

APPENDIX A
OTTER CREEK MINE BASELINE REPORT 304E
MONITORING WELL LOGS

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: A1

Date Hole Started: 7/25/11 Date Hole Finished: 7/25/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 9; N
475750.513, E 2820589.42
Location Description: Stevens crossing near
SW-2
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron and Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 20

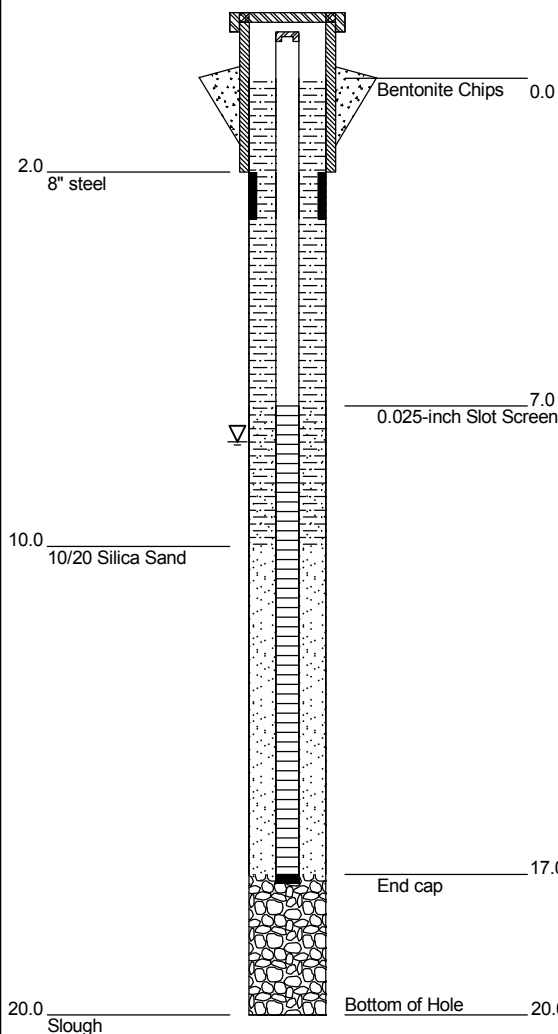
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-17
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	7-17
Sand Pack?	Y	10/20 silica sand	10-17
Annular Seal?	Y	Bentonite Chips	+1-10
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 475750.513	Easting: 2820589.42	
Static Water Level Below MP: 8.98	Surface Casing Height (ft): 1.58	
Date: 7/25/2011	Riser Height (ft): 1.22	
MP Description: Top PVC	Ground Surface Elevation (ft): 3033.71	
MP Height Above or Below Ground (ft): 1.22	MP Elevation (ft): 3034.93	

Remarks: Hole sloughed from 17'-20' bgs. Yield approximately 15 gpm. Water quality after development; SC=3000 μ mhos/cm, pH=8.14, Temp=14.8°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 2.0'	Silt and clay Slightly moist, moderate brown, loose, soft, non-plastic, roots
2.0 - 8.0'	Silt, clay and sand [Alluvium] Slightly moist to very moist, dark yellow brown, non-plastic, loose
8.0 - 15.0'	Gravel [Alluvium] Wet, medium reddish brown, clinker origin, sub-angular, to sub-rounded, some sand, sizes up to 1.5"
15.0 - 20.0'	Thermally altered sandstone [Clinker] Wet, very hard, mostly medium reddish brown, some light brown (5YR 6/4), angular fragments (clinker), making a lot of water

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Monitor Well Log

Hole Name: A2

Date Hole Started: 12/29/10 Date Hole Finished: 12/29/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T3S R45E Sec. 26 NENW;
N 493037.18, E 2827469.82
Location Description: 50' NW of stock well at
homestead
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in):
Total Depth Drilled (ft): 80

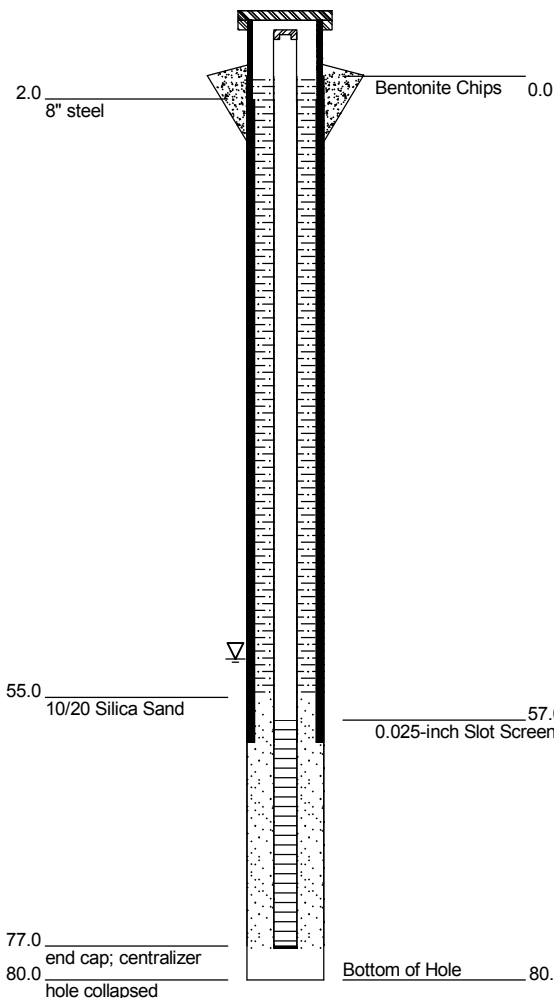
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-77
Surface Casing Used?	Y	8" steel	+2-59
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	57-77
Sand Pack?	Y	10/20 Silica Sand	55-77
Annular Seal?	Y	Bentonite Chips	0-55
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Rotary
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 493037.18	Easting: 2827469.82	
Static Water Level Below MP: 53.5	Surface Casing Height (ft): 2.39	
Date: 12/29/10	Riser Height (ft): 1.91	
MP Description: Top PVC	Ground Surface Elevation (ft): 3100.88	
MP Height Above or Below Ground (ft): 1.91	MP Elevation (ft): 3102.79	

Remarks: Drill to 50' set surface casing; hole collapse from 77'-80'; centralizer placed at 77'; SWL=53.5 bgs.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 10.0'	Clayey silt [Alluvium] Dry, loose, roots, medium olive brown (5Y 4/4), color change at 3'
10.0 - 15.0'	Silt [Alluvium] Dry, soft, minor very fine sand, medium olive brown (5Y 4/4)
15.0 - 20.0'	Clayey silt [Alluvium] Dry, soft, medium olive brown (5Y 4/4)
20.0 - 25.0'	Silty very fine sand Dry, loose
25.0 - 27.0'	Sand, fine Slightly moist, loose, moderate yellowish brown (10YR 5/4)
27.0 - 33.0'	Gravelly sand Moist, fine clinker gravels (red-orange). Clinker gravels up to 2", sub-rounded, minor clay, medium brown (5YR 4/4) at 30'-33'
33.0 - 35.0'	Clayey sand Moderate brown (5YR 4/4), no gravels
35.0 - 41.0'	Clayey sand Moderate brown (5YR 4/4), fine sand, gravel comprised of clinker present
41.0 - 45.0'	Gravelly sand Very moist, moderate brown (5YR 4/4), red-orange clinker gravels
45.0 - 50.0'	Gravels Clinker gravels increase in size and occurrence, angular, flaggy, clayey
50.0 - 55.0'	Gravelly sand Very moist, few fines, moderate brown (5YR 4/4), medium gravels, flaggy
55.0 - 65.0'	Silty gravels Wet, poorly sorted gravels up to 3" diameter (clinker), sub-rounded, minor fine sand, moderate brown (5YR 3/4)
65.0 - 75.0'	Gravels [Alluvium] Wet, multicolored, angular, poorly sorted, moderate brown, becomes clayey at 66', cobbles up to 4", sub-rounded, color change to grayish brown (5YR 3/2)
75.0 - 79.0'	Sand [Bedrock - weathered] Wet, yellowish brown, fine, poorly cemented
79.0 - 80.0'	Claystone [Bedrock] Firm, greasy texture, greenish gray (5GY 6/1), streaks of carbonaceous material

