High Strength Wastewater Treatment Systems

In addition to the requirements of this Appendix, all proprietary and high strength wastewater treatment systems must have both an initial and a renewed service contract for the life of the system. Service contracts must include:

A. Owner's name and address;

B. Property address and legal description;

C. Local health department permit requirements;

D. Detail of service to be provided. The owner must be notified, in writing, about any improper system function that cannot be remedied during the time of inspection, and an estimate for the date of correction;

E. Schedule of service provider duties. Initial 2-year service policies must stipulate a minimum of 4 inspection/service visits, scheduled at least once every 6 months over the 2-year period, during which electrical, mechanical, and other components are inspected, adjusted, and serviced;

F. Cost and length of service contract/time period;

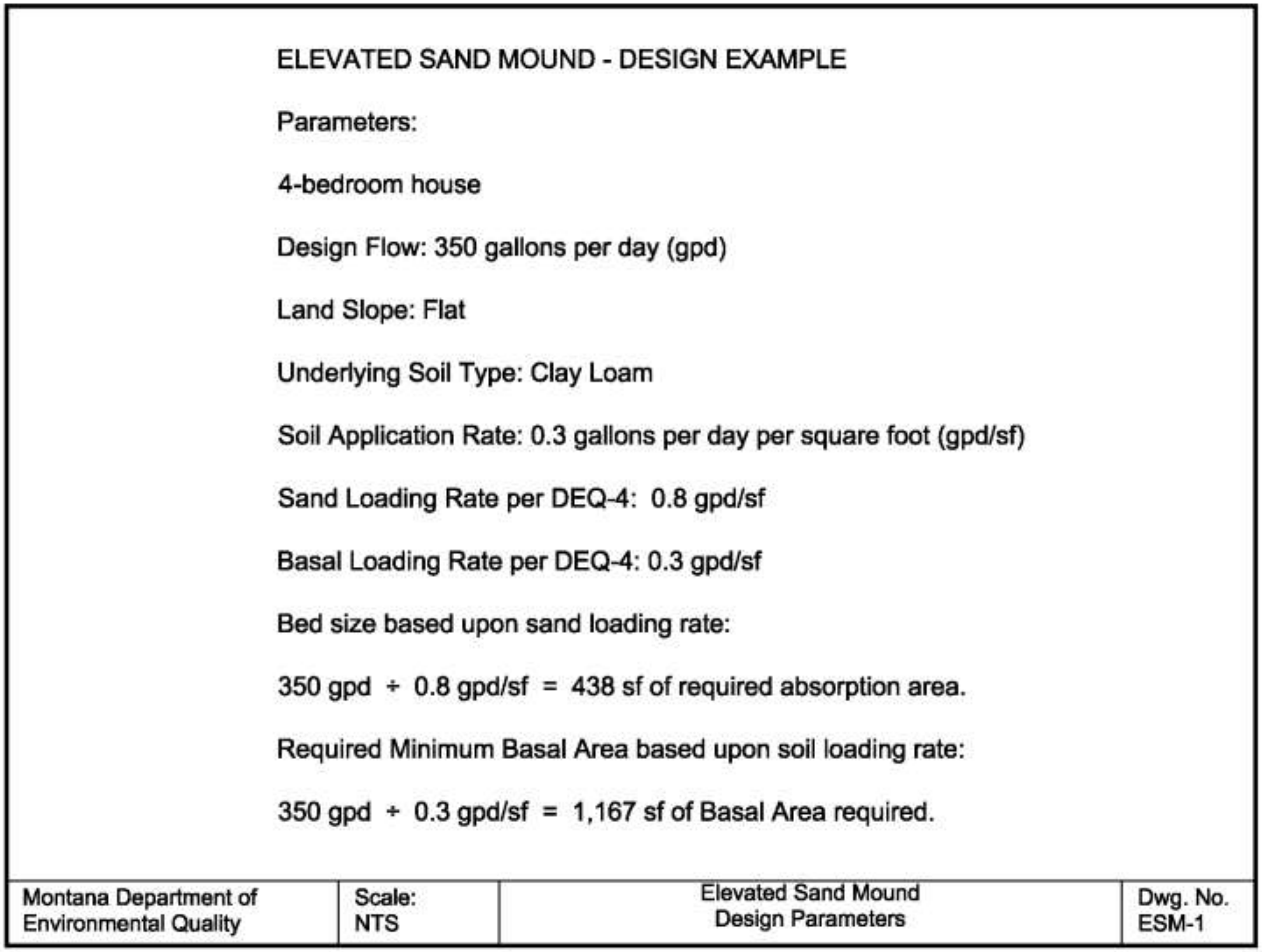
G. Details of product warranty; and

H. Owner's responsibilities.

For subsurface wastewater treatment systems, classified under ARM 17.30.718 as Level 1a, Level 1b, or Level 2 for nutrient reduction, the system vendor or manufacturer must offer an operation and maintenance plan that meets the requirements of this Appendix and ARM 17.30.718.

APPENDIX E - DESIGN EXAMPLES

ESM - Elevated Sand Mound Example



ELEVATED SAND MOUND - DESIGN EXAMPLE

Parameters:

4-bedroom house

Design Flow: 350 gallons per day (gpd)

Land Slope: Flat

Underlying Soil Type: Clay Loam

Soil Application Rate: 0.3 gallons per day per square foot (gpd/sf)

Sand Loading Rate per DEQ-4: 0.8 gpd/sf

Basal Loading Rate per DEQ-4: 0.3 gpd/sf

Bed size based upon sand loading rate:

350 gpd ÷ 0.8 gpd/sf = 438 sf of required absorption area.

Required Minimum Basal Area based upon soil loading rate:

350 gpd ÷ 0.3 gpd/sf = 1,167 sf of Basal Area required.

Montana Department of Environmental Quality	Scale: NTS	Elevated Sand Mound Design Parameters	Dwg. No. ESM-1

BED DESIGN

438 sf of bed required.

§6.6.3.7 requires a minimum 3:1 ratio of length to width.

Let "x" = width, then "3x = length

Thus:

$3x^2 = 438$

$x = \sqrt{438/3}$

x = 12.08' ; 3x = 32.25'

Round to 12.5' x 37.5' so §6.6.3.7 is still met.

Check Basal Area Requirements:

Overall Width of Mound:

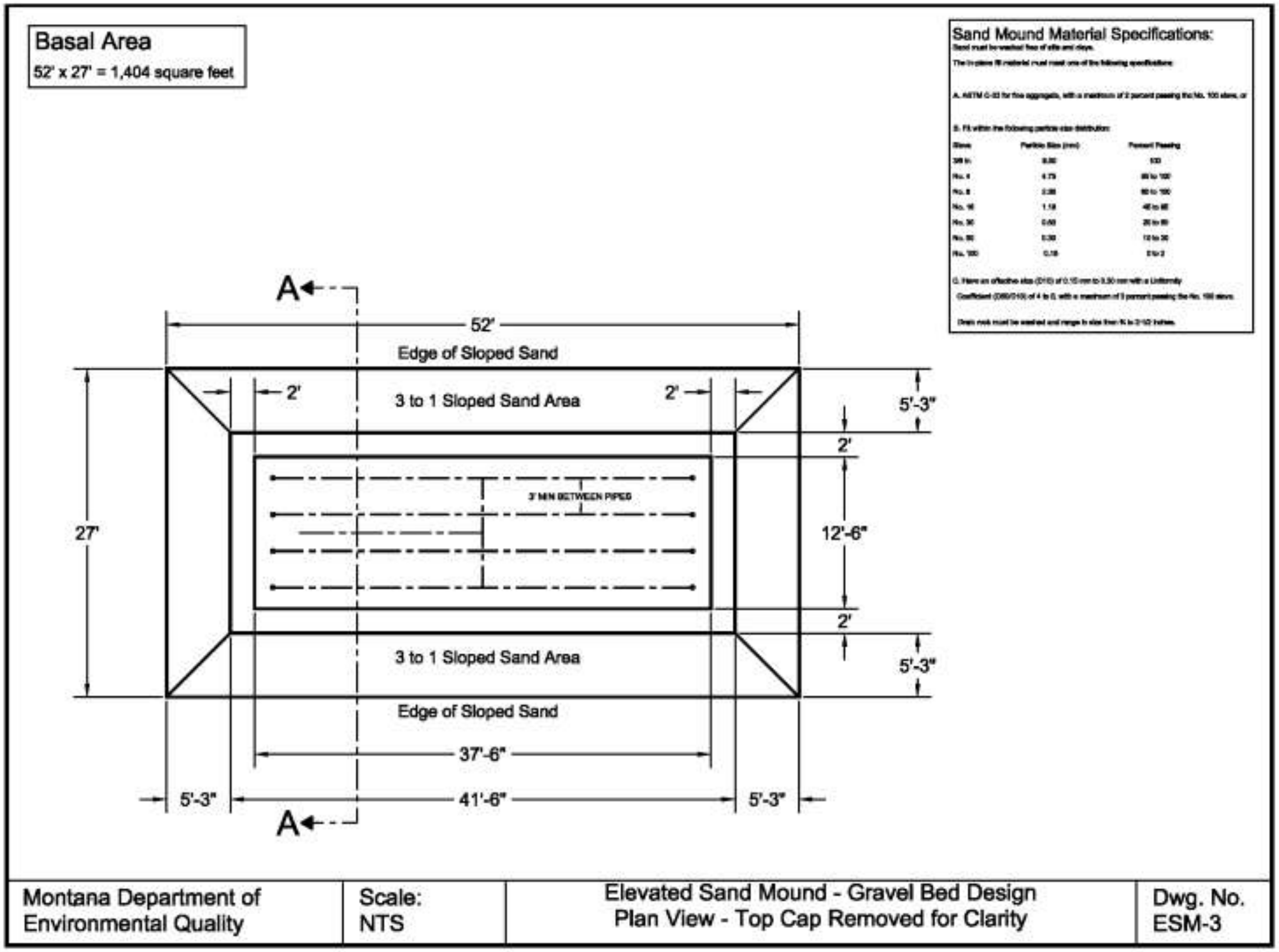
5.25' + 2' + 12.5' + 2' + 5.25' = 27'

