January 9, 2015

Ms. Carrie Wildin, P.E., Division Engineer
Phillips 66 Pipeline LLC
2626 Lillian Avenue
Billings, Montana 59101

Re: Revised Geotechnical Report, Proposed Horizontal Directional Drill
Spokane – Parkwater YP03 10-inch Pipeline – MP 1.3
Terracon Project No. 26145031

Dear Ms. Wildin:

Introduction

Terracon Consultants, Inc. (Terracon) has completed the geotechnical services for the proposed horizontal directional drill (HDD) crossing of the 10-inch, Yellowstone Pipeline YP03 at Spokane River, MP 1.3, located within SW ¼ NE ¼ Section 11, Township 25 North, Range 43 East, Spokane Washington. This report includes the results of pH, sulfates and resistivity testing. This report presents the results of the geotechnical investigation regarding:

- Subsurface soil conditions;
- Groundwater conditions;
- pH, Soluble Sulfates and resistivity testing and
- Feasibility and design recommendations for the proposed HDD crossing.

The attached Appendix A includes our site and HDD layout figures, Boring Logs, and laboratory reports. Appendix B includes general notes on our drilling and exploration activities and the Unified Soil Classification System. Appendix C includes our HDD installation stress calculations, and Appendix D includes the drilling Photo Summary.

In addition to the geological requirements for the HDD crossing, Terracon also considered entry and exit drilling work areas and access road locations, possible wetland impacts, water requirements for the HDD installation, land ownership, and existing Right-of-Way limits when designing the layout for the HDD crossing. Discussions of these considerations follow.

Project Background

Terracon along with Phillips 66 Pipeline Company, LLC (Phillips 66) personnel completed stream crossing condition and depth of cover surveys of Phillips 66's pipeline systems annually from 2011 to 2014.

The Terracon surveys consisted of a GPS mapping of pipe depth, an evaluation of stream stability, stream change when compared to historic aerial photography and a projection of potential change that may affect the pipe line. The primary emphasis was to identify areas of active lateral erosion, which have exposed or threaten to expose the pipe line due to bank erosion, and to identify reaches where the channel is incised and degrading, which have exposed or threaten to expose the pipe line in the active channel due to bed degradation.

The depth of cover was measured using a Radio detection RD8000 cable and pipe locator. The depth of cover measurements were paired with a topographic profile performed in the field using a survey grade Leica Viva GPS Surveying System. Pipe line depth of cover and topographic measurements were obtained across the modern floodplain and areas of potential channel change. The measurements of depth of cover obtained during these surveys were compared with historic depth of cover measurements to identify changes in bed elevation over time.

Site Conditions

Yellowstone Pipeline, YP03 10-inch pipeline crosses Spokane River approximately 2800 feet downstream from the Spokane Upriver Dam & Facility, Spokane, Washington. The active 10-inch line runs in the north-south direction, and a small exposure was observed in the south half of the channel, and limited 2.8 feet cover in parts of the north half of the channel.

Spokane River is an east-west oriented drainage with its headwaters formed by the outlet of Coeur d'Alene Lake in Idaho, and flows westerly for 112 miles to the confluence with the Columbia River. Although the source of Spokane River is in Idaho, groundwater from the Spokane Valley-Rathdrum Prairie (SVRP) aquifer recharges the river through hydraulic conductivity and deeper cavities within the drainage. While drilling, DH-1 and DH-2 both encountered the aquifer at approximate elevation 1868 feet or about the stream level.

Near the potential HDD project location, Spokane River has a laminar flow of pattern with a deep broad u-shaped channel. The maximum water depth of the river during our August 2014 survey was approximately 12 feet.

The north bank is a moderately steep (5H:1V) slope rising approximately 40 feet above the water surface to Upriver Road with a sand, cobble and boulder bank, and thick tree cover. The Northwest Pipeline right of way lies further north, adjacent to an apartment complex and an empty field.

The south bank of the main channel, as shown in the photograph below, is a gradual sandy beach with rocks, cobbles and boulders creating shoreline protection. Beyond the shoreline the slope continues to rise gently rise on a 3 ½H :1V slope for about 80 feet. The area has considerable tree cover, and power lines parallel the south shore. Further south is North Waterworks Street and still further south is Spokane Felts Field Airport, owned by the City of Spokane. In low water the rocks form an eddy along the left south bank, just below the proposed HDD crossing.

Note - Photograph taken looking southeast in August 2014

At the project site, the USDA Soil Survey classifies the soils north and south of the river as *Garrison very gravelly ashy loam*, with the parent material described as, “Sandy and gravelly glaciofluvial deposits with minor amounts of volcanic ash and loess in the upper part.” Further north and south where the proposed HDD entry and exit points the soils were classified as *Urban land-opportunity disturbed complex* with the parent material described in the same manner.

The regional geology for the Spokane River can be described as *Quaternary Alluvium and Pleistocene Outburst Flood Deposits* according to the Washington State Department of Natural Resources, Surface Geology Information System Website. As the nearby glacial lakes were flooded, alluvial sands, gravels and fines were carried down the sub-basin and deposited along the Spokane River. The following description was written by the Washington State Department of Ecology in their publication, *The Spokane River – Geographic Response Plan of July 2011*:

> The Spokane River sub-basin is represented by the Okanogan Highlands to the north and Columbia basin, also known as the Columbia Plateau, to the south. Basalt flows during the tertiary (Miocene epoch) period and glacial activity during the quaternary (Pleistocene epoch) period define the land formation and geological characteristics of the Columbia Plateau. Land formation and sculpting in the Okanogan Highlands was largely associated with glacial activity during the Pleistocene Epoch. Floods from glacial Lake Columbia and glacial Lake Missoula had the most significant impacts on the formation and shaping of the scablands characteristic of the Spokane River sub-basin.

Field Exploration

A total of two soil borings, DH-1 and DH-2, were drilled for the project on November 11 through November 15, 2013 to depths of approximately 137.5 feet and 129.5 feet, respectively, below existing grades. The boring locations are provided on the attached Figure 2. The borings were drilled with a Sonic 9221 drill rig operated by Cascade Drilling, L.P. (Cascade) based in Milton, Washington. Cascade used the truck mounted Sonic 9221 drilling rig with a six inch casing for all drilling.

Our field engineer recorded a log of each boring during the drilling operations. At selected intervals, samples of the subsurface materials were taken by driving a split-spoon sampler where possible. Penetration resistance measurements were obtained by driving the samplers into the subsurface materials with a 140-pound automatic hammer falling 30 inches. The penetration resistance value is a useful index in estimating the relative density, or consistency, of the materials encountered. A measurement for groundwater was made while each boring was being performed.

An automatic SPT hammer was used to advance the split-spoon sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The drill cuttings were collected and bagged by Cascade. Terracon's field engineer photographed, logged and disposed of the sample or re-bagged it for transport to our laboratory.
The borings were located by Terracon personnel using a handheld GPS unit and tied into the stream crossing and topographic surveys.

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer, and soil samples were classified in general accordance with the Unified Soil Classification System (USCS). At that time, the field descriptions were confirmed or modified as necessary, and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples, and the test results are presented herein as well as in Appendices A and B and as indicated on the boring logs. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected representative soil samples obtained from the site were tested for the following engineering properties:

- Water Content
- Sieve Analysis
- Atterberg Limits

Representative samples were submitted to Energy Laboratories, Inc. in Billings, Montana for determination of pH, sulfate, and resistivity content. The results are presented below, and a complete laboratory report is attached to this report:

Table 1 - pH, Sulfate, and Resistivity Results

Boring ID	*Sample*	*pH*	*Soluble Sulfate*	*Resistivity*
DH-1	3.67 feet	7.6	ND	1790 ohm-cm
DH-2	11.0 feet	7.8	ND	2330 ohm-cm

Note - ND - Not detected at reporting limit.

Soluble Sulfate values from 0.00 to 0.10 mg/kg are considered to have negligible attack on normal strength concrete. As a result, Type I Portland cement can be specified for project concrete placed on and below grade. However, if potential sulfate attack is of concern, Type II cement, with a low water: cement ratio, is customarily used. Foundation concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4.

Resistivity values between 1,000-3,000 ohm-cm are considered to be strongly aggressive with regard to corrosion of buried metals. If corrosion of buried metal is critical, it should be protected using a non-corrosive backfill, wrapping, coating, sacrificial anodes, or a combination of these methods, as designed by a qualified corrosion engineer.

Segregation of the drill cutting is common with Sonic drill rigs. As such, entire samples were collected and re-mixed in the laboratory to confirm the approximate soil gradations for different depths.

Subsurface Soil and Groundwater Conditions

The proposed HDD at this location will span Spokane River and be located within recent valley fill deposits. Drill holes DH-1 and DH-2 were located adjacent to the river and extended below the potential HDD profile and to sufficient depths for characterization of the subsurface at the entry/exit points of the proposed HDD. Their locations are presented on the attached Figures 2 and 3 in Appendix A.

DH-1 was located south of the Spokane River at the end of an unnamed, side road off of North Water Works Street. The proposed south HDD exit point is further south between DH-1 and the road. This boring was advanced to a depth approximately 137.5 feet below the ground surface (bgs).

DH-2 was located on an upper bench of the drainage to the north of the Spokane River and adjacent to the existing Yellowstone Pipeline 10 inch line. It was drilled in a grassy field in flat terrain, near the proposed entry point. The elevation of the boring is approximately 44 feet above the river. This boring was advanced to a depth approximately 129.5 feet bgs.

Encountered in both borings were two parent soil types; a well-graded gravel with sand and clay (GW-GC); and a well-graded sand with gravel and clay, (SW-SC). The soils were similar in appearance, so final designation was achieved through laboratory testing. The materials encountered were dense to medium dense alluvial, sub-rounded and rounded sands and gravels, interbedded with each other. Very small portions of cohesive fines were encountered and for the majority were considered non-plastic. The fines percentages ranged between 1 and 8.6 percent. The SVRP aquifer was encountered at about 30 feet and 44 feet bgs in DH-1 and DH-2. Cobbles were encountered throughout depths in both borings. Boulders were not present in core samples in any of the cuttings. The course nature of the sands and gravels encountered may present difficulties in keeping the hole open while drilling without the use of a casing.

We expect that groundwater will be encountered at about the elevation of the water surface in the river. These observations represent groundwater conditions at the time of the field exploration and may not be indicative of other times, or at other locations.

Photographs of the soil profiles are included in Appendix D.

HDD Profile

A plan and profile for the HDD crossings was developed using the 2014 site survey data and is provided on Figure 2 in Appendix A. A geologic profile showing the approximate soil contact was projected using the results of the geotechnical drilling program and observations. A potential HDD bore path is provided on the figures and essentially the shortest profile that can be developed at this location and provide adequate separation between the drill path and streambed. The individual HDD contractor will need to revise the bore path as appropriate for their equipment and experience. The potential HDD bore options were projected using the following parameters:

- A 20° entry and exit angle;
- 10-inch diameter pipe;
- Allowing for a minimum tangent of 40 feet from the entry/exit point before initiating curve to the horizontal;
- Allowing for a minimum of 40 feet of cover over the bore path in alluvial material as it passes under the river.

We have provided a preliminary design for the HDD. The pipe would be within the valley fill and would span the modern floodplain and the projected limits of the potential stream migration zone. The difference in elevation between the entry and exit points is approximately 20 feet.