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Monitor Well Log

Hole Name: A3

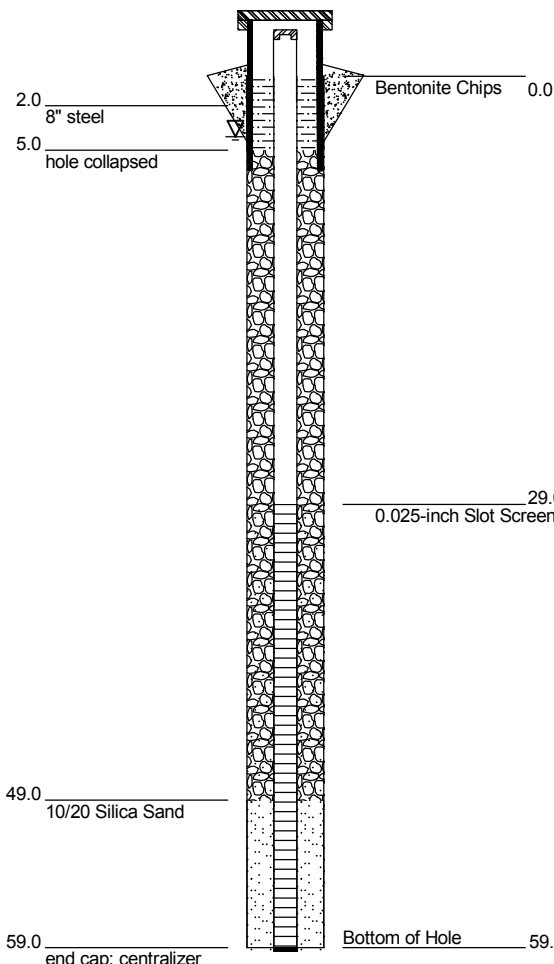
Date Hole Started: 7/18/11 Date Hole Finished: 7/18/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T5S, R45E, Sec 2, NW 1/4; N 449796.22, E 2828377.84
Location Description: Next to fence-Denson Otter Creek crossing
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 59

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-59
Surface Casing Used?	Y	8" steel	+2-2
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	29-59
Sand Pack?	Y	10/20 silica sand	49-59
Annular Seal?	Y	Bentonite Chips	0-5
Surface Seal?	N		
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Rig Air-20 minutes	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 449796.22		Easting: 2828377.84	
Static Water Level Below MP: 5.82		Surface Casing Height (ft): 1.92	
Date: 7/18/2011		Riser Height (ft): 1.73	
MP Description: Top PVC		Ground Surface Elevation (ft): 3104.93	
MP Height Above or Below Ground (ft): 1.73		MP Elevation (ft): 3106.66	

Remarks: Drove 8" steel 60'; air lift for 20 minutes; SC=3430 μ mhos/cm. Hole collapsed 5'-49'. Centralizer placed at 59' bgs.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' Sandy silt Dry, firm, minor fine gravels, moderate brown (5YR 4/4), becomes moist at 3', becomes wet at 4'; adding water at 4'-5'
5.0 - 8.0' Sandy gravel [Alluvium] Wet; with silt; loose gravels, angular, medium, (moderate reddish brown (10R 4/6) clinker); matrix is dark yellowish brown (10YR 4/2)
8.0 - 25.0' Sand [Alluvium] Medium, dark yellowish brown (10YR 4/2), few fine to medium slightly rounded flaggy gravels 10%, gravels increasing in size and occurrence, some coal gravels, sub-rounded, weathered
25.0 - 40.0' Gravel [Alluvium] Poorly sorted; multi-colors (moderate brown, dark yellowish brown, dark yellowish orange), black to red (clinker and sandstone) cobbles up to 5", rounded to angular; making water, sandstone gravels increase with depth; some sand 10-15%
40.0 - 57.0' Gravel [Alluvium] Multi-colors (moderate brown, dark yellowish brown, dark yellowish orange); making water; sand <5%, poorly sorted, up to 4" diameter, rounded to angular
57.0 - 59.0' Siltstone [Bedrock] Moist, weak, dark yellowish brown (10YR 4/2) to light olive gray; very fine bedding

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Monitor Well Log

Hole Name: A4

Date Hole Started: 3/17/2011 Date Hole Finished: 3/17/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T5S, R45E, Sec. 1; N 451653.18, E 2836778.79
Location Description: Ten Mile Creek, Denson meadow
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Ten Mile Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 70

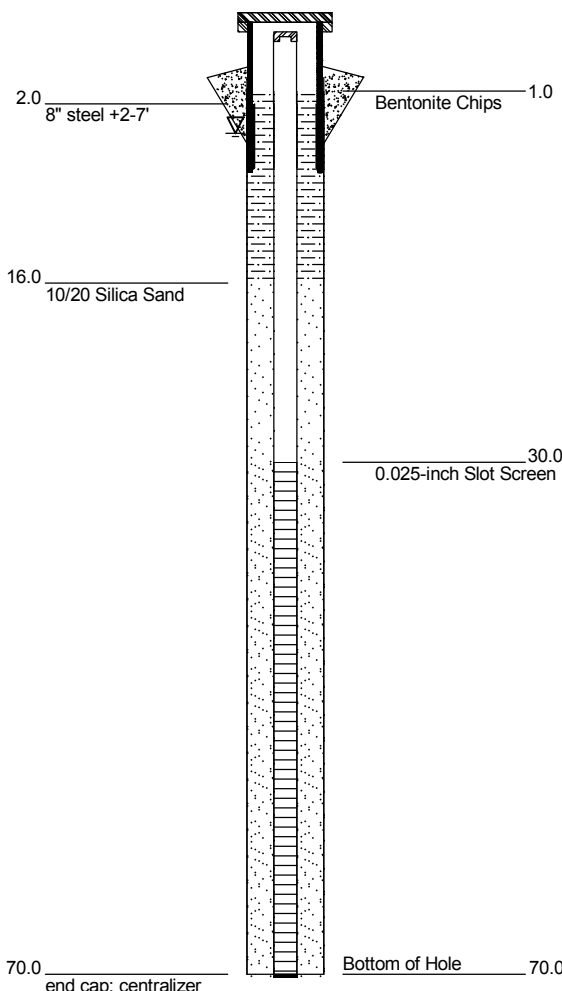
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-70
Surface Casing Used?	Y	8" steel	+2-7
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	30-70
Sand Pack?	Y	10/20 silica sand	16-70
Annular Seal?	Y	Bentonite Chips	+1-16
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 451653.18	Easting: 2836778.79	
Static Water Level Below MP: 5.97	Surface Casing Height (ft): 1.97	
Date: 3/18/2011	Riser Height (ft): 1.68	
MP Description: Top PVC	Ground Surface Elevation (ft): 3171.91	
MP Height Above or Below Ground (ft): 1.68	MP Elevation (ft): 3173.59	

Remarks: Drill to 20' with 7 7/8" drag bit, drive 8" steel (65'). Drill out with 4" bit, then ream with 7 7/8" bit. Developed with rig air, yield ~40 gpm. SC= 3090 µmhos/cm, pH=8.13

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 10.0'	Silty clay [Alluvium/Colluvium] Moist to wet at 4'; pale yellowish brown and light olive gray (5Y 5/2), mild plasticity, roots, moderately loose; color to light olive gray and greenish gray (5GY 6/1) at 6'; start injecting water at 6'
10.0 - 14.0'	Sand, moderately fine, clayey/silty Wet, pale yellowish brown and light olive gray (5Y 5/2), very loose
14.0 - 19.0'	Silty, sandy, clay Wet, pale yellowish brown, dense, moderately plastic, rolls to 1/8"
19.0 - 22.0'	Gravel [Alluvium] Wet, medium reddish brown, clinker, burned siltstone, hard, loose, flaggy, sub-round to sub-angular
22.0 - 26.0'	Clay and gravel Wet, clay is light olive gray and pale yellowish brown, pea size gravels, clinker, medium reddish brown, loose
26.0 - 28.0'	Gravel Wet, mostly pea gravel, sub-angular to sub-round, clinker origin and trace sandstone
28.0 - 31.0'	Very sandy gravel, poorly sorted, sand to 50% Wet, medium yellowish brown sand, clinker (burned sandstone/shale) gravels, hard, coarse gravels to 1"
31.0 - 50.0'	Gravel and sand, poorly sorted Wet, multi-colored: dark yellowish orange, medium yellowish brown, medium reddish brown, light brown (5YR/5/6); clinker and sandstone origin, increasing sandstone gravel with depth, increasing gravel size with depth, gravels to 3", sand to 30% at 32'-39' then sand decreases to 10% at 40'
39'-40'	clay stringer, silty, light olive gray to dark olive gray, soft, moderately plastic
50.0 - 55.0'	Sandy clay Wet, dark greenish gray (5GY 4/1), loose, soft, moderately plastic
55.0 - 68.5'	Gravel, some sand (2%) [Alluvium] Wet, multi-colored: light gray, light brown, medium reddish brown, pale yellowish brown, and light olive gray, clinker and sandstone origin, hard, gravels to 5"
68.5 - 69.0'	Claystone [Bedrock] Medium gray, soft, very thinly bedded
69.0 - 70.0'	Coal [Bedrock] Black, cleated multiple planes, stiff