Overall Length of Mound:

5.25' + 2' + 37.5' + 2' + 5.25' = 52'

52' x 27' = 1,404 sf > 1,167 sf so §6.6.3.3 requirement met

Montana Department of Environmental Quality	Scale: NTS	Elevated Sand Mound Gravel Bed Design Parameters	Dwg. No. ESM-2


Basal Area
52' x 27' = 1,404 square feet
Sand Mound Material Specifications:
A
A
52'
Edge of Sloped Sand
2'
3 to 1 Sloped Sand Area
2'
5'-3"
2'
3' MIN BETWEEN PIPES
27'
12'-6"
2'
3 to 1 Sloped Sand Area
5'-3"
Edge of Sloped Sand
37'-6"
5'-3"
41'-6"
5'-3"
Montana Department of Environmental Quality
Scale: NTS
Elevated Sand Mound - Gravel Bed Design
Plan View - Top Cap Removed for Clarity
Dwg. No. ESM-3

Sand Mound Material Specifications:

Sand must be washed free of silts and clays.

The in-place fill material must meet one of the following specifications:

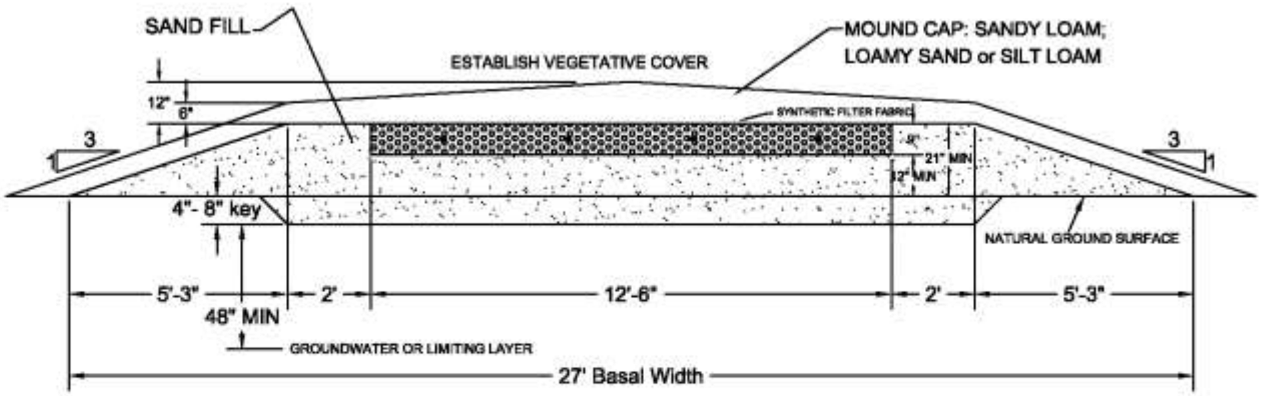
A. ASTM C-33 for fine aggregate, with a maximum of 2 percent passing the No. 100 sieve, or

B. Fit within the following particle size distribution:

Sieve	Particle Size (mm)	Percent Passing
3/8 in	9.50	100
No. 4	4.75	95 to 100
No. 8	2.36	80 to 100
No. 16	1.18	45 to 85
No. 30	0.60	20 to 50
No. 50	0.30	10 to 30
No. 100	0.15	0 to 2

C. Have an effective size (D10) of 0.15 mm to 0.30 mm with a Uniformity Coefficient (D60/D10) of 4 to 6, with a maximum of 3 percent passing the No. 100 sieve.

Drain rock must be washed and range in size from ¾ to 2-1/2 inches.



Montana Department of Environmental Quality	Scale: NTS	Elevated Sand Mound - Bed Design Section A-A View	Dwg. No. ESM-4

LEECHING BED DESIGN

438 sf of bed required.

§6.6.3.7 requires a minimum 3:1 ratio of length to width.

Let "x" = width, then "3x = length

Thus:

$3x^2 = 438$

$x = \sqrt{438/3}$

x = 12.08' ; 3x = 32.25'

Round to 15' x 36' for standard 3' wide x 4' long chambers: §6.6.3.7 is met.

Check Basal Area Requirements:

Overall Width of Mound:

6' + 2' + 15' + 2' + 6' = 31'

Overall Length of Mound:

6' + 2' + 36' + 2' + 6' = 52'

52' x 31' = 1,612 sf > 1,167 sf so §6.6.3.3 requirement met

Montana Department of Environmental Quality	Scale: 1" = 1' - 0"	Elevated Sand Mound Leeching Chamber Bed Design Parameters	Dwg. No. ESM-5

Basal Area

52' x 31' = 1,612 square feet

Sand Mound Material Specifications:

Sand must be washed free of silts and clays.

The in-place fill material must meet one of the following specifications:

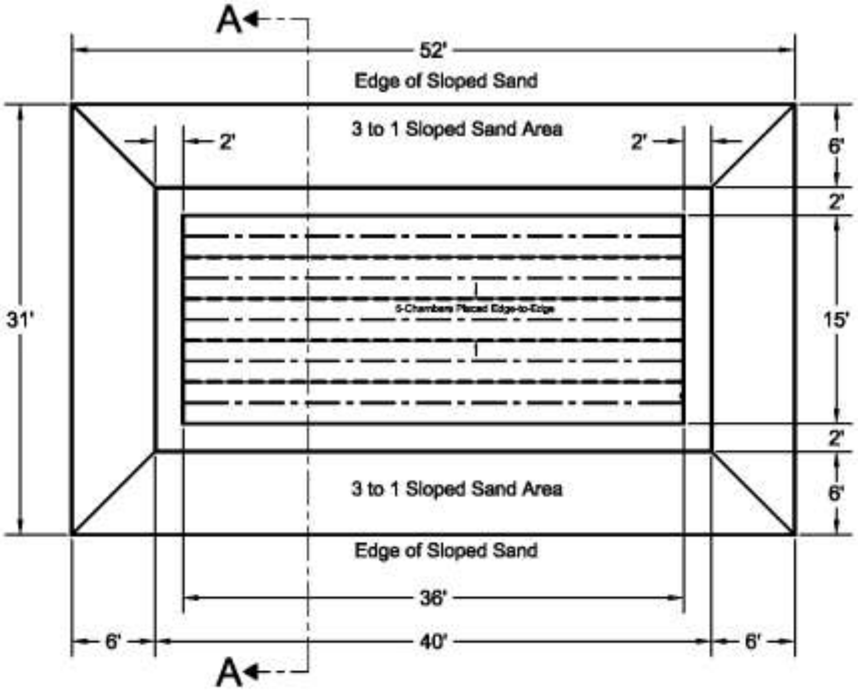
A. ASTM C-33 for fine aggregate, with a maximum of 2 percent passing the No. 100 sieve, or

B. Fit within the following particle-size distribution:

Sieve	Particle Size (mm)	Percent Passing
3/8 in	9.50	100
No. 4	4.75	95 to 100
No. 8	2.36	80 to 100
No. 16	1.18	45 to 85
No. 30	0.60	25 to 60
No. 50	0.30	10 to 30
No. 100	0.15	0 to 2

C. Have an effective size (D10) of 0.15 mm to 0.30 mm with a Uniformity Coefficient (D60/D10) of 4 to 6, with a maximum of 3 percent passing the No. 100 sieve.