Table 2 – HDD Criteria

	HDD (A-A')
Entry Angle, degrees	20
Exit Angle, degrees	20
Radius of Curvature	1000
Total Horizontal Distance, ft.	825
Total Pipe Length, ft.	848

HDD Pull Back Stress Analysis Recommendations

The estimated installation loads and resulting stresses on the pipe were analyzed using calculations presented in *Installation of Pipelines by Horizontal Directional Drilling* prepared for the American Gas Association by J.D. Hair & Associates, Inc., 1995.

For this location a 10-inch I.D., API X5L steel pipe, with a 0.365 inch wall thickness and specified minimum yield stress of 52,000 psi is to be used. The two paths of the HDD pipe were developed using the preliminary design drawing in Appendix A, Figure 2. We have assumed that the pilot hole will be reamed to a minimum of 20 inches in diameter (minimum twice the pipe inner diameter) and the reamed hole will be filled with drilling mud during pulling. Finally, we have calculated the pullback stresses for assuming that the pipe line will be either filled with water or filled with air and capped before it is pulled.

The total force required to pull the entire 10-inch pipe line while filled with water, as designed, into the reamed pilot hole was estimated at 19,500 lbs. Calculated installation stresses versus allowable stresses were compared at selected locations along the pathway using API Recommended Practice 2A-WSD; all cases were satisfied. The total force required to pull the entire 10-inch pipe line while empty, as designed, into the reamed pilot hole was estimated at 26,000 lbs. Calculated installation stresses versus allowable stresses were compared at selected locations along the pathway using API Recommended Practice 2A-WSD; all cases were satisfied.

The force required during pull back for an empty pipe is greater than the force required during pull back for a pipe filled with water as the buoyancy forces on the pipe must be overcome to drag the pipe down the hole. Table 3 below summarizes the pullback force.

Table 3 – Pullback Force

	HDD (A-A')
Pullback Force - water filled, lbs.	19,500
Pullback Force - air filled, lbs.	26,000
Maximum Pull Force, lbs.	309,100

If during the pipe line pull back operation, for either method described above, the 10-inch pipe gets "hung up" and the pulling force must be increased, a maximum pull of 309,100 lbs., which provides a safety factor of 2.0, should not be exceeded. Instead, we recommend that the pipe backed out of the hole and reamed again. A summary of the pull-back stress analysis calculations for the 10-inch pipe line is located in Appendix C.

The analysis was based on the surroundings and additional space and realignment will be required to layout the pipe before pulling in a linear fashion.

Water Sources for HDD Drilling Operations

A reliable water source is needed for the HDD drilling and installation process. Water may be purchased locally from Spokane County's municipal water supply, or from the Spokane Neighborhood Action Pro, owners of the River Walk Point Apartments located adjacent to exit location in the north. During geotechnical drilling water was purchased from the apartments, and the hydrant was tapped to fill the water tank.

Permits and Easements

The HDD installation and operation will not affect the river bed or banks as the entry and exit points will be located in the upland areas, and no wetlands will be affected. A Storm Water Pollution Prevention Plan will need to be submitted to the United States Environmental Agency before work can commence. Also, additional easements from the City of Spokane and potentially the State of Washington will be required. Phillips 66 is preparing the necessary permit and easement applications.

Abandoned Pipe Removal

Following completion of the new HDD crossing, Phillips 66 Pipeline LLC is proposing that the existing pipe line section in the river be abandoned in-place. In-place abandonment was determined to be the most viable alternative as removal would likely involve considerable disturbance to the river bed and banks with downstream sedimentation and would require closing this section of the river during the in-stream removal activities. For the abandonment, the pipe line section will be purged and swabbed then the line grouted with a weak, one-sack flowable sand/cement mixture and the ends capped. In this manner, over time without cathodic protection, the pipe will eventually degrade and the flowable fill become part of the valley fill that the pipe is buried in. The pipe line section, however, will continue to be monitored by Phillips 66 Pipeline LLC for further potential exposure. If further exposure of the abandoned section occurs in the future, alternatives will be assessed at that time, as they are generally dependent of the current situation.

If required to remove the existing crossing of North Spokane River, Phillips 66 Pipeline LLC will prepare separate permit applications for the removal.

General Comments

The subsurface information and opinions presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations which may occur between borings or across the site. The nature and extent of such variations may not become evident until construction. If variations appear, it will be necessary to reevaluate the suitability of the site conditions for a horizontal bore or HDD.

The scope of services for this project does not include, either specifically or by implication, any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical practices. No warranties, expressed or implied, are intended or made. In the event that changes in the nature, design, or location of the project, as outlined in this report, are planned, the opinion contained in this report shall not be considered valid unless Terracon reviews the changes, and either verifies or modifies the opinion of this report in writing.

Closing

We appreciate the opportunity to provide this service. Please contact us with any questions or further information regarding our analysis and for any additional services.

Sincerely,

TERRACON

State Of Washington Licensed Geologist
Engineering Geologist
2035
Daniel C. Nebel
Jan 9, 2015

Sarah R.P. Garland

Dan C. Nebel

Sarah R.P. Garland, P.E.
Project Manager, Geotechnical Engineer

Dan Nebel, P.G.
Principal

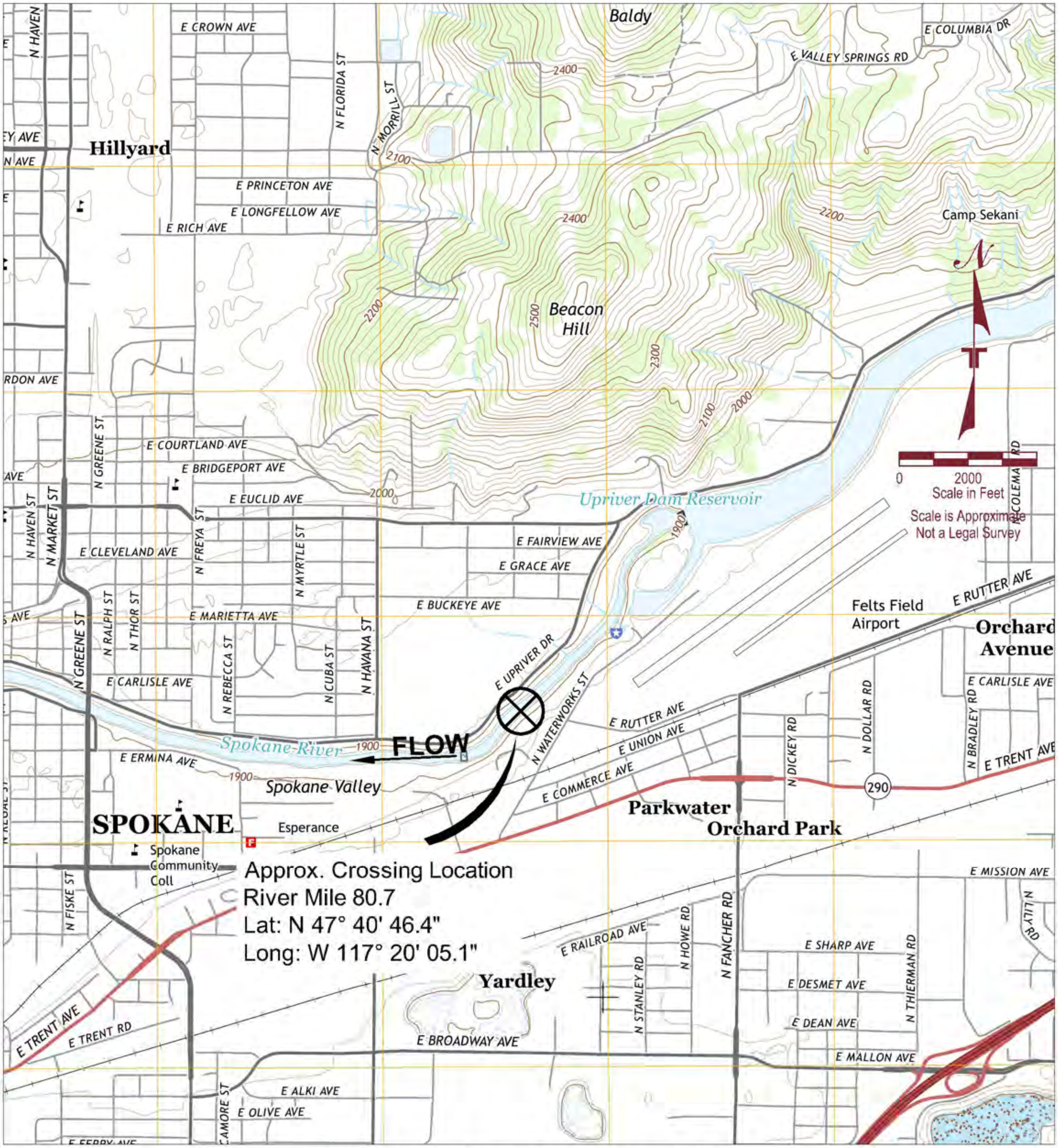
GARY W. ROME
Gary Rome
EXPIRES 3-11-2016

Reviewed by: Gary Rome, P.E.

Enclosures: Appendices

APPENDIX A

Legend: ━ Section Line



Approx. Crossing Location
River Mile 80.7
Lat: N 47° 40' 46.4"
Long: W 117° 20' 05.1"

NW/4 NW/4 Section 11, T.25N., R.43E.

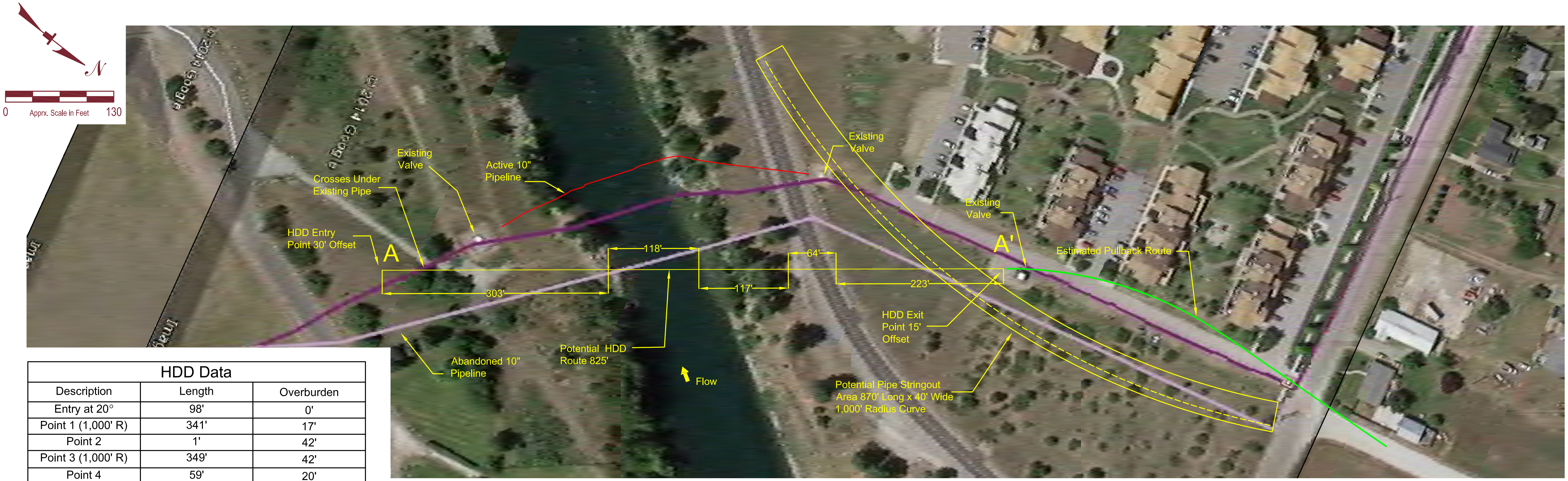
REV.	DATE	BY	DESCRIPTION

Terracon
Consulting Engineers and Scientists
2110 Overland Avenue, Suite 124 Billings, MT 59102
PH (406) 656-3072 FAX (406) 656-3578