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Monitor Well Log

Hole Name: A5

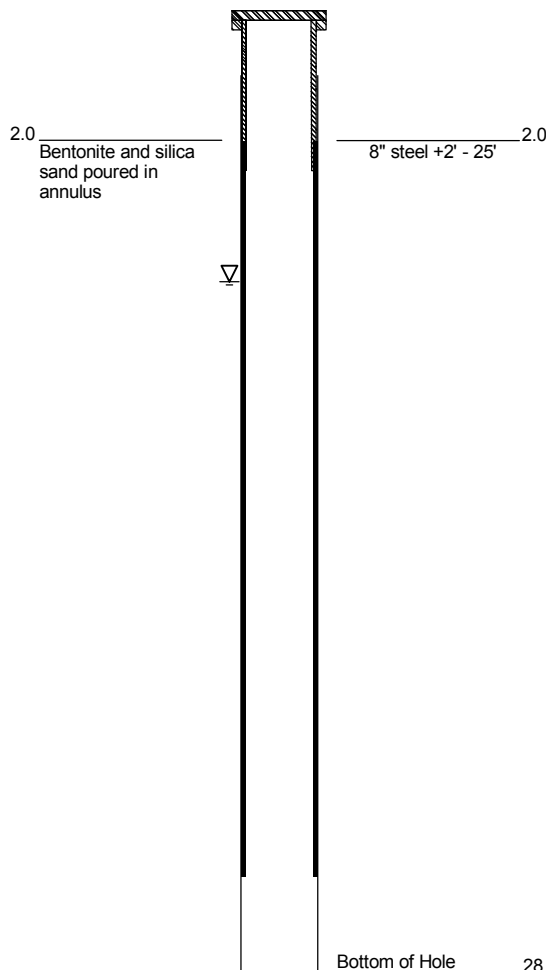
Date Hole Started: 8/18/11 Date Hole Finished: 8/18/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T 4S, R45E, Sec. 12; N 477695.18, E 2836255.5
Location Description: Tarter meadow on Three Mile Creek
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron and Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer:
Hole Diameter (in): 10" (0'-20'), 8" (20'-25')
Total Depth Drilled (ft): 28

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	8" steel open bottom	+2-25
Surface Casing Used?	Y	8" steel	+2-25
Screen/Perforations?	N		
Sand Pack?	N		
Annular Seal?	Y	Bentonite Chips	annulus - drill/drive
Surface Seal?	N		
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Rig Air	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 477695.18		Easting: 2836255.5	
Static Water Level Below MP: 8.45		Surface Casing Height (ft): 2.07	
Date: 8/18/2011		Riser Height (ft):	
MP Description: Top of Steel		Ground Surface Elevation (ft): 3134.77	
MP Height Above or Below Ground (ft): 2.03		MP Elevation (ft): 3136.84	

Remarks: Injecting water at 5', open hole with 9 7/8" bit to 20'. Drive 28' 8-inch steel, silica sand and bentonite poured in annulus. Developed with rig air; SC=4800 µmhos/cm, pH= 8.00, temp= 11.1°C, open hole yield=~50 gpm.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 12.0' **Silty clay**
Dry to wet with depth, pale yellowish brown to dark yellowish brown, w moisture at depth; some fine sand at 2'-5', becomes wet at 5'; medium to high plasticity, mostly soft and loose; trace gravel at 6'-1', becomes sandy at 8'; increasing gravel at 10'-12'

12.0 - 26.0' **Sand and gravel**
Wet, moderate yellowish brown sand with light brown and moderate reddish brown clinker gravels, some sandstone gravels, light olive gray and yellowish brown, gravels to 2", mostly flat to moderate sphericity; sub-angular to sub-round, size increases to 3" at 20', increasing with depth

26.0 - 28.0' **Claystone, silty** [Bedrock]
Light olive gray to greenish gray, moderate dense but soft, low to medium plasticity, calcareous

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Monitor Well Log

Hole Name: A6

Date Hole Started: 3/23/11 Date Hole Finished: 3/23/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 22; N 467961.91, E 2823051.32
Location Description: Near Otter Creek Crossing
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 11"(0-20'), 8"(20-25')
Total Depth Drilled (ft): 25

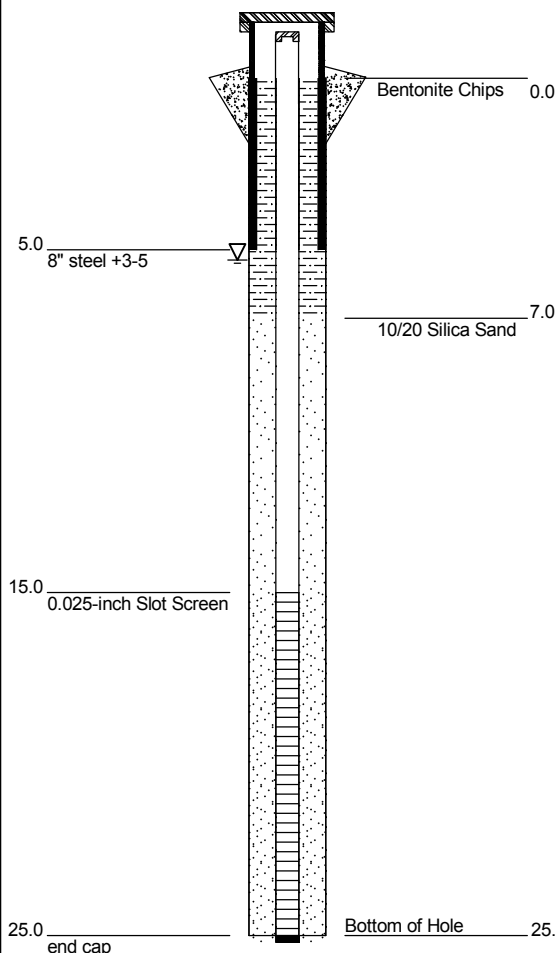
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+3-25
Surface Casing Used?	Y	8" steel	+3-5
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	15-25
Sand Pack?	Y	10/20 silica sand	7-25
Annular Seal?	Y	Bentonite Chips	+2-7
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 467961.91	Easting: 2823051.32	
Static Water Level Below MP: 7.6	Surface Casing Height (ft): 2.57	
Date: 3/23/2011	Riser Height (ft): 2.30	
MP Description: Top PVC	Ground Surface Elevation (ft): 3051.71	
MP Height Above or Below Ground (ft): 2.30	MP Elevation (ft): 3054.01	

Remarks: Start injecting water at ground surface, 11 7/8" bit to 20', drive 25' of 8" steel to bedrock. Developed with rig air, stopped after 10 minutes to avoid flooding field or discharging to creek. SC=5700 μ mhos/cm, pH=8.15, temp= 10.9° C, yield=50 gpm after development

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0'	Silty clay [Topsoil/Colluvium] Dry, moderate to dark yellowish brown, loose to moderate cohesive, non-plastic, roots, trace very coarse sand and fine gravel at depth
5.0 - 10.0'	Clayey sandy gravel [Alluvium] Light brown and moderate reddish brown clinker gravels, moderate yellowish brown sand fine to medium gravel, loose, roots in top 1'
10.0 - 20.0'	Sand and gravel (50/50) [Alluvium] Wet, moderate yellowish brown sand, light brown and grayish orange clinker gravels; gravel size increases with depth to 3" gravels
20.0 - 23.0'	Gravel, clean moderately poorly sorted up to 1" [Alluvium] Wet, color from black to very pale orange, moderately loose to dense, sub-round, low to high sphericity; coal and clinker origin
23.0 - 25.0'	Siltstone [Bedrock] Dry, pale to dark yellowish orange with light olive gray, soft, non-plastic; some very thin dark colored laminations

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Monitor Well Log

Hole Name: A7

Date Hole Started: 7/19/11 Date Hole Finished: 7/19/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 27, NE
SE 1/4; N 459251.91, E 2825659.93
Location Description: Just West of Otter Creek

Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 44

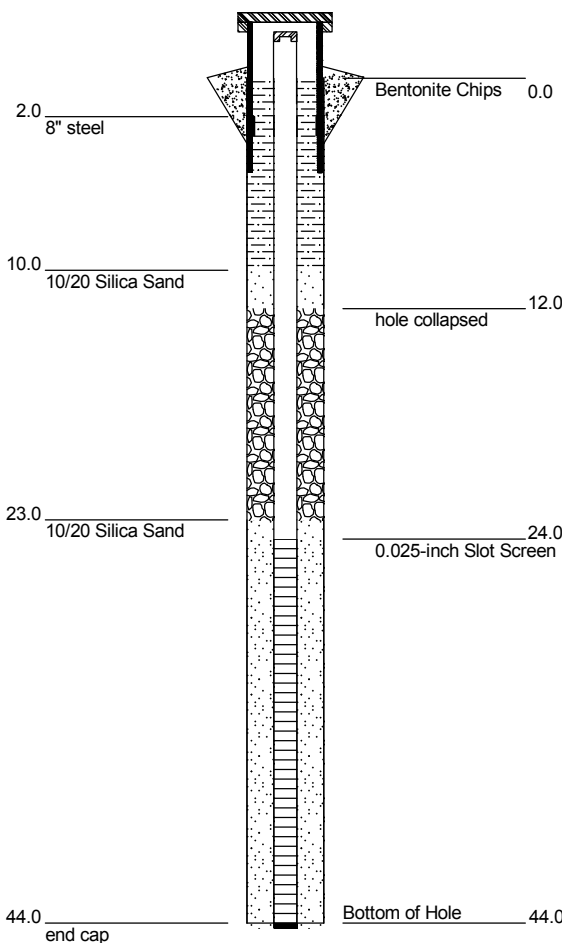
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-44
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	24-44
Sand Pack?	Y	10/20 silica sand	10-12
Annular Seal?	Y	Bentonite Chips	0-10
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 459251.91	Easting: 2825659.93	
Static Water Level Below MP: 8' 7"	Surface Casing Height (ft): 1.95	
Date: 7/19/2011	Riser Height (ft): 1.61	
MP Description: Top PVC	Ground Surface Elevation (ft): 3079.33	
MP Height Above or Below Ground (ft): 1.61	MP Elevation (ft): 3080.94	