Drain rock must be washed and range in size from ¾ to 2-1/2 inches.



Montana Department of Environmental Quality	Scale: NTS	Elevated Sand Mound - Bed Design with Leaching Chambers Plan View - Top Cap Removed for Clarity	Dwg. No. ESM-6

Sand Mound Material Specifications:

Sand must be washed free of silts and clays.

The in-place fill material must meet one of the following specifications:

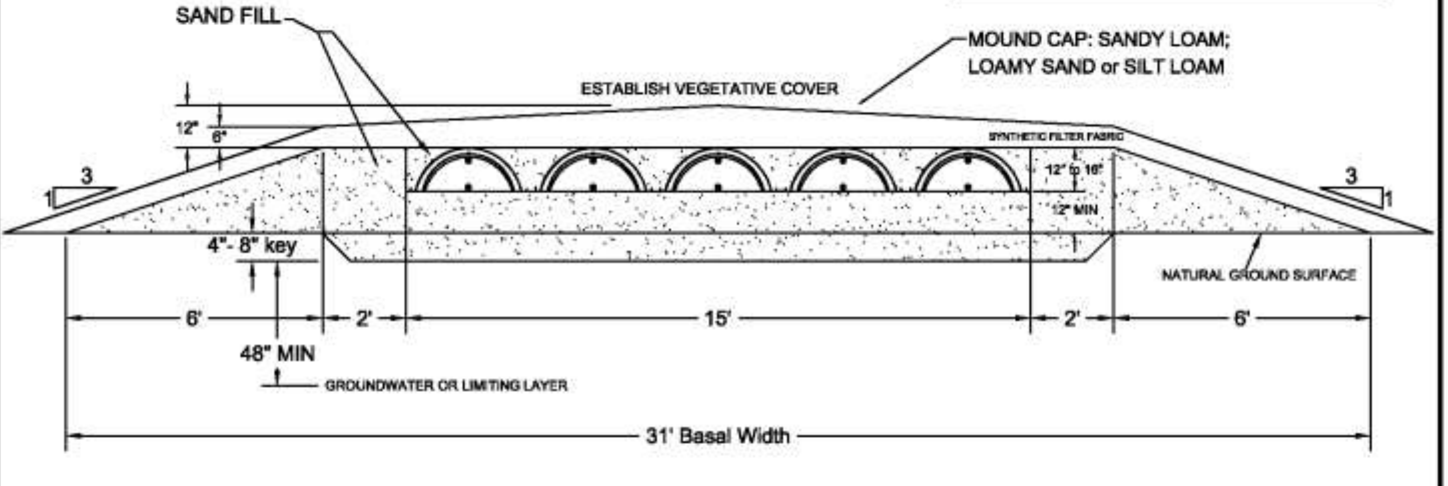
A. ASTM C-33 for fine aggregate, with a maximum of 2 percent passing the No. 100 sieve, or

B. Fit within the following particle size distribution:

Sieve	Particle Size (mm)	Percent Passing
3/8 in	9.50	100
No. 4	4.75	95 to 100
No. 8	2.36	80 to 100
No. 16	1.18	45 to 85
No. 30	0.60	20 to 60
No. 50	0.30	10 to 30
No. 100	0.15	0 to 2

C. Have an effective size (D10) of 0.15 mm to 0.30 mm with a Uniformity Coefficient (D60/D10) of 4 to 6, with a maximum of 3 percent passing the No. 100 sieve.

Drain rock must be washed and range in size from ¾ to 2-1/2 inches.



Montana Department of Environmental Quality	Scale: NTS	Elevated Sand Mound - Leaching Chamber Trench Design Section A-A View	Dwg. No. ESM-7

ETA Evapotranspiration Absorption System Example

EVAPOTRANSPIRATION ABSORPTION SYSTEM - DESIGN EXAMPLE

Parameters: 4-bedroom house near Terry; design flow 350 gallons per day (gpd)

Land Slope: Flat; Underlying Soil Type: Clay

Soil Application Rate Based Upon Percolation Test: 0.15 gpd/sf (Section 6.7.3.5)

Bed Material Void Ratio 40 %

Required Factor of Safety: 1.5 (per Section 6.7.3.7)

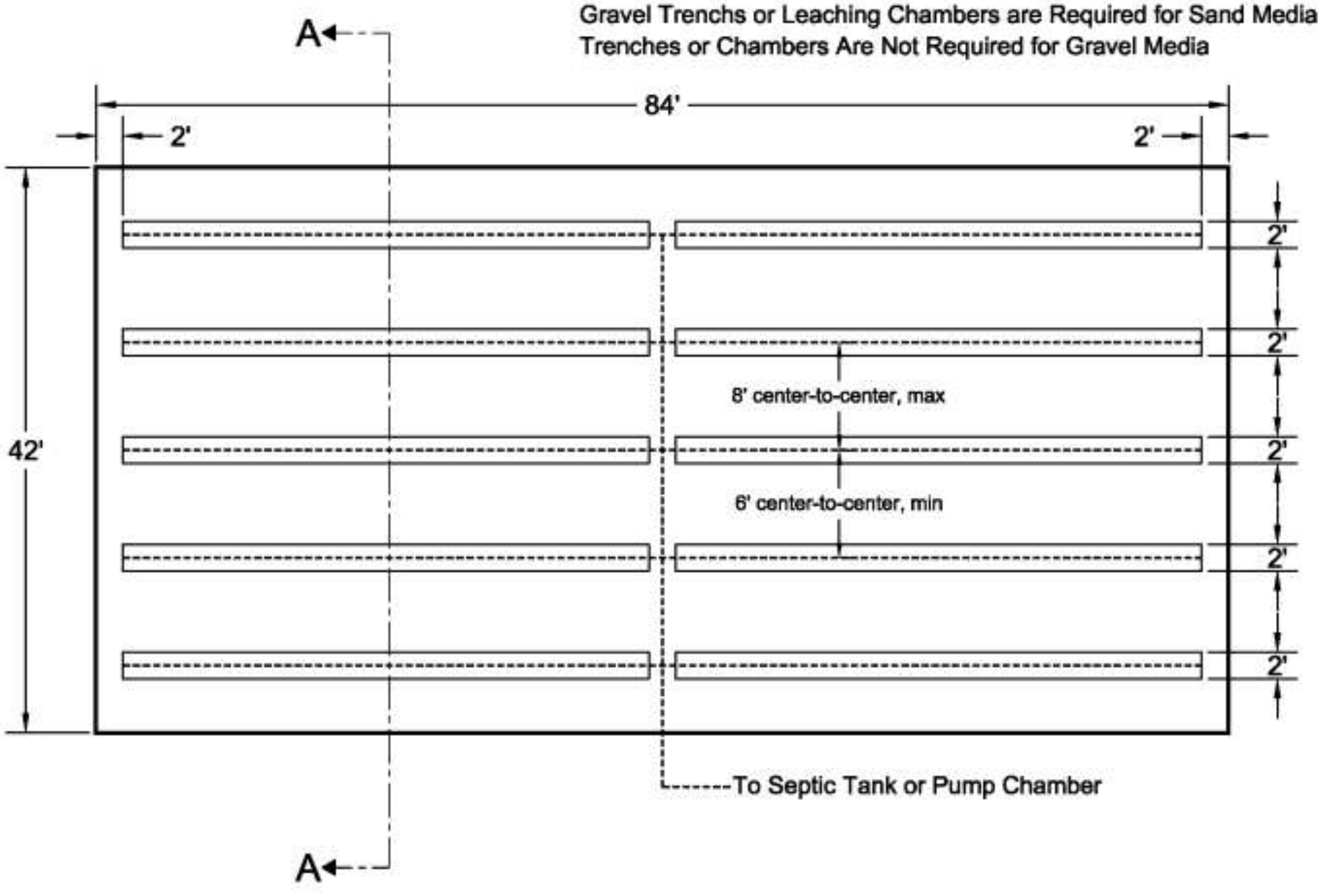
ET Bed Size Based Upon Maximum Allowed Application Rate: 0.15gpd/sf (per Section 6.7.3.5)