Spokane River
Spokane to Parkwater
Phillips 66 Pipeline LLC
Yelowstone 10" Pipeline
Spokane County Washington

1

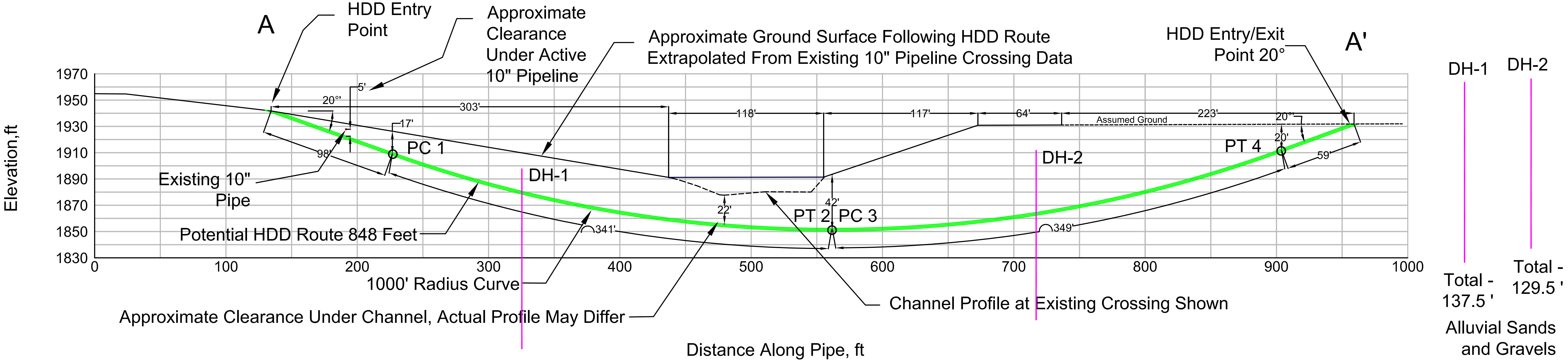
DESIGNED BY:	SGarland
DRAWN BY:	SGarland
APPVD. BY:	DNebel
SCALE:	1" = 1'
DATE:	December 2014
JOB NO.	26145031
FILE NAME:	HDD Spokane YP03
SHEET NO:	1 OF 6



Aerial Dated July 2, 2014; Excerpted From Google Earth

HDD Data		
Description	Length	Overburden
Entry at 20°	98'	0'
Point 1 (1,000' R)	341'	17'
Point 2	1'	42'
Point 3 (1,000' R)	349'	42'
Point 4	59'	20'
Exit at 20°	-	0'
Horizontal Distance =825'		
HDD Pipe Length = 848'		

HDD Profile Looking Downstream at Crossing



REV.	DATE	BY	DESCRIPTION

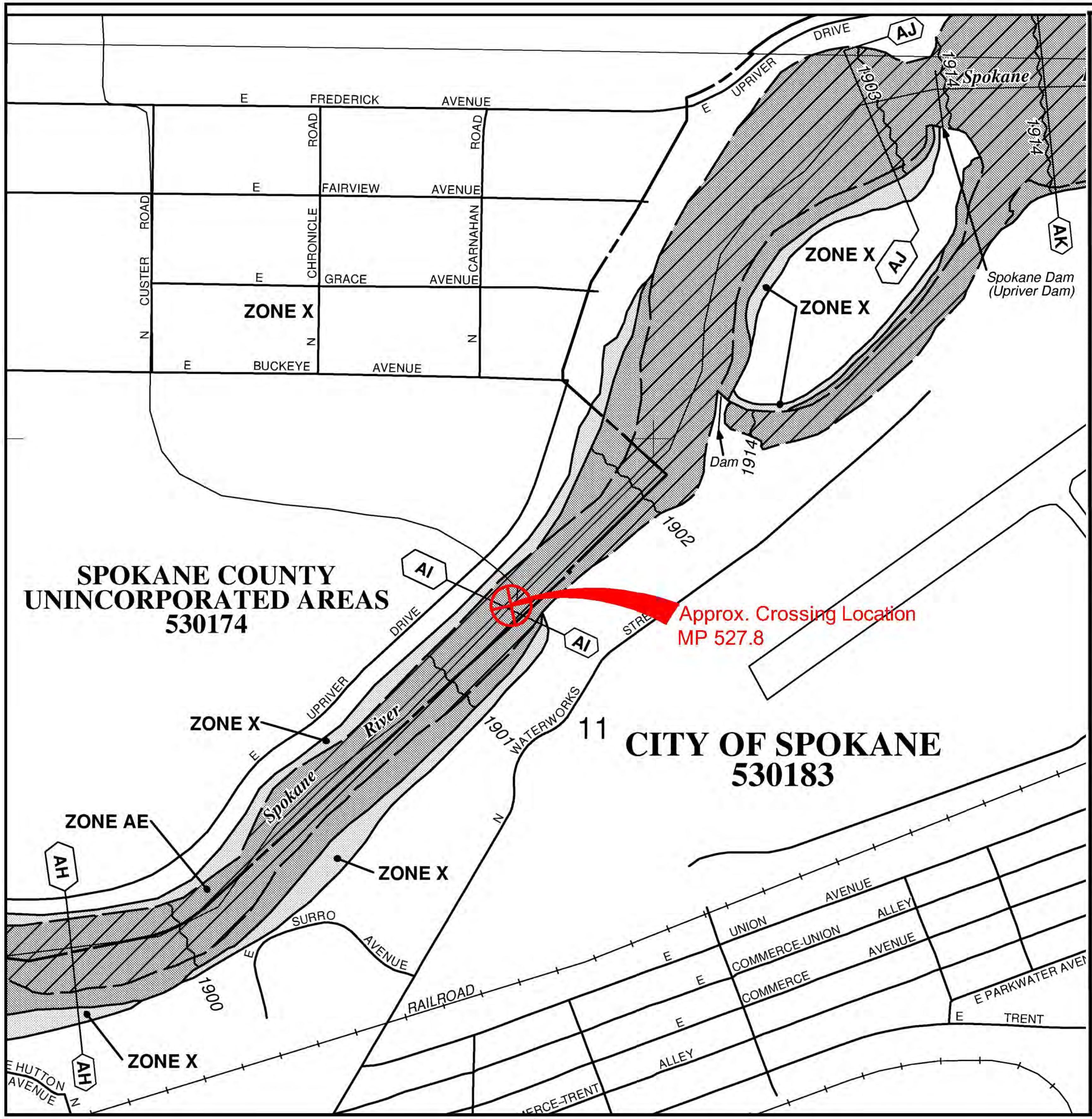
Terracon
Consulting Engineers and Scientists
2110 Overland Avenue, Suite 124 Billings, MT 59102
PH. (406) 656-3072 FAX. (406) 656-3578

Spokane River Potential HDD

Spokane - Parkwater
Phillips 66 Pipline LLC.
YPO3 - 10" Pipeline
Spokane County Washington

2

DESIGNED BY:	ATorres
DRAWN BY:	ATorres
APPVD. BY:	DNebel
SCALE:	As Shown
DATE:	August 2014
JOB NO.	26145013
FILE NAME:	Spkn prwtr.dwg
SHEET NO.:	2 OF 6



LEGEND

▨ SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

▨ FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

▨ OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

☐ OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

▨ COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

▨ OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

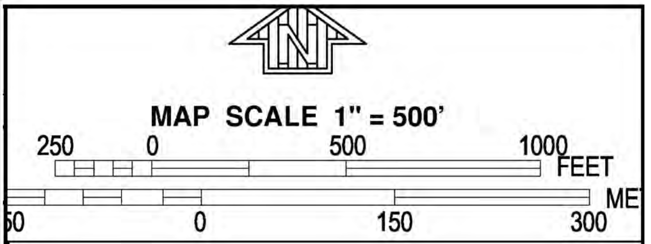
———————	Floodplain boundary
— — —	Floodway boundary
- ———— ———— -	Zone D boundary
•••••••••••••••••	CBRS and OPA boundary
▭ ←	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ 513 ~~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

(A)———(A)	Cross section line
(23)- - - - - - - -(23)	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid ticks, zone 11
6000000 M	5000-foot grid ticks: Washington State Plane coordinate system, north zone (FIPSZONE 4601),Lambert Conformal Conic
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES

Refer to Map Repositories list on Map Index



MAP SCALE 1" = 500'

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0562D

FIRM
FLOOD INSURANCE RATE MAP
SPOKANE COUNTY, WASHINGTON
AND INCORPORATED AREAS

PANEL 562 OF 1150
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SPOKANE COUNTY	530174	0562	D
SPOKANE VALLEY, CITY OF	530342	0562	D
SPOKANE, CITY OF	530183	0562	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
53063C0562D

EFFECTIVE DATE
JULY 6, 2010

Federal Emergency Management Agency

REV.	DATE	BY	DESCRIPTION
1	12/22/14	SG	

Terracon
Consulting Engineers and Scientists

2110 Overland Avenue, Suite 124
Billings, MT 59102
PH. (406) 656-3072
FAX (406) 656-3578

Spokane River Potential HDD

Spokane to Parkwater

Phillips 66 Pipline LLC.