Remarks: SC at start of air lift = 3000 μ mhos/cm; SC at completion = 3970 μ mhos/cm, stable. SWL= 8'7". Hole collapsed 12'-23'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' Silt Dry to 2' then moist, adding water at 4'; minor very fine sand, soft, roots, moderate yellowish brown (10YR 5/4)
5.0 - 14.0' Silty clay [Alluvium] Stiff, moderate yellowish brown (10YR 5/4); some fine sand, orange oxidation at 10'-12'
14.0 - 23.0' Silty gravels [Alluvium] Multi-color clinker, flaggy, sub-rounded, very sandy below 20'
23.0 - 26.0' Clay Stiff, moderate olive brown (5Y 4/4)
26.0 - 41.0' Gravels [Alluvium] Multi-colored clinker; making water, very little sand at 26', increases with depth to ~15%; coal pieces in gravels at 34'
41.0 - 43.5' Clay [Alluvium] Stiff, plastic, medium gray (N5), minor fine sand, finely laminated
43.5 - 44.0' Sandstone [Bedrock] Very hard, medium grained, well-sorted, well cemented, medium light gray (N6)

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Billings, Montana



Monitor Well Log

Hole Name: A8

Date Hole Started: 6/5/14 Date Hole Finished: 6/6/14

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land
Legal Description: T4S, R45E, Sec 4, NESWSE
Location Description: Just west of Otter Creek and upstream of SW-25
Recorded By: JS
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Potable Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvial
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 64

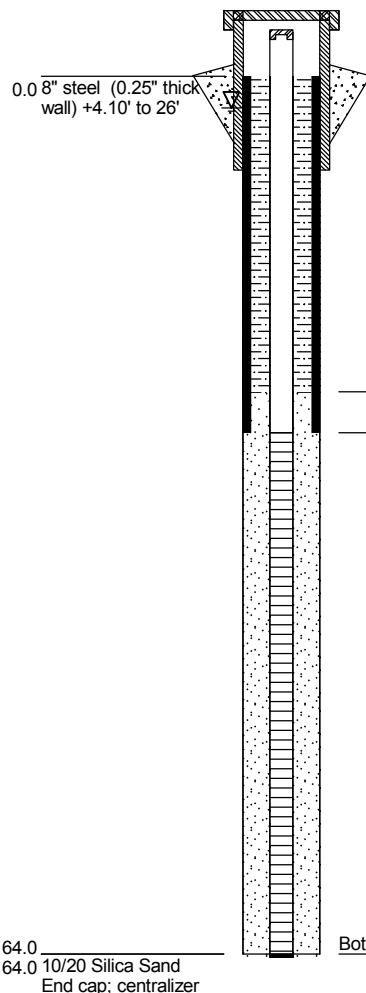
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+3.57'AGL - 64'
Surface Casing Used?	Y	8" steel 0.250" wall	+4.10'AGL - 26'
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	26'-64'
Sand Pack?	Y	10/20 silica sand	23'-64'
Annular Seal?	Y	Bentonite Chips	0'-23'
Surface Seal?	Y	Bentonite around steel csg	

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 478460.18	Easting: 2818976.75	
Static Water Level Below MP: 5.89	Surface Casing Height (ft): 4.10	
Date: 6/10/2014	Riser Height (ft): 3.57	
MP Description: BMP (TOPVC)	Ground Surface Elevation (ft): 3022.13	
MP Height Above or Below Ground (ft): 3.57	MP Elevation (ft): 3025.61	

Remarks: Developed with air injection 30 minutes. Total steel 30' at 26' set below ground level (BGL) and 4' above ground level (AGL); SC= 3,844 µmhos/cm. June 10, 2014 water level at 2.32' below ground,

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' Clayey sand - Loam [Topsoil] Wet; olive gray; loose; fine to very fine grain; high plasticity, cohesive
3' below ground level - first groundwater (driller)
5.0 - 10.0' Clayey sand [Alluvium] Wet; increase in clay; saturated black organics (charcoal) inclusions
10.0 - 15.0' Clinker gravel, sandy with clay [Alluvium] Angular pieces, flat <1"
15.0 - 20.0' Clinker gravel, sandy with clay [Alluvium] Olive gray with red, brown, dark gray; clinker pieces; increase in size to 2"
20.0 - 21.0' Clinker gravel, sandy with clay Small pieces to < 1/2-1/4", sub-angular to angular
21.0 - 25.0' Clay, sandy Olive green; stiff; cohesive; high plasticity
25.0 - 26.0' Clay, sandy Olive green; stiff; cohesive; high plasticity
26.0 - 30.0' Clinker gravel, sandy with clay Includes coal chips; large; sub-angular and sub-round < 2"
30.0 - 35.0' Clinker gravel, sandy with clay [Alluvium] Varies between sub-angular and sub-round; increase in sand
35.0 - 40.0' Clinker gravel, sandy with clay [Alluvium] Decrease in sand; clean clinker; no clay; no bedrock; clinker sub-round
40.0 - 45.0' Clinker gravel, sandy with clay [Alluvium] Decrease in sand; clean clinker; no clay; no bedrock; clinker sub-round
45.0 - 50.0' Clinker gravel, sandy with clay [Alluvium] Decrease in sand; slight increase in clay; clean clinker; no clay; no bedrock; clinker sub-round
50.0 - 55.0' As above, Clinker gravel, sandy with clay [Alluvium] Slight increase in clay percent; large cobbles to 6"; no bedrock material; increase in coal chips in Alluvium
55.0 - 63.0' Weathered silty clay (shale) [Bedrock] Damp; greenish gray, moderately stiff; non plastic; no cohesiveness

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Billings, Montana



Monitor Well Log

Hole Name: A9

Date Hole Started: 7/7/14

Date Hole Finished: 7/7/14

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T3S, R44E, Sec 12, SW 1/4; N 504771.35, E 2799819.15
Location Description: 1/4 mile East of Otter Creek bridge on south side of Hwy 212
Recorded By: TS
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Air & Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 11" (0-20'), 7 7/8" (20'-40')
Total Depth Drilled (ft): 50

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-20
Surface Casing Used?	Y	8 5/8" steel	+2-18
Screen/Perforations?	Y	4.5" Sch40 0.020-inch slot SDR-17	20-40
Sand Pack?	Y	10/20 Silica Sand	11-40
Annular Seal?	Y	Bentonite Chips	+2-11
Surface Seal?	N		

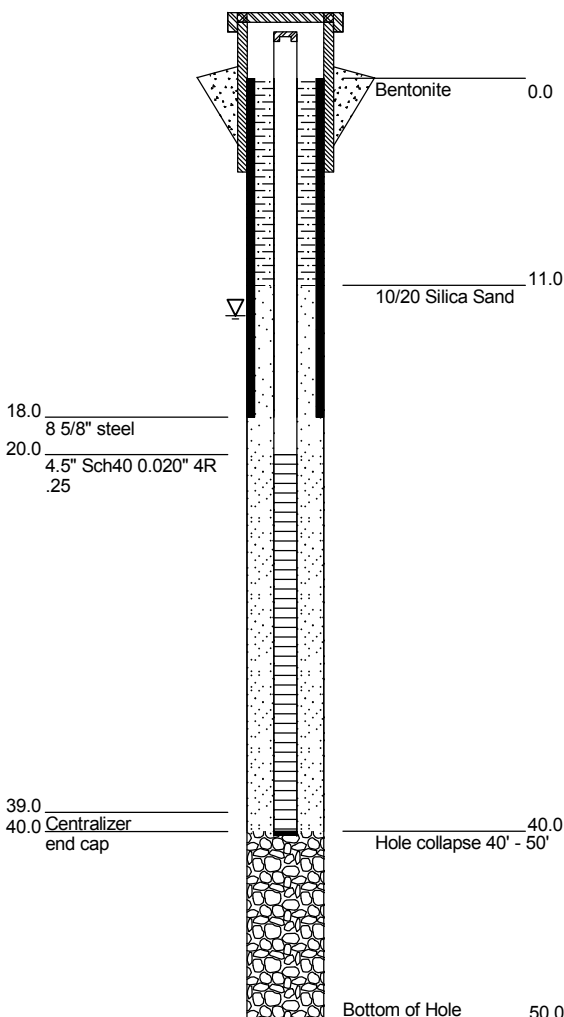
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air	developed for 35 min.
Water Samples Taken?	N		
Boring Samples Taken?	N		