350/0.15 = 2,333 square feet. 2,333 square feet x 1.5 factor of safety = 3,500 square feet

Bed Dimensions: Square 59' x 59'

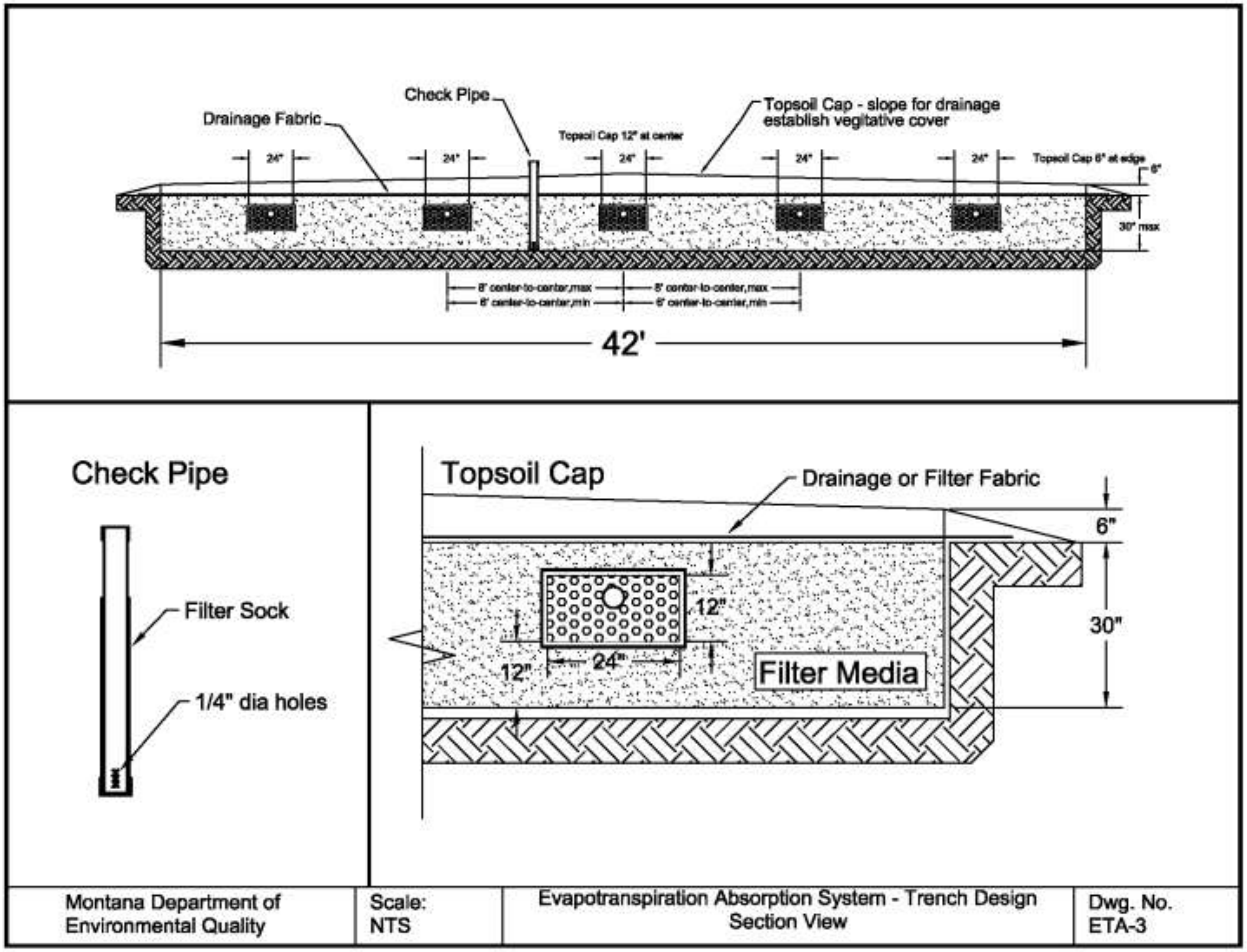
Bed Dimensions: 2:1 Rectangle 42' x 84'

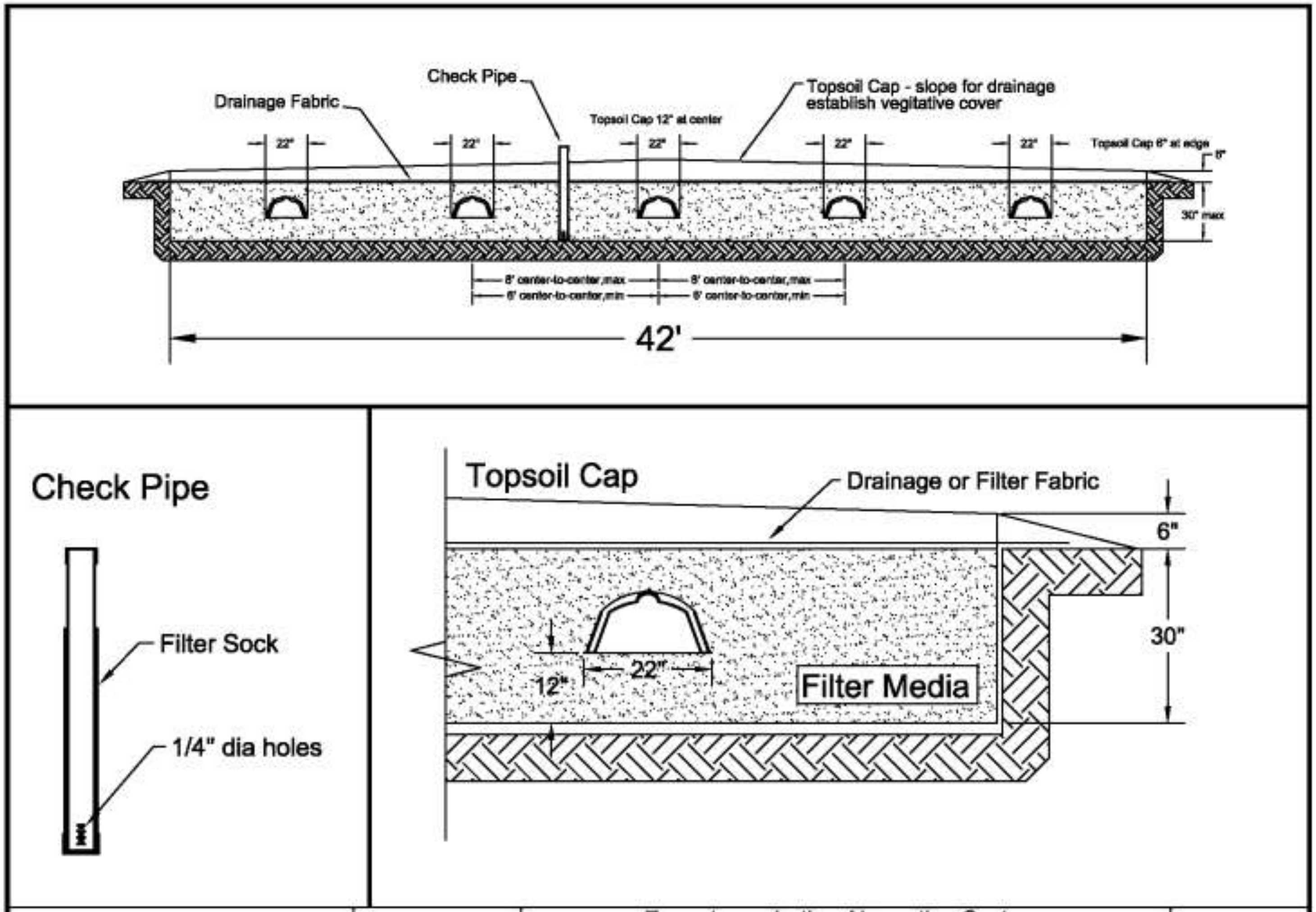
Montana Department of Environmental Quality	Scale: NTS	Evapotranspiration Absorption System Design Parameters	Dwg. No. ETA-1