YPO3 - 10" Pipeline

Spokane County
Washington

3

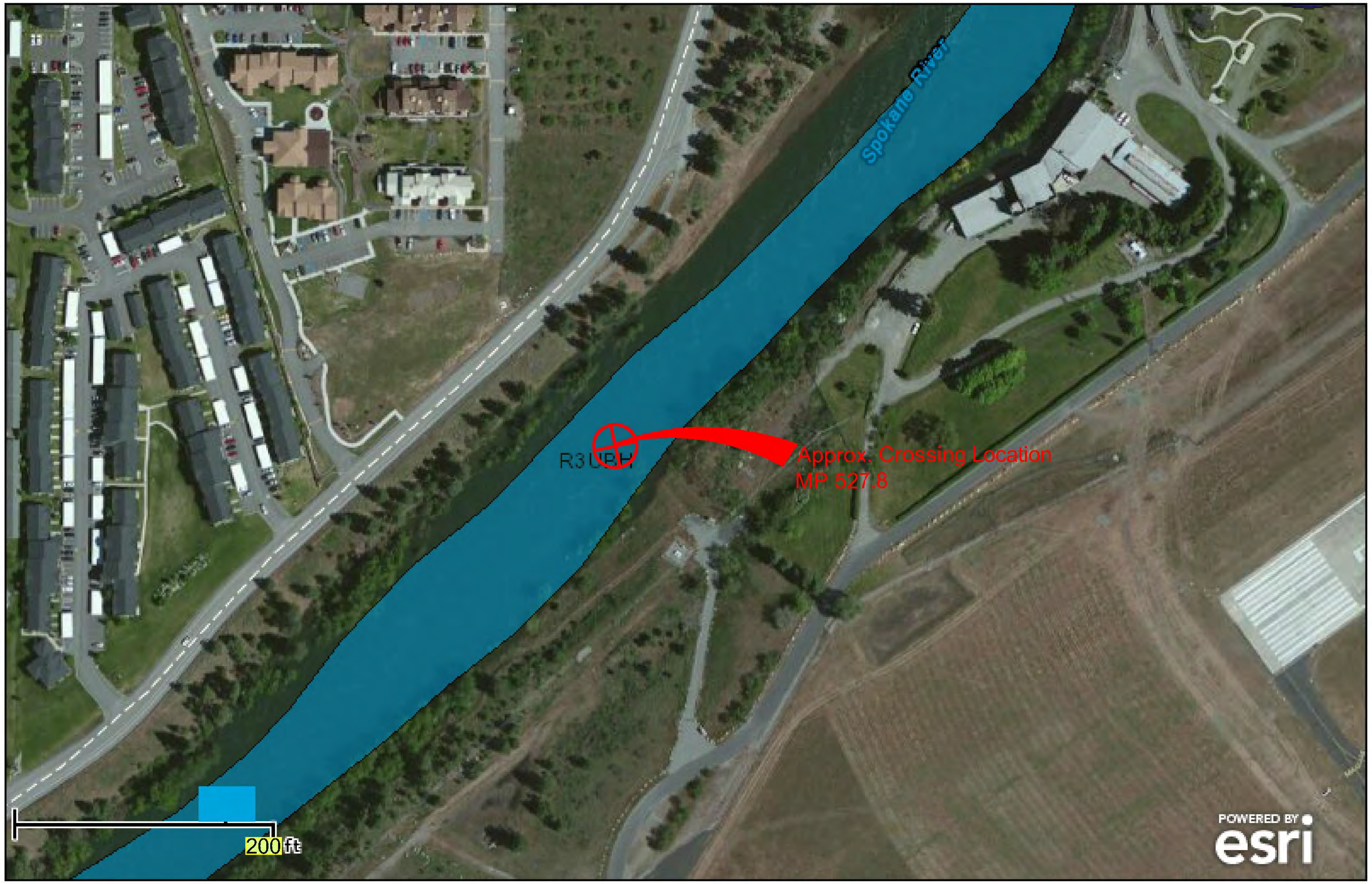
DESIGNED BY:	ATorres & S Garland
DRAWN BY:	ATorres
APPVD. BY:	DNebel
SCALE:	As Shown
DATE:	December 2014
JOB NO.	26145031
FILE NAME:	Spkn prwtr.dwg
SHEET NO.:	3 OF 5

U.S. Fish and Wildlife Service

National Wetlands Inventory

Spokane River - YP03 10" P66 Crossing

Dec 17, 2014



Wetlands

- 🟩 Freshwater Emergent
- 🟩 Freshwater Forested/Shrub
- 🟦 Estuarine and Marine Deepwater
- 🟩 Estuarine and Marine
- 🟦 Freshwater Pond
- 🟦 Lake
- 🟦 Riverine
- 🟫 Other

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

REV.	DATE	BY	DESCRIPTION
1	12/22/14	SG	

Terracon
Consulting Engineers and Scientists
2110 Overland Avenue, Suite 124
Billings, MT 59102
PH. (406) 656-3072
FAX. (406) 656-3578

Spokane River Potential HDD
Spokane to Parkwater
Phillips 66 Pipline LLC.
YPO3 - 10" Pipeline
Spokane County
Washington

4

DESIGNED BY:	S Garland
DRAWN BY:	SGarland
APPVD. BY:	DNebel
SCALE:	1" = 200'
DATE:	December 2014
JOB NO.	26145031
FILE NAME:	Spkn prwtr.dwg
SHEET NO.:	4 OF 5

Legend: 🟥 City of Spokane 🟦 Spokane Neighborhood Act Pro.
🟩 Riverwalk Point I LLC.

NW/4 NW/4 Section 11, T.25N., R.43E.

REV.	DATE	BY	DESCRIPTION

Terracon
Consulting Engineers and Scientists
2110 Overland Avenue, Suite 124 Billings, MT 59102
PH. (406) 656-3072 FAX (406) 656-3578

Spokane River
Spokane to Parkwater
Phillips 66 Pipeline LLC
Yelowstone 10" Pipeline
Spokane County Washington

5

DESIGNED BY:	SGarland
DRAWN BY:	SGarland
APPVD. BY:	DNebel
SCALE:	NTS
DATE:	December 2014
JOB NO.	26145031
FILE NAME:	HDD Spokane YP03
SHEET NO.:	5 OF 5

BORING LOG NO. DH-1

Page 1 of 2

PROJECT: YPL HDD of Spokane River

CLIENT: Phillips 66 Pipeline LLC
Billings, MT

SITE: YP03 Parkwater to N. Spokane Terminal
Spokane, WA

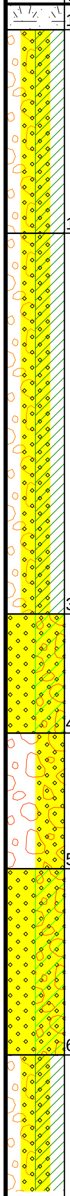
SG

LOCATION See Exhibit A-1

Latitude: 47.67963883° Longitude: 117.33475°

Approximate Surface Elev: 1898 (Ft.) +/-

GRAPHIC LOG



DEPTH		ELEVATION (Ft.)
1.5	**TOPSOIL**	1896.5+/-
13.5	**WELL GRADED GRAVEL WITH CLAY AND SAND (GW-GC)**, Interbedded light brown, coarse and fine, angular alluvial gravel with clay and sand, very dense to dense, hit cobble in last six inches of spoon at 7.0 feet.	1884.5+/-
36.0	**WELL GRADED GRAVEL WITH CLAY AND SAND (GW-GC)**, Visible increase in moisture content to a brown, fine, rounded-subrounded gravel with coarse sand and clay, medium dense to dense with an increase. **Interbedded coarse gravels and cobbles throughout.**	1862+/-
43.0	**WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC)**, Brown, coarse and fine, rounded, glacial outwash sand with gravel and clay lenses, interbedded, medium dense, occasional cobbles.	1855+/-
51.0	**WELL GRADED GRAVEL WITH SAND (GW)**, Brown, coarse and fine, rounded-subrounded gravel with coarse sand, medium dense, very little fines, with subrounded cobbles intermixed. **Casing and SPT sampler dropped within hole due to loosness of soil matrix, no samples collected as all retreival attempts were empty.**	1847+/-
62.0	**WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC)**, Brown, coarse and fine, rounded, glacial outwash sand with gravel and clay lenses, interbedded, medium dense, occasional cobbles. **Casing and SPT sampler dropped within hole due to loosness of soil matrix, no samples collected as all retreival attempts were essentially empty, and cobbles were pushed below casing.**	1836+/-
	WELL GRADED GRAVEL WITH CLAY AND SAND (GW-GC), Brown, coarse and fine, rounded-subrounded gravel with coarse to fine sand and clay, medium dense, very little fines, with subrounded cobbles intermixed.	

DEPTH (Ft.): 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70

WATER LEVEL OBSERVATIONS: ▽ (approx. 29 ft)

SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Percent Fines
	0	No sample	10		
☒	1.5	18-15-50 N=65	4		
☒	1	11-14-18 N=32	3		
☒	0.67	15-15-11 N=26	5		
☒	0.58	17-27-18 N=45	3		
☒	0.58	6-8-12 N=20	5		7
☒	0.58	34-11-17 N=28	3		
☒	0.75	7-9-10 N=19	16		
☒	0.92	2-4-12 N=16	2		
☒	0				
☒	1.1	4-9-13 N=22	17		
☒	1.1	1-4-8 N=12	27		
☒	0.42	2-9-9 N=18	14		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Sonic

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit 7 for description of field procedures

See Appendix A-9 for description of laboratory procedures and additional data, (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Spokane Valley-Rathdrum Prairie Aquifer*

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

Boring Started: 11/11/2014	Boring Completed: 11/14/2014
Drill Rig: Sonic	Driller: Dave Donnelly
Project No.: 26145031	Exhibit: A-6

BORING LOG NO. DH-1

PROJECT: YPL HDD of Spokane River

CLIENT: Phillips 66 Pipeline LLC
Billings, MT

SITE: YP03 Parkwater to N. Spokane Terminal
Spokane, WA

SG

LOCATION See Exhibit A-1

Latitude: 47.67963883° Longitude: 117.33475°

Approximate Surface Elev: 1898 (Ft.) +/-

DEPTH	GRAPHIC LOG / DESCRIPTION	ELEVATION (Ft.)
71.0	**WELL GRADED SAND WITH GRAVEL (SW)**, Brown, coarse and fine, interbedded lenses of glacial outwash sand with coarse and fine gravels intermixed. There were very few fines within this stratum.	1827+/-
83.0	**WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC)**, Brown, coarse and fine, rounded, glacial outwash sand with gravel and clay lenses, interbedded, medium dense, occasional cobbles. **Approximately 8% of sample had cobbles 3 inches and larger.** **Clay fines cementing to gravels and sands.** **Heaving of sand within casing exibited and remained throughout remaining portion of hole.**	1815+/-
137.5	*Boring Terminated at 137.5 Feet*	1760.5+/-

DEPTH (Ft.): 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135

SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Percent Fines
☒	0.42	44-15-15 N=30	9		1
☒	1.5	2-4-8 N=12	8		
☒	1.5	2-2-6 N=8	19		
☒	0.5	36-48-50 N=98	15		
☒	0.67	16-19-27 N=46	8		5
	0		11		
☒	1.5	4-8-10 N=18	14		
				44-17-27	
			13		
☒	1.5				
					9
☒	1.5	1-1-1 N=2	15		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Sonic

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit 7 for description of field procedures

See Appendix A-9 for description of laboratory procedures and additional data, (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Spokane Valley-Rathdrum Prairie Aquifer*

2110 Overland Ave., Suite 124
Billings, Montana

Boring Started: 11/11/2014	Boring Completed: 11/14/2014
Drill Rig: Sonic	Driller: Dave Donnelly
Project No.: 26145031	Exhibit: A-7

BORING LOG NO. DH-2

PROJECT: YPL HDD of Spokane River

CLIENT: Phillips 66 Pipeline LLC
Billings, MT

SITE: YP03 Parkwater to N. Spokane Terminal
Spokane, WA

SG

LOCATION See Exhibit A-1

Latitude: 47.68077778° Longitude: 117.3359722°

Approximate Surface Elev: 1912 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)
0.7	**TOPSOIL**	1911.5+/-
7.5	**WELL GRADED GRAVEL WITH CLAY AND SAND (GW-GC)**, Interbedded light brown, coarse and fine, angular alluvial gravel with clay and sand, very dense to dense.	1904.5+/-
44.0	**WELL GRADED GRAVEL WITH CLAY AND SAND (GW-GC)**, Visible increase in moisture content to a brown, fine, rounded-subrounded gravel with coarse sand and clay, medium dense to dense.	1868+/-
	WELL GRADED GRAVEL WITH SAND (GW), Brown, coarse and fine, rounded-subrounded gravel with coarse to fine sand, medium dense, with subrounded cobbles intermixed.	