Northing: 504771.35	Easting: 2799819.15
Static Water Level Below MP: 14.52	Surface Casing Height (ft): 2.28
Date: 7/8/14	Riser Height (ft): 1.90
MP Description: Top PVC	Ground Surface Elevation (ft): 2937.84
MP Height Above or Below Ground (ft): 1.90	MP Elevation (ft): 2939.75

Remarks: Drove steel to 40' then pulled back to 18'; flow ~20 gpm. Poured sand on outside of 8" steel to 10' below ground surface (bgs); poured bentonite on outside of 8" steel from 0'-10' bgs. Started injecting water at 20' (water from Askin's shop). After 15 minutes of developoing pH 7.99, SC=3355 µmhos/cm, temp=15.3°C. After 30 minutes of developing pH 7.88, SC=3271 µmhos/cm, temp=13.5°C

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 12.0'	Sandy silt [Alluvium] Dry to moist; light brown (7.5YR 7/4) to moderate brown (7.5YR 4/4); slightly cohesive
12.0 - 20.0'	Sandy gravel with clay [Alluvium] Wet; moderate reddish brown (7.5YR 5/3); gravels are sub-rounded to sub-angular; gravels are platy, gravels 5" minus; poorly sorted
20.0 - 24.0'	Silty sand [Alluvium] Wet; olive gray (7.5YR 5/1); moderately cohesive
24.0 - 33.0'	Sandy gravel with clay [Alluvium] Wet; moderate reddish brown (7.5YR 5/3); gravels are sub-rounded to sub-angular; gravels are platy, gravels 3" minus; poorly sorted
33.0 - 50.0'	Silty sand with clay [Alluvium] Wet; olive gray (7.5YR 5/1); very to moderately cohesive; flowing sands

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Monitor Well Log

Hole Name: AVF1-1

Date Hole Started: 1/27/2011 Date Hole Finished: 1/27/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 30; N
492770.89, E 2809604.69
Location Description: Trusler meadow south of
house
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 11 3/4" to 10' then 7 7/8"
Total Depth Drilled (ft): 36

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	8" steel open bottom	+2-32
Surface Casing Used?	Y	8" steel	+2-32
Screen/Perforations?	N		
Sand Pack?	N		
Annular Seal?	Y	Bentonite Chips	drill & drive
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 492770.89	Easting: 2809604.69	
Static Water Level Below MP: 9.97	Surface Casing Height (ft): 2.25	
Date: 1/27/2011	Riser Height (ft):	
MP Description: Top of Steel	Ground Surface Elevation (ft): 2976.90	
MP Height Above or Below Ground (ft): 2.25	MP Elevation (ft): 2979.15	

Remarks: 11 3/4" bit to 10' then 7 7/8" bit, drove 8" steel to 36', pulled back to 32'. Developed with rig air 20 min. Pile cuttings next to well for Trusler to remove (per Trusler). SC=1555 µmhos/cm, pH=8.00, temp=10.6°C, yield ~100 gpm.

WELL CONSTRUCTION



32.0
8" steel open bottom

Bottom of Hole 36.0

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0' **Clayey silt** [Alluvium]
Dry, moderate yellowish brown, loose, roots in top 1'

3.0 - 5.0' **Silty clayey sand** [Alluvium]
Moist, moderate yellowish brown, very loose, poorly sorted, trace coarse sand, < 2%

5.0 - 15.0' **Silty clay, some sand** [Alluvium]
Moist, moderate yellowish brown to dark yellowish brown, very soft, rolls from 1/8" to 1/16", plasticity increases with depth, poorly sorted, fines with depth in this interval, calcareous, reacts with HNO₃, wet at 10'

15.0 - 32.5' **Gravel and sand, poorly sorted**
Wet, sand to 50%, gravels from 0.125" up to 1.5", gravels composed of coal, clinker and shale bedrock origin, low sphericity, sub-rounded, less sand with depth to 10% sand, gravel coarse to 2" size, more round (sub-round), moderate to high sphericity, sandstone and clinker origin, some coal

32.5 - 33.0' **Clay**
Wet, pale yellowish brown, high plasticity, rolls to 1/16", soft

33.0 - 36.0' **Siltstone, very fine sandstone** [Bedrock]
Pale yellowish brown, with very thin dark yellowish brown beds, calcareous (reacts with acid)

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Monitor Well Log

Hole Name: AVF1-2

Date Hole Started: 1/27/2011 Date Hole Finished: 1/27/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 30; N 492760.99, E 2809578.22
Location Description: AVF1 on Trusler meadow south of house
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 32

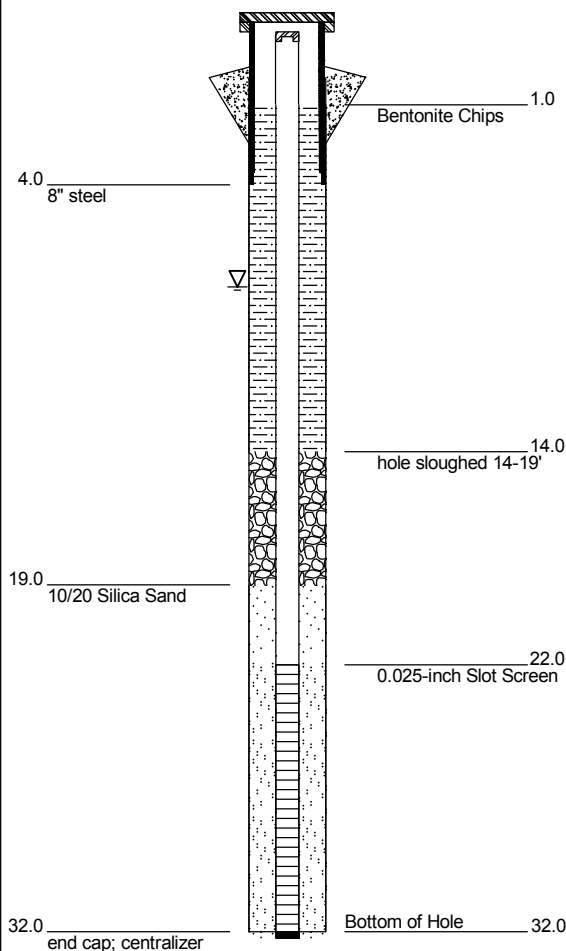
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-32
Surface Casing Used?	Y	8" steel	+2-4
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	22-32
Sand Pack?	Y	10/20 silica sand	19-32
Annular Seal?	Y	Bentonite Chips	+1-14
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 492760.99	Easting: 2809578.22	
Static Water Level Below MP: 9.20	Surface Casing Height (ft): 1.71	
Date: 1/27/2011	Riser Height (ft): 1.38	
MP Description: Top PVC	Ground Surface Elevation (ft): 2977.01	
MP Height Above or Below Ground (ft): 1.38	MP Elevation (ft): 2978.39	

Remarks: Drove 8" steel to 30', pulled out, replaced with 5 ft steel, slough from 14-19' bgs; SC=1776 µmhos/cm, pH=7.99, temp=10.8°C after development.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Clayey silt [Alluvium] Dry, moderate yellowish brown, loose, roots in top 1'
3.0 - 5.0'	Silty clayey sand [Alluvium] Moist, moderate yellowish brown, very loose, poorly sorted, trace coarse sand, < 2%
5.0 - 15.0'	Silty clay, some sand [Alluvium] Moist, moderate yellowish brown to dark yellowish brown, very soft, rolls from 1/8" to 1/16", plasticity increases with depth, fines with depth, calcareous, wet at 10'
15.0 - 25.0'	Gravel and sand, poorly sorted [Alluvium] Wet, gravels to 1.5", low sphericity, sub-rounded, sand to 50% less with depth to 10%, gravel to 2", gravel, clinker, coal, bedrock origin
25.0 - 26.0'	Woody debris
26.0 - 32.0'	Gravel and sand Wet, as above

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Billings, Montana



Monitor Well Log

Hole Name: AVF1-3

Date Hole Started: 7/25/2011 Date Hole Finished: 7/25/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 20
SW1/4, SW1/4; N 493518.19, E 2810154.49
Location Description: East side of Otter Creek
AVF1-1
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 38

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-38
Surface Casing Used?	Y	8" steel	+2-4
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	18-38
Sand Pack?	Y	10/20 silica sand	8-14, 27-38
Annular Seal?	Y	Bentonite Chips	+1-8
Surface Seal?	N		