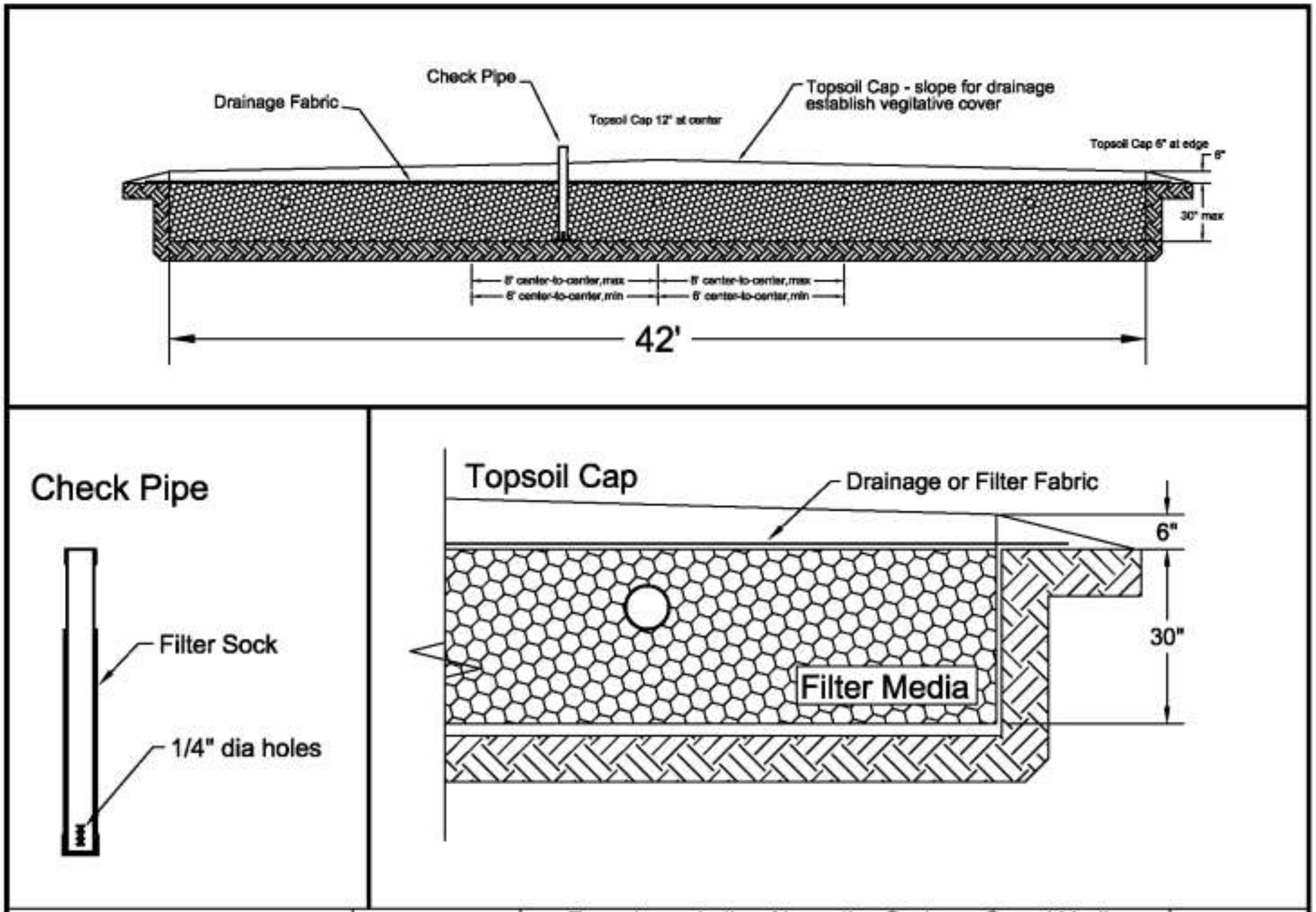
Gravel Trenches or Leaching Chambers are Required for Sand Media
Trenches or Chambers Are Not Required for Gravel Media

Montana Department of Environmental Quality	Scale: NTS	Evapotranspiration Absorption System - Trench Design Plan View - Top Cap Removed for Clarity	Dwg. No. ETA-2


Check Pipe
Drainage Fabric
Topsoil Cap - slope for drainage establish vegitative cover
Topsoil Cap 12" at center
24"
24"
24"
24"
24"
Topsoil Cap 6" at edge
6"
30" max
8' center-to-center,max
6' center-to-center,min
8' center-to-center,max
6' center-to-center,min
42'
Check Pipe
Filter Sock
1/4" dia holes
Topsoil Cap
Drainage or Filter Fabric
6"
30"
12"
12"
24"
Filter Media
Montana Department of Environmental Quality
Scale: NTS
Evapotranspiration Absorption System - Trench Design Section View
Dwg. No. ETA-3



Montana Department of Environmental Quality	Scale: NTS	Evapotranspiration Absorption System Section View - Leaching Chamber Design	Dwg. No. ETA-4



Montana Department of Environmental Quality	Scale: NTS	Evapotranspiration Absorption System - Gravel Media Section View	Dwg. No. ETA-5

APPENDIX F
Documents Adopted by Reference And Other Referenced Documents

A Montana agency adopting a standard by reference in a rule must provide a citation to the material adopted by reference and a statement of the general subject matter of the omitted rule and must state where a copy of the omitted material may be obtained. § 2-4-307(2), Montana Code Annotated (MCA). Standards developers have copyrights that protect against unauthorized use of their standards, and an agency cannot, without permission, provide free paper or internet copies of those standards. Table 1, column 2, provides the web address where the sources of all standards being proposed for adoption by reference in DEQ-4 can be purchased. Copies of the documents also may be viewed at the Helena office of the Public Water and Subdivision Section, Department of Environmental Quality, 1520 East 6th Ave., Helena, MT.

Table 1

Adopted-by-Reference	**Web Addresses Where Documents can be Purchased**
ASTM C117-13	http://global.ihs.com
ASTM D5093-02	http://global.ihs.com
ASTM D3034-08	http://global.ihs.com
ASTM D1785-12	http://global.ihs.com
ASTM D3350-12	http://global.ihs.com
ASTM D2729-11	http://global.ihs.com
ASTM D2241-09	http://global.ihs.com
ASTM C1227-12	http://global.ihs.com
ASTM C150-12	http://global.ihs.com
ASTM C 990-09	http://global.ihs.com
ASTM C 33-13	http://global.ihs.com
IAPMO/ ANSI Z1000-07	http://webstore.ansi.org

IAPMO PS 63-2005	http://iapmomembership.org
ACI 318-11	http://www.concrete.org

Table2 contains web addresses to other sources of information referenced in DEQ-4.

Table2

Underwriters Laboratories (http://www.ul.com)
Canadian Standards Association (http://www.csagroup.org)
National Electric Code Class 1, Division 2 locations (http://www.osha.gov)
ANSI/NSF Standard 46 (http://www.nsf.org)
USDA Soils Report (http://www.nrcs.usda.gov)
NSF Standard 40 (for class 1 certification) (http://www.nsf.org)
"The Wisconsin Mound Soil Absorption System Siting, Design, and Construction Manual", January 2000 (recommended) (http://www.soils.wisc.edu)
EPA Manual, "On-Site Wastewater Treatment Systems Manual", February 2002, pages TFS 41 to 52 (http://www.norweco.com)
NSF Standard 41 (http://www.nsf.org)
National Drought Mitigation Center (definition of drought) (http://drought.unl.edu)
MSU Extension Service, "Septic Tank and Drainfield Operations" (http://msuextension.org)
MSU Extension Service, "Maintenance and Septic System Inspection and Troubleshooting" (http://msuextension.org)

Region and Area Office Service Agreement	**SA NO:**	MB-St. Mary's Diversion Dam - 2021 - 1	
FEATURE:	St. Mary's Diversion, Montana		
PROJECT:	Milk River	**ORIGINAL DATE:**	1/13/2022
COST AUTHORITY:		**REVISION DATE:**	