DEPTH (Ft.): 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70

WATER LEVEL OBSERVATIONS: ▽ at approximately 44 ft

SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Percent Fines
☒	0.33		3		
☒	1.08	21-23-17 N=40	5		
☒	1.33	14-11-8 N=19	8		
☒	0.92	9-6-7 N=13	7		
☒	1	16-10-10 N=20	7		
☒	0.67	14-13-8 N=21	10		
☒	0.67	13-11-9 N=20	8		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Sonic

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit 7 for description of field procedures

See Appendix A-9 for description of laboratory procedures and additional data, (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Spokane Valley-Rathdrum Prairie Aquifer*

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

Boring Started: 11/14/2014	Boring Completed: 11/15/2014
Drill Rig: Sonic	Driller: Dave Donnelly
Project No.: 26145031	Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 26145031 - SPOKANE P66.GPJ ODOT TEST.GPJ 1/9/15

BORING LOG NO. DH-2

Page 2 of 2

PROJECT: YPL HDD of Spokane River

CLIENT: Phillips 66 Pipeline LLC
Billings, MT

SITE: YP03 Parkwater to N. Spokane Terminal
Spokane, WA

SG

LOCATION See Exhibit A-1

Latitude: 47.68077778° Longitude: 117.3359722°

Approximate Surface Elev: 1912 (Ft.) +/-

GRAPHIC LOG	DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Ft.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	Percent Fines
	73.0		1839+/-								
		WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC), Brown, coarse and fine, rounded, glacial outwash sand with gravel and clay, medium dense, occasional cobbles.		75		☒	0.42	3-3-2 N=5	24		
				80 85 90 95							
	96.0		1816+/-								
		WELL GRADED GRAVEL WITH SAND (GW), Brown, coarse and fine, rounded-subrounded gravel with coarse sand, medium dense, with subrounded cobbles intermixed.				☒	0.75	37-23-16 N=39	2		5
				100 105							1
						☒	0	No sample			
				110 115							
	121.0		1791+/-	120							
		WELL GRADED GRAVEL WITH CLAY AND SAND (GW-GC), Brown, coarse and fine, rounded-subrounded gravel with coarse to fine sand and clay, medium dense, 5.5% fines, with subrounded cobbles intermixed.									6
	126.0		1786+/-	125							
		WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC), Brown, coarse and fine, rounded, glacial outwash sand with gravel and clay, interbedded, medium dense, occasional cobbles.				☒	0.75	29-24-17 N=41	11		
	129.5	***Boring Terminated at 129.5 Feet***	1782.5+/-								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Sonic

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit 7 for description of field procedures

See Appendix A-9 for description of laboratory procedures and additional data, (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

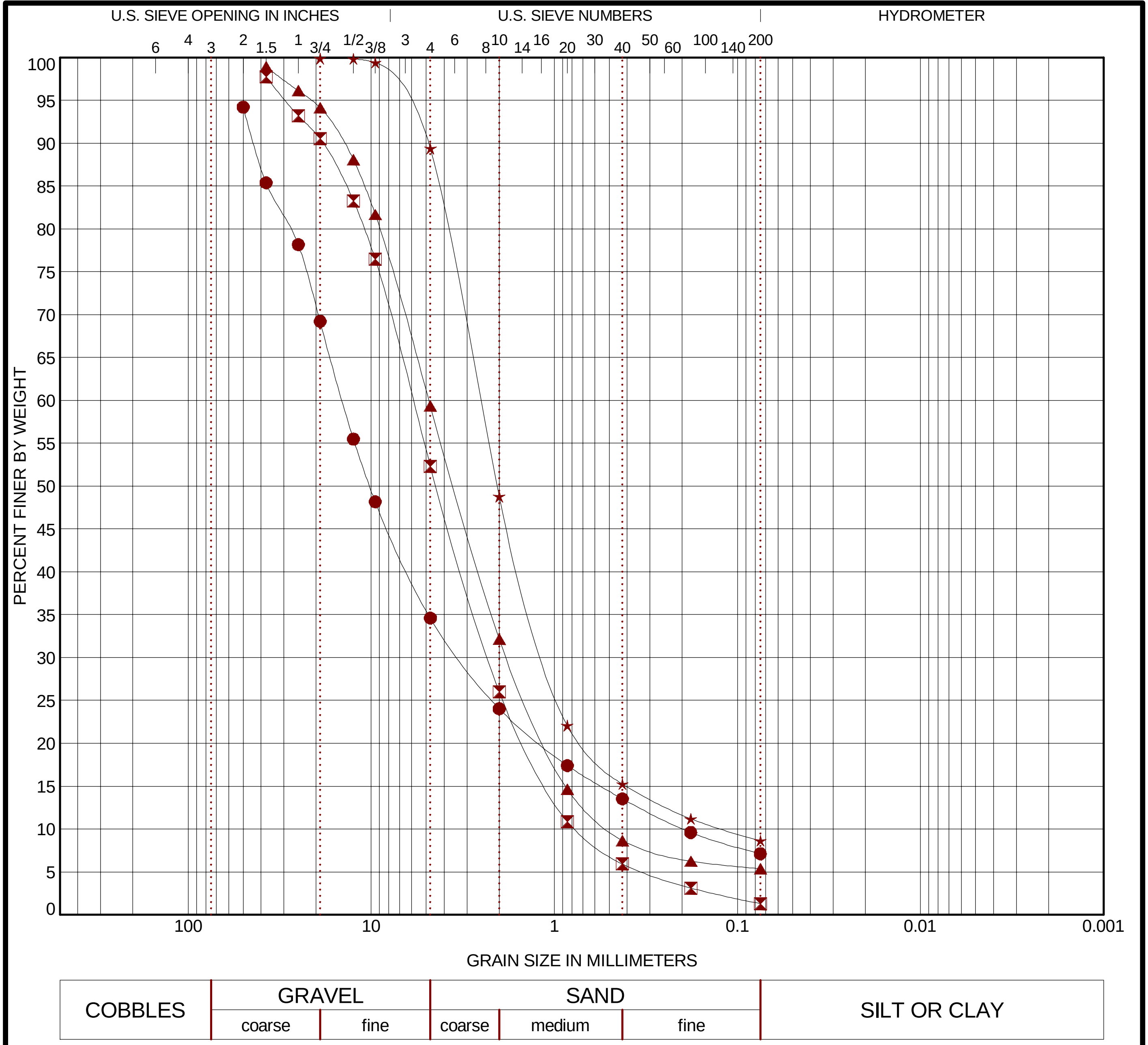
▽ *Spokane Valley-Rathdrum Prairie Aquifer*

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

Boring Started: 11/14/2014	Boring Completed: 11/15/2014
Drill Rig: Sonic	Driller: Dave Donnelly
Project No.: 26145031	Exhibit: A-9

GRAIN SIZE DISTRIBUTION

ASTM D422



	Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	DH-1	26.0	WELL-GRADED GRAVEL WITH SAND & CLAY(GW-GC)				3.77	72.85
⊠	DH-1	72.0	WELL-GRADED SAND with GRAVEL(SW)				1.17	7.87
▲	DH-1	92.0	WELL-GRADED SAND WITH GRAVEL & CLAY(SW-SC)				1.35	9.75
★	DH-1	135.0	WELL-GRADED SAND WITH GRAVEL & CLAY(SW-SC)				3.95	21.19

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	DH-1	26.0	50	14.342	3.261	0.197	59.6	27.5	7.1	
⊠	DH-1	72.0	37.5	5.925	2.281	0.753	45.5	51.0	1.3	
▲	DH-1	92.0	37.5	4.845	1.801	0.497	39.6	54.0	5.4	
★	DH-1	135.0	19	2.539	1.096	0.12	10.5	80.8	8.6	

PROJECT: YPL HDD of Spokane River

SITE: YP03 Parkwater to N. Spokane Terminal
Spokane, WA

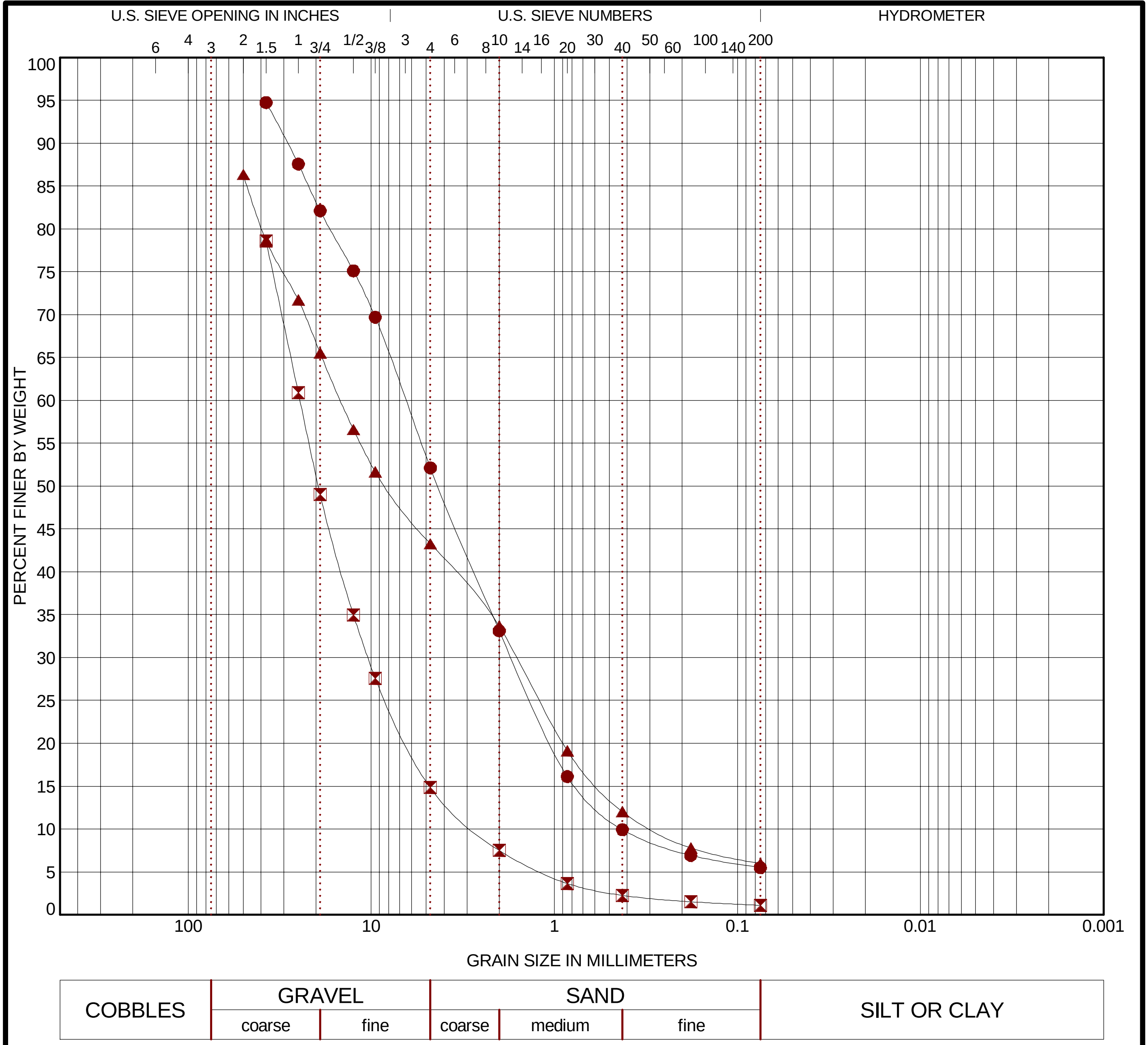
Terracon
2110 Overland Ave., Suite 124
Billings, Montana