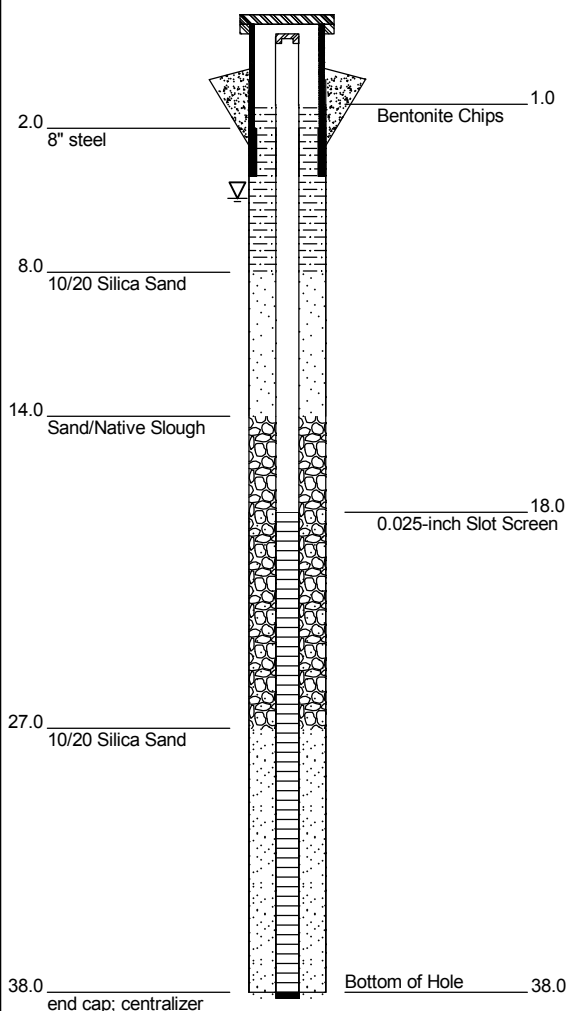
DEVELOPMENT/SAMPLING

Well Developed?	N
Water Samples Taken?	N
Boring Samples Taken?	N

Northing: 493518.19	Easting: 2810154.49
Static Water Level Below MP: 6.4	Surface Casing Height (ft): 1.86
Date: 8/18/2011	Riser Height (ft): 1.48
MP Description: Top PVC	Ground Surface Elevation (ft): 2976.09
MP Height Above or Below Ground (ft): 1.48	MP Elevation (ft): 2977.57

Remarks: Drilled to 20' with 7 7/8" bit. Set 32' of 8-inch casing, drilled out steel with 6 1/4" bit. Reamed with 7 7/8" bit to 38'. Pulled 8" steel during completion. Sand 27'-37' and in annulus before steel was pulled. Sand/native sloughed to 14' when pulled. Placed bentonite less than 1 bag from 37.5'-38' below ground surface.

WELL CONSTRUCTION



GEOLOGICAL DESCRIPTION

0.0 - 5.0' Silty clay Dry to wet at 5', pale yellowish brown to medium yellowish brown with moisture and depth. roots to 3', non-plastic to medium plastic with depth and moisture. some fine sand at 5', very loose and soft
5.0 - 16.0' Clayey sand Wet, dark yellowish brown. Very soft, loose, flowing. trace gravel of clinker origin at 15'
16.0 - 33.0' Gravel Some sand, wet, light brown, reddish brown, pale yellowish orange. Clinker and sandstone origin. loose, hard, flat, sub-rounded size to 2". Trace coal/shale gravel at 25'. Shale gravels more angular than clinker and sandstone
33.0 - 38.0' Claystone [Bedrock] Pale yellowish brown, soft to medium firm, medium plasticity, rolls to 1/8", possibly tagged coal at 38'

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Monitor Well Log

Hole Name: AVF1-PH1

Date Hole Started: 1/27/2011 Date Hole Finished: 1/27/2011

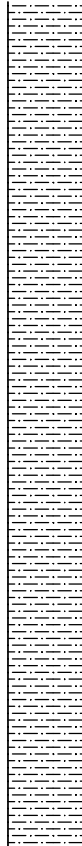
Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 30; N 491950.29, E 2808542.68
Location Description: Near fence at west edge of Trusler meadow at AVF1
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 22

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	N		NA
Surface Casing Used?	N		NA
Screen/Perforations?	N		NA
Sand Pack?	N		NA
Annular Seal?	Y	Bentonite Chips	0-22
Surface Seal?	N		NA
DEVELOPMENT/SAMPLING			
Well Developed?	N		
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 491950.29		Easting: 2808542.68	
Static Water Level Below MP: 7		Surface Casing Height (ft): NA	
Date: 1/27/2011		Riser Height (ft): NA	
MP Description: Ground Surface		Ground Surface Elevation (ft): 2977.26	
MP Height Above or Below Ground (ft): NA		MP Elevation (ft):	

Remarks: Drill with 7 7/8" bit to 13', then drive and drill with 8" steel casing 22', pull steel; plug hole with 3/8" bentonite chips.

WELL CONSTRUCTION

0.0 3/8" Bentonite Chips



Bottom of Hole 22.0

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0' **Silty clay** [Alluvium/Colluvium]
Slightly moist, grayish orange pink, loose, roots, some weakly cemented

1.0 - 7.0' **Silty sand**
Moist, moderate yellowish brown, loose, soft

7.0 - 10.0' **Sandy clay**
Wet, dark yellowish brown, moderate plasticity, rolls to 1/8"

10.0 - 11.0' **Clay**
Wet, dark yellowish brown and olive gray (5Y 3/2), very plastic rolls to 1/16"

11.0 - 12.0' **Gravel some sand**
Wet, gravels to 3/4", flat, mostly clinker, sub-angular to sub-round

12.0 - 13.0' **Clay**
Wet, brownish gray (5YR 4/1), very plastic rolls to 1/16"

13.0 - 21.0' **Silty clayey sands** [Alluvium]
Wet, dark yellowish brown, very loose, possibly flowing

21.0 - 21.5' **Coal/carbonaceous shale** [Bedrock]
Wet, medium dark gray to black, soft, weathered, making ~15 gpm, SC=3220 μmhos/cm

21.5 - 22.0' **Siltstone, some fine sand** [Bedrock]
Medium light gray to moderate olive brown with thin dark beds, calcareous

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Billings, Montana



Monitor Well Log

Hole Name: AVF1-PH2

Date Hole Started: 7/25/2011 Date Hole Finished: 7/25/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 20
SW 1/4, SW 1/4; N 493745.15, E 2810283.93
Location Description: Trusler Meadow, first
terrace above creek, AVF1
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Define AVF
Target Aquifer: Alluvium
Hole Diameter (in): 8" (0-40'), 4" (40-68')
Total Depth Drilled (ft): 68

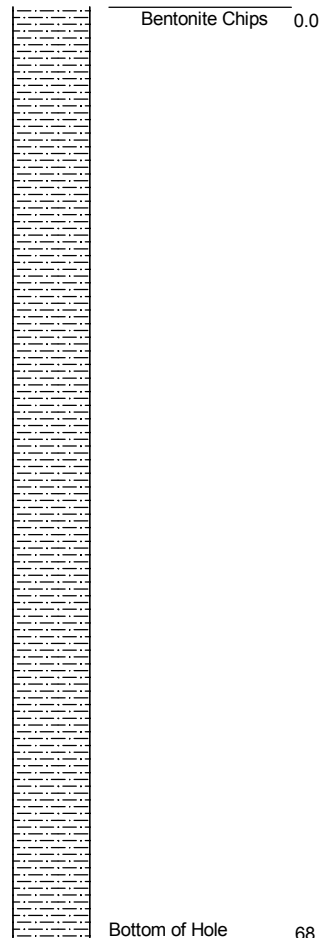
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	N		NA
Surface Casing Used?	N		NA
Screen/Perforations?	N		NA
Sand Pack?	N		NA
Annular Seal?	N		NA
Surface Seal?	Y	Bentonite Chips	0-68

DEVELOPMENT/SAMPLING

Well Developed?	N
Water Samples Taken?	N
Boring Samples Taken?	N
Northing: 493745.15	Easting: 2810283.93
Static Water Level Below MP:	Surface Casing Height (ft): NA
Date:	Riser Height (ft): NA
MP Description:	Ground Surface Elevation (ft): 3004.29
MP Height Above or Below Ground (ft):	MP Elevation (ft):

Remarks: 7 7/8" bit for 0-40' interval. 3 7/8" bit for 40-68' interval. Set 66' of 8" steel, pulled before abandoning hole. Plugged hole with 3/8" bentonite chips.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' Silt [Topsoil] Some clay present, dry, moderate yellowish brown; loose, roots, and trace white precipitates
5.0 - 6.0' Silty clay [Colluvium] Slightly moist, moderate yellowish brown, loose, low plasticity
6.0 - 27.0' Sand with clay [Alluvium/Colluvium] Fine grained, slightly moist, pale to moderate yellowish brown, loose, soft. Becomes clayey at 15', trace gravel at 20'. Increasing clay 20'-27' with less gravel
27.0 - 35.0' Sandy clay [Alluvium] Slightly moist to wet with depth, moderately loose to moderately dense. Light olive gray. Non-plastic=27'-33', moderately plastic=33'-35'
35.0 - 66.0' Gravel [Alluvium] Wet, sand is dark yellowish brown. Multicolored clinker gravels: light brown, moderate reddish brown, etc.; sandy. Gravels are flat to moderate sphericity, sub-round, size to 2", less sand at 45'. Trace coal gravel at 55', becomes more blocky and angular at 58' and sizes to 3". Sandy again at 60'; dark yellowish brown. Open hole yields approximately 100 gpm
66.0 - 68.0' Claystone [Bedrock] Medium dark gray to brownish gray; soft to moderately dense; moderate plasticity