SCOPE OF WORK

SCOPE:	This Field Exploration Request (FER) is to detail exploration requirements to study foundation and groundwater conditions at the St. Mary's Diversion Dam and to evaluate potential borrow sources for various construction materials. The groundwater conditions will be used to develop de-watering requirements for the development of specifications for the proposed St. Mary's Diversion Dam replacement.
TASK 1:	**Mobilization, Travel, and Demob:** Mobilization from Billings, MT to St. Mary's Diversion, MT. This includes development of FER and cost estimate.
TASK 2:	**Pump Well Drill Hole PW-21-1 (FER Item 1):** Use sonic drilling methods to predrill the pump well with an 8-inch diameter casing until either 5-feet of bedrock or a maximum of 80-feet is drilled. If bedrock is encountered before 80 feet of depth, then advance the drill hole 5 feet into bedrock and terminate drilling. Conduct eccentric duplex percussive drilling (similar to ODEX) methods to install 10-inch diameter pump well for a pump out test.
TASK 3:	**Pump Well Drill Hole PW-21-1 Install, Development, & Step Test (FER Appendix A):** The pump well is to be constructed with a 10-inch-diameter wire wrapped well screen with gravel filter pack. The existing observation wells and PW-21-1 will need to be developed after drilling, prior to the step test. Results of the step test for PW-21-1 will be used to determine the appropriate pump and pumping rates, as well as determine if the observation well locations are adequate for the pump out tests.
TASK 4:	**PW-21-1 Pump Test (FER Appendix A):** Upon completion of the step test, conduct the pump out test in PW-21-1. **TSC will provide their own cost estimate for on-site 24 hour pump test personel.**
TASK 5:	**Drill Hole DH-21-1 (FER Item 2):** Advance drill hole using Sonic drilling method 5 feet into bedrock or to a maximum of 80 feet of depth. as determined from drill cuttings and drilling action by the geologist.
TASK 6:	**Lab Testing and Water Sampling (FER Items 3, 4, 5, 7, & 8):** Collect samples (FER Item 3) for laboraory standard physical property testing. Collect water quality samples (FER Item 4) from both upstream and downstream of the St. Mary's Diversion dam and submit to laboratory for water dispersivity and conductivity testing. Collect water samples from the pump well discharge (FER Item 5) to conduct a series of inorganic chemical and microbiological tests to identify the potential impacts of fouling and corrosion during the operation of the sampled well by contract lab. Collect material samples (FER item 7) for laboratory analysis of borrow area 1, 2 and 3 for potential use for core material, filter sand and gravel drain materials. Collect samples (FER item 8) for testing to determine pH, resistivity, sulfate concentration, and chloride concentration. Cost includes collection, packaging, and transport.
TASK 7:	**Percolation Test (FER Item 10):** Perform percolation test in accordance with Montana State Department of Environmental Quality (DEQ) Circular DEQ4- 2013.
TASK 8:	**Surveys (FER Item 9):** A location survey will be conducted upon completion of the drilling to the nearest 0.1 foot accuracy. Survey will include coordinates of borehole location; and elevations of collar, top of PVC, and top of steel casing. This cost estimate only includes the cost for a GP geologist to meet a surveyor on-site. Cost of surveyor and survey are not included in this estimate. The estimate for the site survey will be provided by the Montana Area Office
TASK 9:	**Commercial Borrow Source Investigation (FER Item 6):** Collect samples for laboratory testing of core material, rip rap and rock fill from local commercial quarries.Collect information from local commercial quarries utilizing the questionnaire for concrete.
TASK 10:	**Geologic Report (FER Item 9):** This estimate includes the cost of a report documenting the results of the field exploration program. *Costs associated with drafting of drawings* ***are*** *included in this estimate.*

SCHEDULE			**START DATE**	**TARGET COMPLETE DATE**	**ACTUAL COMPLETION DATE**
TASK 1	**Prep,Mobilization, Demobilization (includes development of FER and cost estimate)**		TBD	TBD	
TASK 2	**Pump Well Drill Hole PW-21-1 (FER Item 1)**		TBD	TBD	
TASK 3	**Pump Well Drill Hole PW-21-1 Install, Development, & Step Test (FER Appendix A)**		TBD	TBD	
TASK 4	**PW-21-1 Pump Test (FER Appendix A)**		TBD	TBD	
TASK 5	**Drill Hole DH-21-1 (FER Item 2)**		TBD	TBD	
TASK 6	**Lab Testing and Water Sampling (FER Items 3, 4, 5, 7, & 8)**		TBD	TBD	
TASK 7	**Percolation Test (FER Item 10)**		TBD	TBD	
TASK 8	**Surveys (FER Item 9)**		TBD	TBD	
TASK 9	**Commercial Borrow Source Investigation (FER Item 6)**		TBD	TBD	
TASK 10	**Geologic Report (FER Item 9)**		TBD	TBD	

BUDGET

TASKS		OFFICE	DISCIPLINE (Geologist, Drill Crew, etc.)	DAYS TO COMPLETE	LABOR	EQUIPMENT	HOTEL/PD	SUPPLIES	TOTAL COST
1	Preperation, Mobilization, and Demobilization (includes development of FER)	MB-2300	Drill Crew	4	$ 26,262.60	$ 4,480.00	$ 579.00	$ 500.00	$ 31,821.60
		MB-2300	Geology	4	$ 3,791.92	$ -	$ -	$ -	$ 3,791.92
		MB-2300	Proj Mgmt	2	$ 2,320.84	$ -	$ -	$ -	$ 2,320.84
		UC	Drill Crew	UC to Provide Estimate for Sonic Prep, Mob., & Demob					
			Task 1 Totals		$ 32,375.36	$ 4,480.00	$ 579.00	$ 500.00	**$ 37,934.36**
2	Pump Well Drill Hole PW-21-1 (FER Item 1) Sonic Pre-drill	MB-2300	Geology	5	$ 4,739.90	$ 220.00	$ 755.00	$ 250.00	$ 5,964.90
		MB-2300	Proj Mgmt	1	$ 1,160.42	$ -	$ -	$ -	$ 1,160.42
		UC	Drill Crew	UC to Provide Estimate for Sonic Drilling					
2	Pump Well Drill Hole PW-21-1 (FER Item 1) ODEX	MB-2300	Drill Crew	6	$ 34,736.52	$ 14,880.00	$ 2,718.00	$ 500.00	$ 52,834.52
		MB-2300	Geology	6	$ 6,288.55	$ 390.00	$ 906.00	$ 500.00	$ 8,084.55
		MB-2300	Proj Mgmt	1	$ 1,160.42	$ -	$ -	$ -	$ 1,160.42
			Task 2 Totals		$ 48,085.81	$ 15,490.00	$ 4,379.00	$ 1,250.00	**$ 69,204.81**
3	Pump Well Drill Hole PW-21-1 Install, Development, & Step Test (FER Appendix A)	MB-2300	Drill Crew	6	$ 34,736.52	$ 14,880.00	$ 2,718.00	$ 15,850.00	$ 68,184.52
		MB-2300	Geology	6	$ 6,288.55	$ 390.00	$ 906.00	$ 500.00	$ 8,084.55
		MB-2300	Proj Mgmt	2	$ 2,320.84	$ -	$ -	$ -	$ 2,320.84
			Task 3 Totals		$ 43,345.91	$ 15,270.00	$ 3,624.00	$ 16,350.00	**$ 78,589.91**
4	PW-21-1 Pump Test (2 Aditional Geologists For 4 Days During 24 Hour Pump Test)	MB-2300	Drill Crew	8	$ 43,210.00	$ 14,880.00	$ 3,624.00	$ 4,000.00	$ 65,714.00
		MB-2300	Geologist	8	$ 8,004.64	$ 3,030.00	$ 1,208.00	$ 500.00	$ 12,742.64
		MB-2300	Geologist	5	$ 6,248.78	$ 679.00	$ 755.00	$ -	$ 7,682.78
		MB-2300	Geologist	5	$ 6,248.78	$ 679.00	$ 755.00	$ -	$ 7,682.78
		TSC	Engineers	TSC to Provide Cost Estimate					
		MB-2300	Proj Mgmt	2	$ 2,320.84	$ -	$ -	$ -	$ 2,320.84
			Task 5 Totals		$ 66,033.04	$ 19,268.00	$ 6,342.00	$ 4,500.00	**$ 96,143.04**
5	Drill Hole DH-21-1 (FER Item 2) Sonic Drilling	MB-2300	Geology	5	$ 5,160.70	$ 325.00	$ 755.00	$ 250.00	$ 6,490.70
		MB-2300	Proj Mgmt	1	$ 1,160.42	$ -	$ -	$ -	$ 1,160.42
		UC	Drill Crew	UC to Provide Estimate for Sonic Drilling					
			Task 6 Totals		$ 6,321.12	$ 325.00	$ 755.00	$ 250.00	**$ 7,651.12**