PROJECT NUMBER: 26145031

CLIENT: Phillips 66 Pipeline LLC
Billings, MT

GRAIN SIZE DISTRIBUTION

ASTM D422



	Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	DH-2	96.0	WELL-GRADED SAND WITH GRAVEL & CLAY(SW-SC)				1.05	15.11
⧗	DH-2	106.0	WELL-GRADED GRAVEL(GW)				1.64	9.11
▲	DH-2	123.0	WELL-GRADED GRAVEL WITH SAND & CLAY(GW-GC)				0.63	51.81

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	DH-2	96.0	37.5	6.478	1.709	0.429	42.6	46.6	5.5	
⧗	DH-2	106.0	37.5	24.489	10.387	2.689	63.8	13.7	1.1	
▲	DH-2	123.0	50	14.653	1.612	0.283	43.1	37.3	6.0	

PROJECT: YPL HDD of Spokane River

SITE: YP03 Parkwater to N. Spokane Terminal
Spokane, WA

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

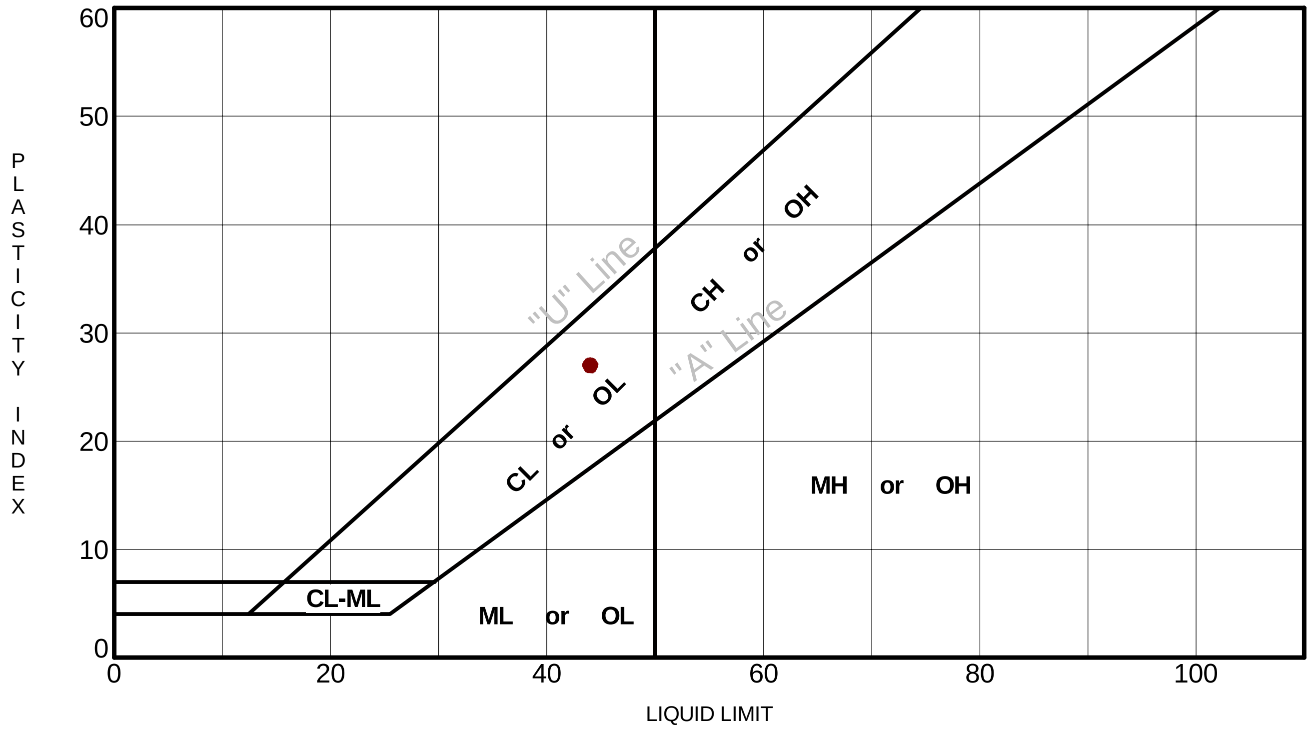
PROJECT NUMBER: 26145031

CLIENT: Phillips 66 Pipeline LLC
Billings, MT

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 26145031 - SPOKANE P66.GPJ TERRACON2012.GDT 12/31/14

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**DH-1**	**111.0**	**44**	**17**	**27**		**SW-SC**	**WELL-GRADED SAND WITH GRAVEL & CLAY(SW-SC)**

PROJECT: YPL HDD of Spokane River

SITE: YP03 Parkwater to N. Spokane Terminal
Spokane, WA

Terracon
2110 Overland Ave., Suite 124
Billings, Montana

PROJECT NUMBER: 26145031

CLIENT: Phillips 66 Pipeline LLC
Billings, MT

ANALYTICAL SUMMARY REPORT

December 24, 2014

Terracon Consultants
6675 Maltese Ln
Bozeman, MT 59718-7550

Work Order: B14121850
Project Name: P66-Spokane

Energy Laboratories Inc Billings MT received the following 2 samples for Terracon Consultants on 12/22/2014 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B14121850-001	DH-1 3 Feet 8 Inches	11/12/14 9:00	12/22/14	Soil	pH, Saturated Paste Resistivity of soil extract Sulfate-Geochemical
B14121850-002	DH-2 11 Feet 0 Inches	11/14/14 9:00	12/22/14	Soil	Same As Above

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

Sonya Mallett

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Terracon Consultants	**Report Date:**	12/24/14
Project:	P66-Spokane	**Collection Date:**	11/12/14 09:00
Lab ID:	B14121850-001	**DateReceived:**	12/22/14
Client Sample ID:	DH-1 3 Feet 8 Inches	**Matrix:**	Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SATURATED PASTE							
pH, sat. paste	7.60	s.u.		0.100		ASAM10-3.2	12/24/14 09:06 / srm
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	ND	wt%		0.01		MTDOT	12/23/14 14:38 / srm
RESISTIVITY OF SOIL							
Resistivity, Sat. Paste	1790	ohm-cm		1		Calculation	12/24/14 09:06 / srm

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client:	Terracon Consultants	**Report Date:**	12/24/14
Project:	P66-Spokane	**Collection Date:**	11/14/14 09:00
Lab ID:	B14121850-002	**DateReceived:**	12/22/14
Client Sample ID:	DH-2 11 Feet 0 Inches	**Matrix:**	Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SATURATED PASTE							
pH, sat. paste	7.80	s.u.		0.100		ASAM10-3.2	12/24/14 09:06 / srm
CHEMICAL CHARACTERISTICS							
Sulfate, HCL Extractable	ND	wt%		0.01		MTDOT	12/23/14 14:38 / srm
RESISTIVITY OF SOIL							
Resistivity, Sat. Paste	2330	ohm-cm		1		Calculation	12/24/14 09:06 / srm

Report Definitions:

RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Terracon Consultants
Project: P66-Spokane

Report Date: 12/24/14
Work Order: B14121850

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASAM10-3.2									Batch: R235864
Lab ID: B14121320-001A DUP	Sample Duplicate				Run: MISC-SOIL_141224A				12/24/14 09:06
pH, sat. paste	7.70	s.u.	0.10				1.3	10	
Lab ID: LCS-1412240906	Laboratory Control Sample				Run: MISC-SOIL_141224A				12/24/14 09:06
pH, sat. paste	7.00	s.u.	0.10	99	90	110			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Terracon Consultants
Project: P66-Spokane

Report Date: 12/24/14
Work Order: B14121850

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: Calculation									Batch: R235864
Lab ID: B14121320-001A DUP	Sample Duplicate				Run: MISC-SOIL_141224A				12/24/14 09:06
Resistivity, Sat. Paste	331	ohm-cm	1.0				0.3	50	
Lab ID: LCS-1412240906	Laboratory Control Sample				Run: MISC-SOIL_141224A				12/24/14 09:06
Resistivity, Sat. Paste	73.0	ohm-cm	1.0	133	50	150			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Terracon Consultants

Project: P66-Spokane

Report Date: 12/24/14

Work Order: B14121850

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: MTDOT									Batch: R235864
Lab ID: MBLK1	Method Blank				Run: MISC-SOIL_141224A				12/23/14 14:37
Sulfate, HCL Extractable	0.004	wt%							
Lab ID: B14121850-001A DUP	Sample Duplicate				Run: MISC-SOIL_141224A				12/23/14 14:38
Sulfate, HCL Extractable	0.00	wt%	0.01					50	
Lab ID: LCS	Laboratory Control Sample				Run: MISC-SOIL_141224A				12/23/14 14:38
Sulfate, HCL Extractable	0.34	wt%	0.01	95	50	150			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Workorder Receipt Checklist

Terracon Consultants

B14121850

Login completed by: Randa Nees

Date Received: 12/22/2014

Reviewed by: BL2000\lcadreau

Received by: lg

Reviewed Date: 12/22/2014

Carrier name: UPS Ground

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☐	No ☑	Not Applicable ☐
Container/Temp Blank temperature:	14.6℃ No Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Contact and Corrective Action Comments:

None

ENERGY

Chain of Custody and Analytical Request Record

Page ____ of ____

PLEASE PRINT (Provide as much information as possible.)

Company Name: Terracon, Inc.