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Billings, Montana



Monitor Well Log

Hole Name: AVF2-1

Date Hole Started: 1/27/2011 Date Hole Finished: 1/27/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 32; N 485147.38, E 2814078.72
Location Description: AVF2 south fence line of Trusler meadow south of cemetery
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 31

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	6-inch Sch 40, PVC	+1-29
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.050-inch slot, 6" PVC	19-29
Sand Pack?	Y	10/20 silica sand	6-29
Annular Seal?	Y	Bentonite Chips	+1-6
Surface Seal?	N		

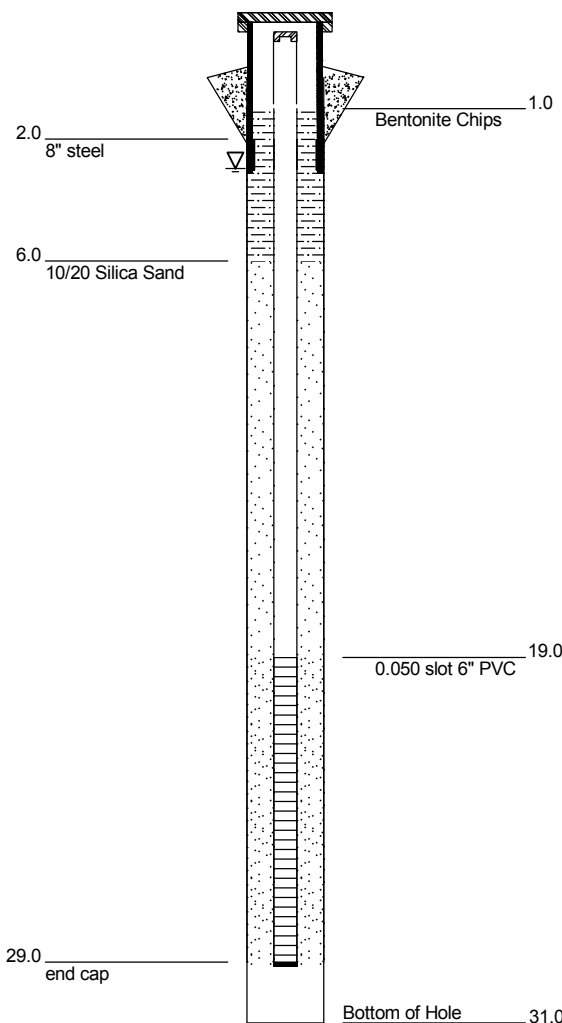
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Rotary
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 485147.38	Easting: 2814078.72
Static Water Level Below MP: 5.09	Surface Casing Height (ft): 2.39
Date: 1/28/2011	Riser Height (ft): 2.13
MP Description: Top PVC	Ground Surface Elevation (ft): 3003.13
MP Height Above or Below Ground (ft): 2.13	MP Elevation (ft): 3005.27

Remarks: Bottom of hole sloughed 2'. Too loose and sandy for open bottom completion. Blew on hole at total depth to clean out, complete with 6" PVC. SC=3110 µmhos/cm, pH=7.84, temp=9.2°C, yield~100 gpm

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Silty clay [Alluvium] Slightly moist, moderate yellowish brown, loose, roots, debris in top 1'
4.0 - 11.0'	Sandy clay [Alluvium] Wet, moderate to dark yellowish brown, non-plastic, calcareous
11.0 - 20.0'	Gravel, silty sandy, poorly sorted [Alluvium] Wet, fines are moderate yellowish brown, gravels multicolored, clinker origin, size up to 1", sub-round, medium sphericity, coarsens with depth to 3.5", sand to 10%, no silt
20.0 - 30.0'	Poorly sorted sand and gravel Wet, multi-color, sand to 50%, flat, sub-angular to sub-round gravels of clinker and sandstone origin, medium sphericity
30.0 - 31.0'	Sandstone, silty clayey [Bedrock] Wet from above, medium gray, soft

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: AVF2-2

Date Hole Started: 1/28/2011 Date Hole Finished: 1/28/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 32; N 485147.86, E 2814118.55
Location Description: AVF2 south fence line of Trusler meadow south of cemetery
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 32

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-32
Surface Casing Used?	Y	8" steel	+2.5-2.5
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	17-32
Sand Pack?	Y	10/20 silica sand	18-32
Annular Seal?	Y	Bentonite Chips	+1-6
Surface Seal?	N		

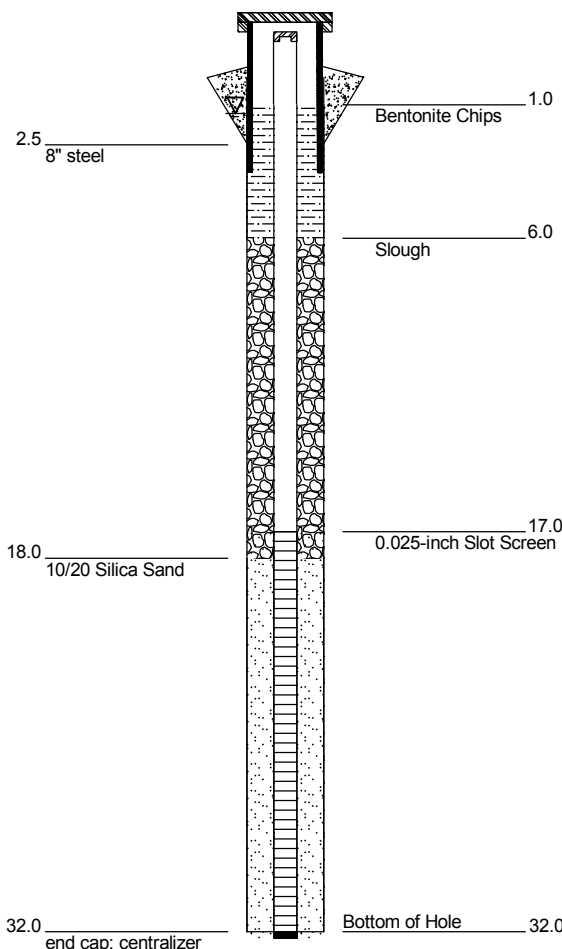
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Rotary
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 485147.86	Easting: 2814118.55
Static Water Level Below MP: 3.54	Surface Casing Height (ft): 2.43
Date: 6/23/2011	Riser Height (ft): 2.22
MP Description: Top PVC	Ground Surface Elevation (ft): 3003.14
MP Height Above or Below Ground (ft): 2.22	MP Elevation (ft): 3005.36

Remarks: Drill to 20' with 7 7/8" bit, drive 8" steel casing 31'; hole sloughed 6-18' bgs. SC=3000 µmhos/cm, pH=8.04, temp=10.4°C, yield ~100 gpm

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Silty clay [Alluvium] Slightly moist, moderate yellowish brown, loose, roots, debris in top 1"
4.0 - 11.0'	Sandy clay [Alluvium] Wet, moderate to dark yellowish brown, non-plastic, calcareous
11.0 - 20.0'	Sand and gravel poorly sorted Wet, multi-colors, moderate reddish brown to dark yellowish brown or dark gray, clinker and sandstone, thin mostly flat, sub-angular to sub-round to 3"; sand 30-50% and grayish brown (5YR 3/2)
20.0 - 20.5'	Clay Moist, medium light gray, gravel from above embedded in surface, streaks of moderate olive brown, calcareous, non-plastic
20.5 - 26.0'	Gravel [Alluvium] Wet, clean, sand less than 2%, gravel multi-colored clinkers and sandstone
26.0 - 30.0'	Gravel, sandy [Alluvium] Wet, multi-colored clinkers and sandstone gravels; moderate yellowish brown (10YR 5/4) sand up to 50%
30.0 - 32.0'	Siltstone [Bedrock/ Fort Union] Dry, light olive gray (5Y 5/2), moderately firm, some very thin dark brown interlayers, calcareous

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: AVF2-3

Date Hole Started: 1/28/2011 Date Hole Finished: 1/28/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 32; N 485192.4, E 2814623.06
Location Description: AVF2 south of cemetery near south edge of Trusler meadow
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 35

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-34
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	19-34
Sand Pack?	Y	10/20 silica sand	12-34
Annular Seal?	Y	Bentonite Chips	+1-12
Surface Seal?	N		