6	Lab Testing and Water Sampling (FER Items 3, 4, 5, 7, & 8)	MB-2300	Geology	4	$ 3,791.92	$ 382.00	$ 604.00	$ 467.00	$ 5,244.92
		TSC	Laboratory	TSC Laboratory to Provide Cost Estimate for Water Testing, Prob Soils, & Comm. Source					
		Provo	Laboratory	1	$ 18,700.00	$ -	$ -	$ -	$ 18,700.00
		MB-2300	Proj Mgmt	1	$ 1,160.42	$ -	$ -	$ -	$ 1,160.42
			Task 7 Totals		$ 23,652.34	$ 382.00	$ 604.00	$ 467.00	**$ 25,105.34**
7	Percolation Test (FER Item 10)	MB-2300	Geology	3	$ 2,843.94	$ 195.00	$ 453.00	$ 350.00	$ 3,841.94
		MB-2300	Proj Mgmt	0	$ -	$ -	$ -	$ -	$ -
			Task 10 Totals		$ 2,843.94	$ 195.00	$ 453.00	$ 350.00	**$ 3,841.94**
8	Surveys (FER Item 9)	MB-2300	Geology	3	$ 2,843.94	$ 195.00	$ 453.00	$ 100.00	$ 3,591.94
		MTAO	Surveyor	Site survey to the 0.1' provided by MT Area Office					
		MB-2300	Proj Mgmt	0	$ -	$ -	$ -	$ -	$ -
			Task 8 Totals		$ 2,843.94	$ 195.00	$ 453.00	$ 100.00	**$ 3,591.94**
9	Commercial Borrow Source Investigation (FER Item 6)	MB-2300	Geology	8	$ 7,583.84	$ 360.00	$ 1,208.00	$ 940.00	$ 10,091.84
		MB-2300	Proj Mgmt	1	$ 1,160.42	$ -	$ -	$ -	$ 1,161.42
			Task 9 Totals		$ 8,744.26	$ 360.00	$ 1,208.00	$ 940.00	**$ 11,253.26**
10	Documentation (FER Item 11)	MB-2300	Geology	30	$ 28,439.40	$ -	$ -	$ -	$ 28,439.40
	CADD	MB-2300	Drafting	4	$ 2,400.00	$ -	$ -	$ -	$ 2,400.00
	Review	MB-2300	Proj Mgmt	4	$ 4,641.68	$ -	$ -	$ -	$ 4,641.68
			Task 11 Totals		$ 35,481.08	$ -	$ -	$ -	**$ 35,481.08**
							TOTAL:		**$ 368,797**

Supplies

Task	**Item**	**Description**	**Quantity**	**Cost**
2	1	CGS Core Box Corrugated Plastic-PQ (3-3/8")	20 ea.	$ 250.00
			Task 2 Total	$ 250.00
3	1	10" Stainless Steel Wired Wrapped 0.1 Screen	60 ft	$ 10,000.00
	2	10" Threaded Blank for Sump	5 ft.	$ 500.00
	3	10" Glue on Cap	1 ea.	
	4	10" Blank Threaded PVC Riser Pipe	20 ft.	
	5	3/8" to No. 8 sieve Filter Pack	65 cu ft.	$ 156.00
	6	Bentonite	13 cu ft.	$ 494.00
	7	14" Steel Protective Casing	7 ft.	$ 500.00
	8	14" Steel Locking Cap	1 ea.	$ 200.00
	9	Cement	2 Bags	
	10	10" Surge Block	1 ea.	
	11	Misc	1 ea.	$ 500.00
			Task 3 Total	$ 11,850.00
5	1	Core Boxes	20 ea.	$ 250.00
			Task 6 Total	$ 250.00
6	1	Soil Sample Bags		$ 143.00
	2	Moisture Tins		$ 37.00
	3	5 gal Buckets for Water Sample Collection	8 ea.	$ 64.00
	4	Sterilized 1 liter Water Sample Containers	6 ea.	$ 23.00
	5	Sample Shipping	2 ea.	$ 200.00
			Task 7 Total	$ 467.00
7	1	PVC Screen, Gravel, and Misc Supplies	1 ea.	$ 350.00
			Task 8 Total	$ 350.00
9	1	5 Gal Buckets with Lids	80 ea.	$ 640.00
	2	Super Sacks	6 ea.	$ 300.00
			Task 10 Total	$ 940.00
			Supplies Total	

Cody Clark - Regional Geologist Date
Geology and Exploration Services, Missouri Basin Region

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE: St. Mary's Dam Sonic Drilling	**PROJECT:**
	WOID: TBD
	FUND: TBD
	REGION: PN-C
	WBS:
	FILE: C:\Users\DNielsen\Documents\Cost Estimates\Cost Estimates\St. Mary's\[Cost Estimate St. Mary's Dam (nielsen).xlsm]

COST TYPE	PAY ITEM	DESCRIPTION	COST CENTER	QUANTITY	UNIT	UNIT PRICE	AMOUNT

DESCRIPTION

Scope:
UC Drill Crew
The Upper Colorado Basin Drill Crew will drill two borings using the sonic drilling method at St. May's Diversion Dam/Canal at St. Mary's, Montana. The wells are to be drilled to approximately 80-feet each in depth. The wells are to be completed with the installation of an observation well in one boring and backfill the other with bentonite to be re-drilled and installed as a well in the future..

Assumptions:

- Drill 2 sonic borings to 80-feet.
- Backfill one sonic boring with bentonite to the surface to be redrilled in the future.
- Install 2-inch diameter Schedule 40 PVC pipe with a 2-foot sump, and 10-feet 0.010-inch slotted U-pack screen into 1 sonic borings.
- Develop the observation wells using a Waterra pump system.
- Complete the observation well with a locking 4x4-inch square x 5-feet standpipe.

Sonic Drilling: 160-ft
Estimated Drilling Duration = 1 drill shift
Estimate Drilling Duration includes preparation work, mobilization and demobilization.

Schedule:
The drilling program is estimates to consist of approximately 1 shift. Work to begin Fall/Winter 2021/22.

PREPARED BY	**DATE**	**APPROVED**	**DATE**
David Nielsen	August 16, 2021	Spencer Strand	August 16, 2021

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

FEATURE:
St. Mary's Dam
Sonic Drilling

PROJECT:

WOID: **TBD**
FUND: **TBD**
REGION: **PN-C**
WBS:
FILE: C:\Users\DNielsen\Documents\Cost Estimates\Cost Estimates\St. Mary's\[Cost Estimate St. Mary's Dam (nielsen).xlsm]

COST TYPE	PAY ITEM	DESCRIPTION	COST CENTER	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		ADMINISTRATION/SECRETARY					
L20	1	Secretary	RR04970000	1	Shifts	$500.00	$500.00
L20	1	Drill Supervisor	RR04975100	1	Shifts	$1,900.00	$1,900.00
L20	1	UC Regional Geologist	RR04975000	1	Shifts	$580.00	$580.00
						Subtotal =	**$2,980.00**
		DRILLING					
L20	2	LABOR	RR04975100	1	Shifts	$17,100.00	$17,100.00
		Assume 3-man crew for 10-days shifts					
N20	2	LODGING M&IE	RR04975100	1	Shifts	$4,210.00	$4,210.00
		Includes allowances for lodging, M&IE, and					
		voucher fees.					
N20	2	**CREW SUPPORT VEHICLE**	RR04975100	1	Shifts	$1,310.00	$1,310.00
		Travel between Pleasant Grove and					
		Little Wood Dam					
N20	2	**EQUIPMENT FEE**	RR04975100	1	Shifts	$22,000.00	$22,000.00
		Drill Rig, Rig Tender fee					
N20	2	**EQUIPMENT FUEL**	RR04975100	1	Shifts	$650.00	$650.00
		fuel for drill rig and tender					
						Subtotal =	**$45,270.00**
		SUBTOTAL THIS SHEET					**$48,250.00**

PREPARED BY	**DATE**	**APPROVED**	**DATE**
David Nielsen	August 16, 2021	Spencer Strand	August 16, 2021

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 3 OF 4

FEATURE:
St. Mary's Dam
Sonic Drilling

PROJECT:

WOID: TBD

FUND: TBD

REGION: PN-C

WBS:

FILE: C:\Users\DNielsen\Documents\Cost Estimates\Cost Estimates\St. Mary's\[Cost Estimate St. Mary's Dam (nielsen).xlsm]

COST TYPE	PAY ITEM	DESCRIPTION	COST CENTER	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	3	**MATERIALS**	RR04975100				
		2-in. diam. Sch40 PVC blank 10-ft lengths		12	ea	$17.25	$207.00
		2-in. diam. Sch40 PVC blank 2-ft lengths		2	ea	$8.00	$16.00
		2-in. diam. Sch40 PVC screen 10-ft lengths		4	ea	$25.55	$102.20
		2-in. diam. threaded PVC end cap		2	ea	$6.25	$12.50
		2-in. diam. PVC slip cap		2	ea	$1.95	$3.90
		Sand, 50-lb bags		1	pallet	$575.00	$575.00
		Bentonite chips, 50-lb sack		1	pallet	$425.00	$425.00
		Bentonite coated pellets		1	pallet	$2,220.00	$2,220.00
		Concrete, 60-lb sacks		6	sacks	$9.00	$54.00
		Sonotube, 24 in.dia. X 10-ft		1	ea	$170.00	$170.00
		4 x 4 x 8-ft locking standpipe		2	ea	$125.00	$250.00
		Misc. fittings		1	ls	$1,500.00	$1,500.00
		Drilling bits and tooling		1	ls	$2,500.00	$2,500.00
N20	3					**Subtotal =**	**$8,035.60**
		SUBTOTAL THIS SHEET					**$8,035.60**