Report Mail Address (Required):
212 ~~[illegible]~~ 2oot Way ste. B
Bozeman MT. 59718

☐ No Hard Copy Email: ____

Invoice Address (Required):
~~[illegible]~~ 2110 overland Ave.
Billing MT. 59102

☐ No Hard Copy Email: ____

Special Report/Formats:
☐ DW
☐ POTW/WWTP
☐ State: ____
☐ Other: ____
☐ EDD/EDT(Electronic Data)
Format: ____
☐ LEVEL IV
☐ NELAC

Project Name, PWS, Permit, Etc.: Pl. 6 - Spokane

Sample Origin State: WA

EPA/State Compliance: Yes ○ No ○

Contact Name: Sarah Gorland

Phone/Fax: (406)581-1979

Cell: sigarland@terracon.com

Sampler: (Please Print) SG

Invoice Contact & Phone: Chris LaRance (406) 371-9855

Purchase Order:

Quote/Bottle Order:

Contact ELI prior to RUSH sample submittal for charges and scheduling – See Instruction Page

Comments:

	SAMPLE IDENTIFICATION (Name, Location, Interval, etc.)	Collection Date	Collection Time	MATRIX	Number of Containers Sample Type: A W S V B O DW Air Water Soils/Solids Vegetation Bioassay Other DW - Drinking Water	pH	Sulfate content	Resistivity							SEE ATTACHED	Standard Turnaround (TAT)	RUSH	
1	DH-1 3'8"	11/12/14	9:00 AM	Soil		X	X	X	☐	☐	☐	☐	☐	☐	☐	○	⊗	B14121850-001
2	DH-2 11'0"	11/14/14	9:00 AM	Soil		X	X	X	☐	☐	☐	☐	☐	☐	☐	○	⊗	⊥ 002
3						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	○	○	
4						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	●	○	
5						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	●	○	
6						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	●	○	
7						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	●	○	
8						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	●	○	
9						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	○	○	
10						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	○	○	

LABORATORY USE ONLY

Shipped by: SG UPS GRD

Cooler ID(s):

Receipt Temp 14.6 °C

On Ice: Y [✓ N]

Custody Seal
On Bottle Y [✓ N]
On Cooler Y [✓ N]
Intact Y N
Signature Match Y N

Custody Record MUST be Signed

Relinquished by (print): Sarah R. P. Gorland Date/Time: 12/16/14 Signature:

Relinquished by (print): Date/Time: Signature:

Received by (print): Date/Time: Signature:

Received by (print): Date/Time: Signature:

Received by Laboratory: Date/Time: 12-22-14 9:15 Signature:

Sample Disposal: Return to Client: ○ Lab Disposal: ○

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.
This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report.
Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

APPENDIX B

Field Exploration Description

The boring locations were staked on the site by our personnel. Ground surface elevations were also determined in the field by Terracon with a handheld GPS unit. Boring elevations are provided to the nearest hundreth of a foot. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with a Sonic 9221 drill rig using vibration. Samples of the soil encountered in the borings were obtained using the split-barrel sampling procedures, and collection of the drill cuttings.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound C.M.E. auto-hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils.

A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller’s interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

Laboratory Test Description

Soil samples were tested in the laboratory to measure their natural water content. Atterberg Limits (soil plasticity determined by the moisture range through which a soil passes from a plastic to liquid consistency) in accordance with ASTM D4318. The results of all these tests have been presented on the Logs as well as the accompanying Plates.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. All classification was by visual manual procedures. Selected samples were further classified using the results of grain size analysis (gradation) and Atterberg limit testing. The gradation and Atterberg limit test results are also provided on the boring logs.

Gradation testing is conducted in general accordance with ASTM C136 procedures. This test determines the particle size distribution of a soil by wet and dry-sieving it over standard sized screens. The particle size distribution plays a large role in determining the soil classification.

Consolidation is the process of time-dependent settlement of clayey soil when subjected to an increased loading. This testing is conducted in a fixed-ring consolidometer in general accordance with the procedures of ASTM D2435-90. The test measures sample strain (settlement) with time for a series of increasing loads applied on the sample surface area; pressure versus strain relations are thereby determined. Specimens for the testing are trimmed from “undisturbed” samples retrieved commonly by Shelby tube or California ring sampler. Specimen dimensions for testing are typically 2.5 inches in diameter by 1.0 inch in height. During the test, specimens may be inundated at a selected normal pressure to simulate field conditions and determine swell behavior. Test data is generally reduced using the square root of time fitting method to determine specimen strain at 100 percent of primary consolidation for each load increment. This strain at progressive load increments is plotted to construct the consolidation curve for which field soil deformation can be approximated.

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SSS: Standard Split Spoon – 1-$^{3}/_{8}$" I.D., 2" O.D., unless otherwise noted
ST: Thin-Walled Tube - 2" O.D., unless otherwise noted
RS: Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted
DB: Diamond Bit Coring - 4", N, B
BS: Bulk Sample or Auger Sample

HS: Hollow Stem Auger
PA: Power Auger
HA: Hand Auger
RB: Rock Bit
WB: Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the “Standard Penetration” or “N-value”.

WATER LEVEL MEASUREMENT SYMBOLS:

WL: Water Level
WCI: Wet Cave in
DCI: Dry Cave in
AB: After Boring

WS: While Sampling
WD: While Drilling
BCR: Before Casing Removal
ACR: After Casing Removal

N/E: Not Encountered

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 – 1	Very Soft
500 – 1,000	2 – 4	Soft
1,001 – 2,000	4 – 8	Medium Stiff
2,001 – 4,000	8 – 15	Stiff
4,001 – 8,000	15 – 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
> 50	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 – 10
Medium	11 – 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	$PI > 7$ and plots on or above “A” line [J]		CL	Lean clay [K,L,M]
			$PI < 4$ or plots below “A” line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K,L,M]
			PI plots below “A” line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ≥ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.

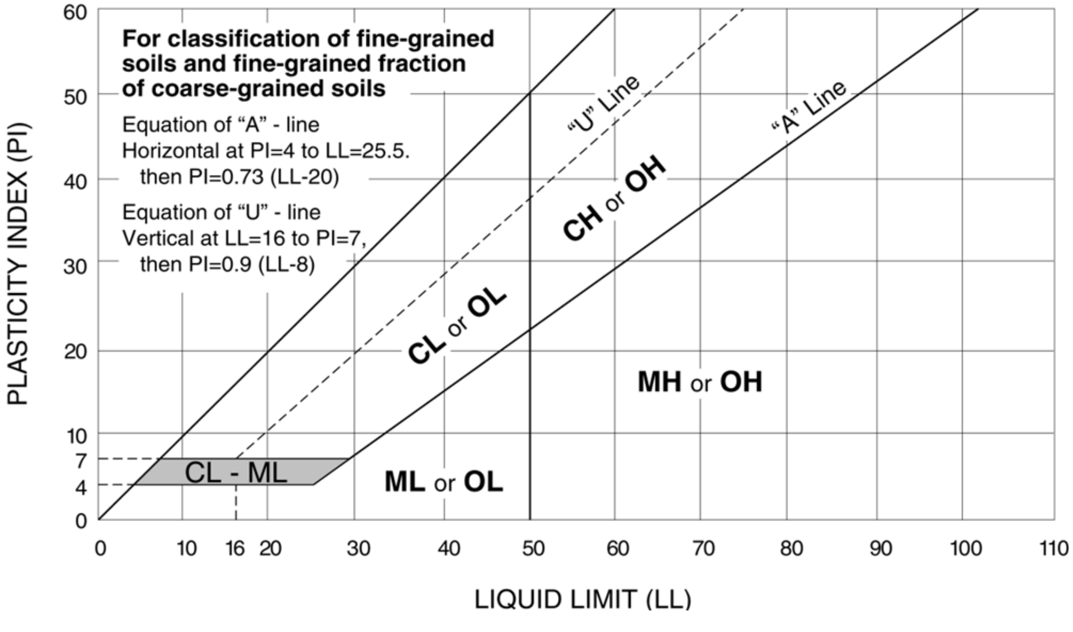
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] $PI \geq 4$ and plots on or above “A” line.

[O] $PI < 4$ or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



RECOMMENDED SPECIFICATIONS FOR
PORTLAND CEMENT CONCRETE PAVEMENT MATERIALS

Subgrade Preparation & Density

Subgrade bases (when employed) should be prepared and compacted in accordance with Minimum Density Requirements of the guidelines for “Flexible Pavement Materials”.

Portland Cement Concrete

Pavement concrete should conform to the requirements of ASTM C94 and have the following properties:

Property	Specification Limits	Test Method
Water/Cement Ratio	Maximum 0.45	---
Slump, inches	1 to 3	C143
Air Content, percent	5 to 7	C231
Compressive Strength, 28 days, psi	4500 minimum	C39

Aggregates

Aggregates should meet the requirements of ASTM C33, with a maximum aggregate size of not more than 1 ½-inches.

Aggregate suitability test results and a concrete mix design should be prepared by a qualified independent laboratory and submitted to the engineer for approval, prior to placement.

Concrete Placement and Curing

Pavement concrete should be placed and cured in accordance with ACI 316, “Recommended Practice for Construction of Concrete Pavements and Concrete Bases”.

APPENDIX C

10" P66 Crossing at Spokane River (YP03)

Project: 26145031
Date: 12/16/2014
Calculations by: CAWright & SRGarland

Description: Pipe filled with water

General Data

Pipe Inner Diameter	10.00	inches
Wall Thickness ***(t)***	0.365	inches
Pipe Outer Diameter ***(D)***	10.73	inches
SMYS (Specified Minimum Yield	52,000	psi
Young's Modulus ***(E)***	2.9E+07	psi
Total Pipe Length	848.00	ft
Moment of Inertia ***(I)***	159.73	in^4
Pipe Face SA	11.89	in^2
Diameter/Wall Ratio	29.40	
Poison's Ratio	0.30	
Mud Weight	89.76	pcf
Coeff. of Soil Friction ***(*** μ_{soil} ***)***	0.30	
Fluid Drag Coeff. ***(*** μ_{mud} ***)***	0.05	psi

Pipe Weight Data

Pipe Weight in Air	40.44	lb/ft
Pipe Int. Volume	0.55	ft^3/ft
Pipe Ext. Volume	0.63	ft^3/ft
Air Line Weight		lb/ft
Air Line Diameter		in
Air Line Ext. Vol.		ft^3/ft
Weight of Water	34.03	lb/ft
Displaced Mud Weight	56.34	lb/ft
Water Density	62.40	pcf
Effective Wt. of Pipe ***(*** W_s ***)***	18.14	lb/ft

Note: + denotes a downward force

Loads for Straight Section (A-B)

Measured Length ***(L)***	98.00	ft
Angle Inclination ***(θ)***	20.00	degrees
	0.35	radians
Drag Forces from Mud ***(DRAG)***	1,981.10	lb
Friction from Soil ***(frict)***	501.17	lb
Effective Weight of Pipe	608.04	lb
Tension on Section ***(*** T_B ***)***	1,874.23	lb
Cumulative Force Exerted ***(*** $T_{A\text{-}B}$ ***)***	1,874.23	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	158	<	46,800
Longitudinal Bending (psi)	0	<	38,911
External Hoop Stress (psi)	48	<	19,144
Combined Stresses: Tensile & Bending	0.01	<	1.00
Combined Stresses: Tensile, Bending & Hoop	0.00	<	1.00

Loads for Curvilinear Section Pulled Downslope (B-C)

Measured Length ***(*** L_{arc} ***)***	341.00	ft
Change in Inclination Angle **(** θ_B**-**θ_C **)**	20.00	degrees
(α)	0.35	radians
Radius of Curvature ***(R)***	1,000.00	ft
Center Displacement ***(h)***	15.19	ft
Assumed Average Tension ***(T)***	5,379.93	lb
Normal Force ***(N)***	-1,986.51	lb
Drag Forces from Mud ***(DRAG)***	6,893.42	lb
Friction from Soil ***(frict)***	595.95	lb
Effective Weight of Pipe	1,074.18	lb
Tension on Section ***(*** T_C ***)***	7,011.15	lb
Average Tension	5,379.81	lb
Cumulative Force Exerted ***(*** $T_{A\text{-}C}$ ***)***	8,885.38	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	748	<	46,800
Longitudinal Bending (psi)	12,965	<	38,911
External Hoop Stress (psi)	118	<	19,144
Combined Stresses, Tensile & Bending	0.36	<	1.00
Combined Stresses, Tensile, Bending, & Hoop	0.11	<	1.00

10" P66 Crossing at Spokane River (YP03)

Project: 26145031
Date: 12/16/2014
Calculations by: CAWright & SRGarland

Description: Pipe filled with water

Analysis of Horizontal Straight Section (C-D)