PREPARED BY	**DATE**	**APPROVED**	**DATE**
David Nielsen	August 16, 2021	Spencer Strand	August 16, 2021

BUREAU OF RECLAMATION

ESTIMATE WORKSHEET

SHEET 4 OF 4

FEATURE: **St. Mary's Dam** **Sonic Drilling**	**PROJECT:**
	WOID: TBD · **FUND:** TBD
	REGION: PN-C · **WBS:**
	FILE: C:\Users\DNielsen\Documents\Cost Estimates\Cost Estimates\St. Mary's\[Cost Estimate St. Mary's Dam (nielsen).xlsm]

COST TYPE	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Sheet Totals					
		Subtotal Sheet 1					$48,250.00
		Subtotal Sheet 2					$8,035.60
		Subtotal 1					**$56,285.60**
		Labor/Non-Labor Totals					
		Labor					$20,080.00
		Non-Labor					$36,205.60
		Subtotal 1					**$56,285.60**
		PROJECT TOTALS					
		Subtotal 1					**$56,285.60**
		Unlisted Items		3%			$1,688.57
		Subtotal 2 (Subtotal 1 with Unlisted Items)					**$57,974.17**
		Contingencies		6%			$3,478.45
		Grand Total (Subtotal 2 with Contingencies)					**$61,452.62**
		Grand Total (Rounded to nearest $1,000)					**$61,000.00**

PREPARED BY	**DATE**	**APPROVED**	**DATE**
David Nielsen	August 16, 2021	Spencer Strand	August 16, 2021

PRELIMINARY COST ESTIMATE
GEOTECHNICAL LABORATORY AND FIELD SUPPORT

Project Title	St. Mary's Diversion Dam
Scope of Estimate	Commercial Borrow Source Testing
WOID	TBD
Date	8/30/2021
GLFS Geotechnical Contact	Brusak, x2212
TSC Geology and Geotechnical Contacts	Lewis, x3365
Fiscal Year	2022

BUREAU OF RECLAMATION

			Staff Days (Level)						
Task	**Code**	**Qty.**	**1**	**2**	**3**	**Labor**	**Non-Labor**	**Fees**	**Total**
1. Project Management	86-68550	1	2.5		7	$11,756			$11,756
2. FER & Lab Program Development	86-68550								
FER Development		1		2		$2,288			$2,288
Sample Receiving		1	1	0.5		$1,444			$1,444
Program Development & Coordination		1		3	0.5	$4,116			$4,116
3. Biological Water Testing	86-68550							$10	$10
Colorado Analytical Samples		2	0.1			$174	$200		$374
Water Systems Engineering, Inc.		2				$0	$1,580		$1,580
4. Core Material - Commerical Borrow Area	86-68550							$415	$415
Processing Bulk Material		1		1.00		$1,144			$1,144
Physical Properties		2	0.1			$174	$400		$574
1D Swell/Consolidation		2		0.75		$1,716			$1,716
Dispersivitiy Testing (Pinhole and Crumb)		10	0.15	0.10		$2,452			$2,452
Permeability (Flex Wall - Falling Tail/Rising Head)		2		0.75		$1,716			$1,716
Standard Proctor Compaction		2		0.50		$1,144			$1,144
CU Triaxial Strength Testing (3 specimens)		6		0.50	0.25	$5,484			$5,484
5. Filter Sand - Commerical Borrow Area	86-68550							$1,505	$1,505
Sample Preparation and Delivery to contract labs		1	1			$872			$872
Gradation (original and post compaction) with #200 wash		3		0.5		$1,716			$1,716
Fine Aggregate C33 suite		3	5			$13,080	$900		$13,980
Vibratory Hammer Compaction		3	0.5			$1,308			$1,308
Vibratory Table and Min Density		3				$0	$975		$975
Modified Sand Castle Test (MSCT) (4 specimens)		3	2			$5,232			$5,232
Unconfined Compressive Strength (UCS) (4 specimens)		3	2			$5,232			$5,232
Petrography		3				$0	$1,200		$1,200
Mica Count		3	1			$2,616			$2,616
6. Gravel Drain - Commercial Borrow Area	86-68550							$655	$655
Coarse Aggregate C33 suite		3	5			$13,080			$13,080
Petrography		3				$0	$1,200		$1,200
7. Rip Rap - Commercial Borrow Area	86-68550							$1,050	$1,050
Rock-Type Physical Properties		2	0.1			$174			$174
Block Inspection		1	2			$1,744			$1,744
Cube Preparation		6	0.5			$2,616			$2,616
Crushing and Grading		2	4			$6,976			$6,976
Freeze-thaw Durability (3 cubes)		2	2			$3,488			$3,488
Sodium Sulfate Soundness (Crushed Material)		2	2.5			$4,360			$4,360
LA Abrasion (crushed material)		2	0.75			$1,308			$1,308
Petrography		2	0.2			$349	$1,000		$1,349
6. Data Analysis & Reporting	86-68550								
Analysis and Interpretation of Test Results		1	1	10	2	$15,048			$15,048
TM Preparation (incl. Peer Review and VI/508)		1	1	5	1	$7,960			$7,960
Sub-Total			79.0	31.00	12.0	$120,768	$7,455	$3,635	$131,858
Contingency (15%)			11.75	4.75	1.8		$1,120		$19,194
Total			**90.75**	**35.8**	**13.8**	**$138,842**	**$8,575**	**$3,635**	**$151,052**

Assumptions:

1. All materials will be delivered to GLFS. GLFS personnel are available to coordinate sample collection, packaging, shipping/delivery at additional cost.
2. Quantities assumed above based on the availability of 2 core and gravel drain sources, and 3 filter sand and riprap sources within the vicinity.
3. Details of testing program will be coordinated with design team staff upon receipt of samples.
4. Excess samples will be disposed of upon completion of program. Sample storage is available for additional cost.
5. This estimate does not provide any information about schedule and duration of the laboratory program.
6. Estimate based on FY22 rates. Costs may increase if work is performed in future years.
7. Contingency will be utilized only at discretion and agreement of Team Lead.
8. All lab testing results will be conveyed in a peer-reviewed GLFS TM upon completion of program.
9. Fine aggregate C33 test suite includes organic impurities, sodium sulfate soundness, lightweight particle, clay lumps and friable particles, and sand equivalency value for fine aggregate.
10. Coarse aggregate C33 test suite includes sodium sulfate soundness, lightweight particle, LA abrasion, and clay lumps and friable particles for coarse aggregate.
11. Rock-type physical properties includes moisture content, degree of saturation, specific gravity, absorption, apparent porosity, and dry unit weight.
12. Estimate assumes nominal 2-foot diameter riprap boulders.

PRELIMINARY COST ESTIMATE

Project Title	St. Mary's Diversion Dam Replacement FER
Region, State	Missouri Basin, MT
Scope of Estimate	Corrosivity Testing
Date	2/1/2022
MCL Contact	Grace Weber
Fiscal Year	2022

Task	**Code**	**Qty.**	**Staff Days (Level)**			**Labor**	**Non-Labor**	**Fees**	**Total**
			1	**2**	**3**				
Soil Corrosivity Testing	86-68540								
Corrosion Suite (Chlorides/Sulfates/pH/resistivity)		10					$3,000		$3,000
Water Corrosivity Testing	86-68540								
Complete Nutrient Analysis		2					$280		$280
Analysis, Reporting, and Peer Review	86-68540			1	1	$2,512			$2,512
Managerial and Clerical	86-68540								
508 compliance, transmittal, documentation			0.25			$188			$188
Total			0.25	1	1	$2,700	$3,280	$0	$5,980

Assumptions

1. Soil corrosivity testing to be done by Kumar & Associates in Denver. If a Montana/other local test lab is found with lower prices, non-labor may be lower.
2. Water sample corrosivity testing will be done at Colorado Analytical Laboratory in Denver. If another lab is used, non-labor cost may change.