Measured Length ***(L)***	1.00	ft
Angle Inclination ***(θ)***	0.00	degrees
	0.00	radians
Drag Forces from Mud ***(DRAG)***	20.22	lb
Friction from Soil ***(frict)***	5.44	lb
Effective Weight of Pipe	0.00	lb
Tension on Section (T_D)	25.66	lb
Cumulative Force Exerted (T_{A-D})	8,911.04	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	750	<	46,800
Longitudinal Bending (psi)	0	<	38,911
External Hoop Stress (psi)	118	<	19,144
Combined Stresses, Tensile & Bending	0.02	<	1.00
Combined Stresses, Tensile, Bending, & Hoop	0.00	<	1.00

Loads for Curvilinear Section Pulled Upslope (D-E)

Measured Length (L_{arc})	349.00	ft
Change in Inclination Angle (θ_D-θ_E)	20.00	degrees
(α)	0.35	radians
Radius of Curvature ***(R)***	1,000.00	ft
Center Displacement ***(h)***	15.19	ft
Assumed Average Tension ***(T)***	13,137.72	lb
Normal Force ***(N)***	-499.35	lb
Drag Forces from Mud ***(DRAG)***	7,055.15	lb
Friction from Soil ***(frict)***	149.80	lb
Effective Weight of Pipe	1,099.38	lb
Tension on Section (T_E)	8,454.14	lb
Average Tension	13,138.11	lb
Cumulative Force Exerted (T_{A-E})	17,365.18	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	1,461	<	46,800
Longitudinal Bending (psi)	12,965	<	38,911
External Hoop Stress (psi)	56	<	19,144
Combined Stresses, Tensile & Bending	0.38	<	1.00
Combined Stresses, Tensile, Bending, & Hoop	0.12	<	1.00

Loads for Straight Section Pulled Upslope (E-F)

Measured Length ***(L)***	59.00	ft
Angle Inclination ***(θ)***	20.00	degrees
	0.35	radians
Drag Forces from Mud ***(DRAG)***	1,192.70	lb
Friction from Soil ***(frict)***	301.73	lb
Effective Weight of Pipe	366.06	lb
Tension on Section (T_F)	1,860.49	lb
Cumulative Force Exerted (T_{A-F})	19,225.67	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	1,618	<	46,800
Longitudinal Bending (psi)	0	<	38,911
External Hoop Stress (psi)	0	<	19,144
Combined Stresses, Tensile & Bending	0.05	<	1.00
Combined Stresses, Tensile, Bending, & Hoop	0.00	<	1.00

Total Pipe Length	**848.00**	**ft**
Total Pulling Force	**19,226**	**lb**
Stress Violations	**0**	
Recommended Maximum	**309,019**	**lb**

ref. Installation of Pipelines by HDD, An Engineering Design Guide, J.D. Hair & Associates, Inc., Louis Capozzoli & Associates, Inc., Stress Engineering Services, Inc. April 15, 1995

10" P66 Crossing at Spokane River (YP03)

Project: 26135031
Date: 12/21/2014
Calculations by: CAWright & SRGarland

Description: Pipe capped and full of air

General Data

Pipe Inner Diameter	10.00	inches
Wall Thickness ***(t)***	0.365	inches
Pipe Outer Diameter ***(D)***	10.73	inches
SMYS	52,000	psi
Young's Modulus ***(E)***	2.9E+07	psi
Total Pipe Length	848.00	ft
Moment of Inertia ***(I)***	159.73	in^4
Pipe Face SA	11.89	in^2
Diameter/Wall Ratio	29.40	
Poison's Ratio	0.30	
Mud Weight	89.76	pcf
Coeff. of Soil Friction (μ_{soil})	0.30	
Fluid Drag Coeff. (μ_{mud})	0.05	psi

Pipe Weight Data

Pipe Weight in Air	40.44	lb/ft
Pipe Int. Volume	0.55	ft^3/ft
Pipe Ext. Volume	0.63	ft^3/ft
Air Line Weight		lb/ft
Air Line Diameter		in
Air Line Ext. Vol.		ft^3/ft
Weight of Water	34.03	lb/ft
Displaced Mud Weight	56.34	lb/ft
Water Density	62.40	pcf
Effective Wt. of Pipe (W_s)	-15.89	lb/ft

Note: + denotes a downward force

Loads for Straight Section (A-B)

Measured Length ***(L)***		98.00	ft
Angle Inclination **(θ)**		20.00	degrees
	454.47	0.35	radians
Drag Forces from Mud ***(DRAG)***		1,981.10	lb
Friction from Soil ***(frict)***		439.08	lb
Effective Weight of Pipe		-532.71	lb
Tension on Section (T_B)		2,952.89	lb
Cumulative Force Exerted $(T_{A\text{-}B})$		2,952.89	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	248	<	46,800
Longitudinal Bending (psi)	0	<	38,911
External Hoop Stress (psi)	48	<	19,144
Combined Stresses: Tensile & Bending	0.01	<	1.00
Combined Stresses: Tensile, Bending & Hoop	0.00	<	1.00

Loads for Curvilinear Section Pulled Downslope (B-C)

Measured Length (L_{arc})	341.00	ft
Change in Inclination Angle $(\theta_B\text{-}\theta_C)$	20.00	degrees
(α)	0.35	radians
Radius of Curvature ***(R)***	1,000.00	ft
Center Displacement ***(h)***	15.19	ft
Assumed Average Tension ***(T)***	8,543.37	lb
Normal Force ***(N)***	5,577.11	lb
Drag Forces from Mud ***(DRAG)***	6,893.42	lb
Friction from Soil ***(frict)***	1,673.13	lb
Effective Weight of Pipe	-941.10	lb
Tension on Section (T_C)	11,180.79	lb
Average Tension	8,543.29	lb
Cumulative Force Exerted $(T_{A\text{-}C})$	14,133.69	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	1,189	<	46,800
Longitudinal Bending (psi)	12,965	<	38,911
External Hoop Stress (psi)	118	<	19,144
Combined Stresses, Tensile & Bending	0.37	<	1.00
Combined Stresses, Tensile, Bending, & Hoop	0.12	<	1.00

10" P66 Crossing at Spokane River (YP03)

Project: 26135031
Date: 12/21/2014
Calculations by: CAWright & SRGarland

Description: Pipe capped and full of air

Analysis of Horizontal Straight Section (C-D)

Measured Length ***(L)***	1.00	ft
Angle Inclination ***(θ)***	0.00	degrees
	0.00	radians
Drag Forces from Mud ***(DRAG)***	20.22	lb
Friction from Soil ***(frict)***	4.77	lb
Effective Weight of Pipe	0.00	lb
Tension on Section ***(T_D)***	24.98	lb
Cumulative Force Exerted ***(T_{A-D})***	14,158.67	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	1,191	<	46,800
Longitudinal Bending (psi)	0	<	38,911
External Hoop Stress (psi)	118	<	19,144
Combined Stresses, Tensile & Bending	0.04	<	1.00
Combined Stresses, Tensile, Bending, & Hoop	0.00	<	1.00

Loads for Curvilinear Section Pulled Upslope (D-E)

Measured Length ***(L_{arc})***	349.00	ft
Change in Inclination Angle **(θ_D-θ_E)**	20.00	degrees
(α)	0.35	radians
Radius of Curvature ***(R)***	1,000.00	ft
Center Displacement ***(h)***	15.19	ft
Assumed Average Tension ***(T)***	19,487.40	lb
Normal Force ***(N)***	7,606.83	lb
Drag Forces from Mud ***(DRAG)***	7,055.15	lb
Friction from Soil ***(frict)***	2,282.05	lb
Effective Weight of Pipe	-963.18	lb
Tension on Section ***(T_E)***	10,656.06	lb
Average Tension	19,486.70	lb
Cumulative Force Exerted ***(T_{A-E})***	24,814.73	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	2,088	<	46,800
Longitudinal Bending (psi)	12,965	<	38,911
External Hoop Stress (psi)	56	<	19,144
Combined Stresses, Tensile & Bending	0.40	<	1.00
Combined Stresses, Tensile, Bending, & Hoop	0.13	<	1.00

Loads for Straight Section Pulled Upslope (E-F)

Measured Length ***(L)***	59.00	ft
Angle Inclination ***(θ)***	20.00	degrees
	0.35	radians
Drag Forces from Mud ***(DRAG)***	1,192.70	lb
Friction from Soil ***(frict)***	264.35	lb
Effective Weight of Pipe	-320.71	lb
Tension on Section ***(T_F)***	1,136.34	lb
Cumulative Force Exerted ***(T_{A-F})***	25,951.07	lb

Compare Actual Stress vs. Allowable Stress

Axial Tension (psi)	2,183	<	46,800
Longitudinal Bending (psi)	0	<	38,911
External Hoop Stress (psi)	0	<	19,144
Combined Stresses, Tensile & Bending	0.07	<	1.00
Combined Stresses, Tensile, Bending, & Hoop	0.00	<	1.00

Total Pipe Length	**848.00**	**ft**
Total Pulling Force	**25,951**	**lb**
Stress Violations	**0**	
Recommended Maximum	**309,019**	**lb**

ref. Installation of Pipelines by HDD, An Engineering Design Guide, J.D. Hair & Associates, Inc., Louis Capozzoli & Associates, Inc., Stress Engineering Services, Inc. April 15, 1995

APPENDIX D

Photo #1 DH-1; 3'-8" to 5'-0".

Photo #2 DH-1; 9'0" to 10'-0".

Photo #3 DH-1; 13'-0" to 14'-0".

Photo #4 DH-1; 17'-6" to 19'-0"

Photo #5 DH-1; 29'-0" to 30'-0".

Photo #6 DH-1; 39'0" to 40'-0".

Photo #7 DH-1; 41'-0" to 42'-0".

Photo #8 DH-1; 46'-0" to 47"-0'

Photo #9 DH-1; 51'-0" to 52'-6".

Photo #10 DH-1; 56'-0" to 57'-0".

Photo #11 DH-1; 63'-0" to 64'-0".

Photo #12 DH-1; 76'-0" to 78'-0"

Photo #13 DH-1; 78-0" to 79'-0".

Photo #14 DH-1; 89'0" to 91'-0".

Photo #15 DH-1; 94'-0" to 96'-0".

Photo #16 DH-1; 100'-0" to 101'-0".

Photo #17 DH-1; 112’-0” to 114’-0”.

Photo #18 DH-1; 115’-0” to 116’-0”.

Photo #19 DH-1; 124’-0” to 126’-0”.

Photo #20 DH-1; 130’-0” to 131’-0”.

Photo #21 DH-2; 7’-0” to 9’-0”.

Photo #22 DH-2; 20’-0” to 22’-0”.

Photo #23 DH-2; 24’-0” to 26’-0”.

Photo #24 DH-2; 38’-0” to 40’-0”.

Photo #25 DH-2; 42'-0" to 44'-0"

Photo #26 DH-2; 54'-0" to 56'-0".

Photo #27 DH-2; 56'-0" to 57'-6.

Photo #28 DH-2; 72'-0" to 74'-0"

Photo #29 DH-2; 94'-0" to 96'-0".

Photo #30 DH-2; Drill rig setup.

Photo #31 Looking southwest at north DH-2 after cleanup.

Photo #32 Looking west at south DH-1 after cleanup.