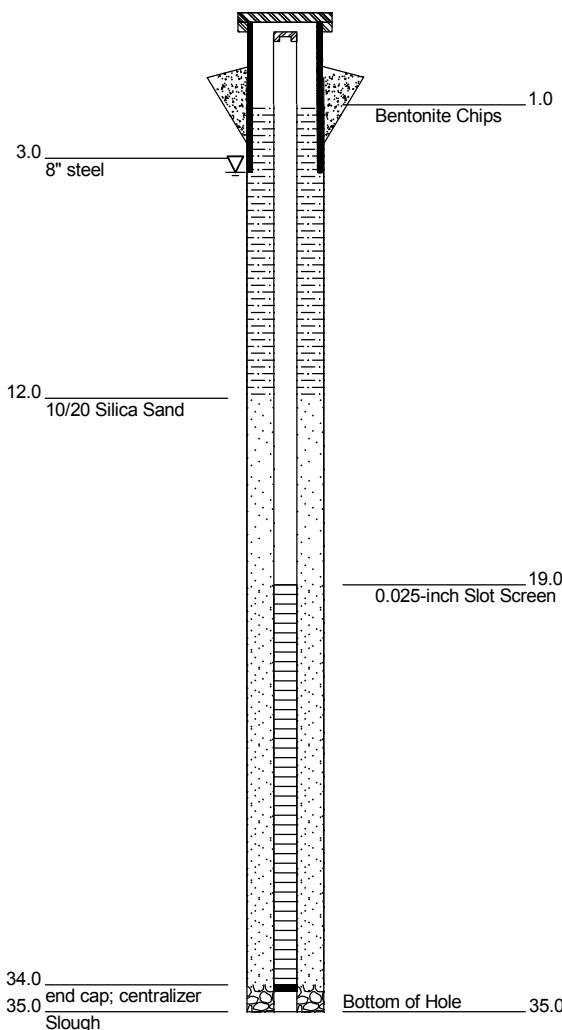
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Rotary
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 485192.4	Easting: 2814623.06
Static Water Level Below MP: 5.33	Surface Casing Height (ft): 2.22
Date: 7/15/2011	Riser Height (ft): 1.80
MP Description: Top PVC	Ground Surface Elevation (ft): 3005.30
MP Height Above or Below Ground (ft): 1.80	MP Elevation (ft): 3007.09

Remarks: Drive 8" steel casing to 32', drilled with 7 7/8" drag bit, all steel and replace with 5' monument. SC=4620 μ mhos/cm, pH=2.93, temp=10.1°C; hole sloughed from 34'-35'

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 2.0' Silty clay [Alluvium/Topsoil] Dry to slightly moist, moderate yellowish brown, loose, roots to 3'
2.0 - 13.0' Silty clay with sand [Alluvium] Moist to wet with depth, moderate to dark yellowish brown, moderate plasticity, rolls to 1/8", calcareous
13.0 - 35.0' Gravel, sandy [Alluvium] Wet, clinker and sandstone origin, multi-colored, sub-round to round, some with moderate sphericity; less sand to <2% at 20'-24.5' Clayey at 24.5', wet, clay=non-plastic, calcareous Sandy again at 24.5'-35', sand=dark yellowish brown, gravels to 3" Total depth, tagged bedrock at 35', no bedrock cuttings logged

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Monitor Well Log

Hole Name: AVF2-4

Date Hole Started: 1/28/2011 Date Hole Finished: 1/28/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 32; N 485129.2 E 2813441.03
Location Description: AVF2 south of cemetery near south edge of Trusler meadow
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 32

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-32
Surface Casing Used?	Y	8" steel	+2.5-2.5
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	22-32
Sand Pack?	Y	10/20 silica sand	17-32
Annular Seal?	Y	Bentonite Chips	+1-9
Surface Seal?	N		

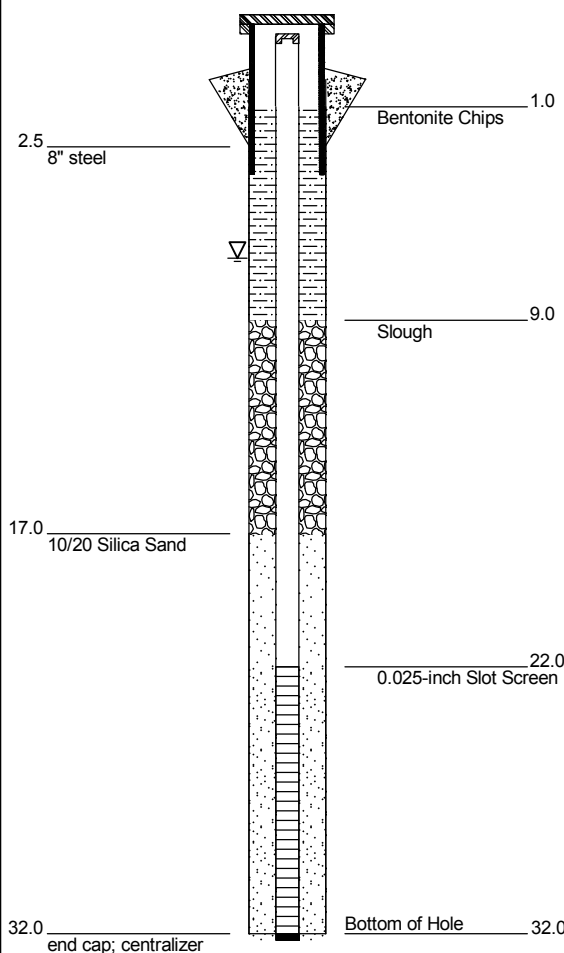
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Rotary
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 485129.2	Easting: 2813441.03
Static Water Level Below MP: 8.96	Surface Casing Height (ft): 2.60
Date: 1/28/2011	Riser Height (ft): 2.29
MP Description: Top PVC	Ground Surface Elevation (ft): 3004.56
MP Height Above or Below Ground (ft): 2.29	MP Elevation (ft): 3006.85

Remarks: Drive 8" steel casing 32', pull casing out 5', drill in casing with 7 7/8" bit. SC=5000 µmhos/cm, pH=7.78, temp=11.8° C, yield = 10-15 gpm. Hole sloughed from 9-17'

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0' **Silty clay** [Alluvium]
Dry, moderate yellowish brown, roots, non-plastic

5.0 - 17.0' **Sandy silty clay**
Wet, pale to moderate yellowish brown, very soft

17.0 - 29.0' **Gravel and sand poorly sorted**
Wet, multi-colored gravel, clinker and sandstone sub-round, moderate sphericity, sand dark yellowish brown, changes to moderate yellowish brown at 25'

29.0 - 30.0' **Coal** [Bedrock]
Black, cleated multiple planes, moderately weathered, moderately firm

30.0 - 32.0' **Claystone** [Bedrock]
Medium light gray, soft, non-plastic, mild calcareous

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Monitor Well Log

Hole Name: AVF2-5

Date Hole Started: 1/28/2011 Date Hole Finished: 1/28/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 32; N 485120.1, E 2813077.86
Location Description: Trusler meadow south of cemetery
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 20

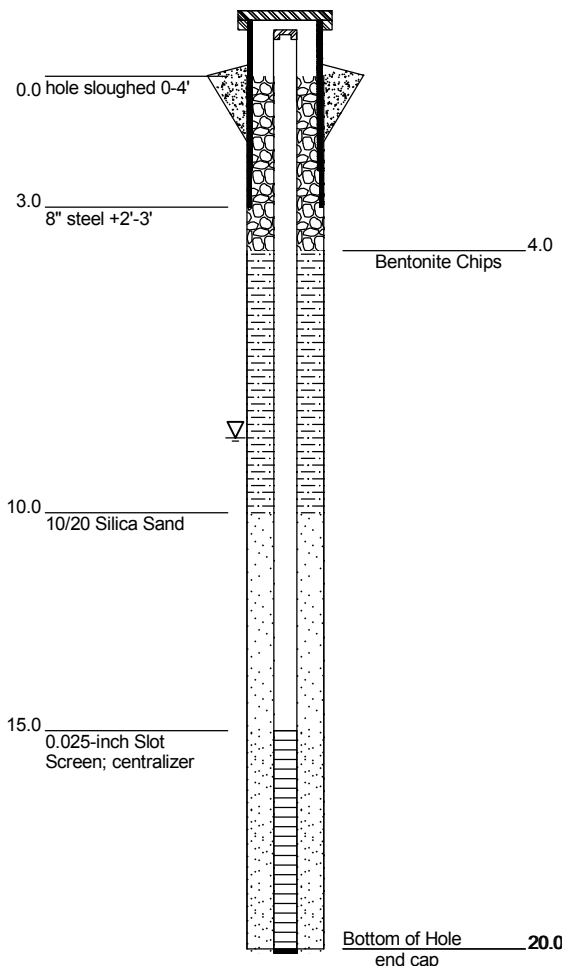
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-20
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	15-20
Sand Pack?	Y	10/20 silica sand	10-20
Annular Seal?	Y	Bentonite Chips	4-10
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 485120.1		Easting: 2813077.86
Static Water Level Below MP: 9.94		Surface Casing Height (ft): 1.92
Date: 1/28/2011		Riser Height (ft): 1.65
MP Description: Top PVC		Ground Surface Elevation (ft): 3005.62
MP Height Above or Below Ground (ft): 1.65		MP Elevation (ft): 3007.28

Remarks: Drilled to 19' with 7 7/8" bit, hole collapsed to 17.5', 4.5" casing pushed through sloughed material to total cased depth of 17.5', fines getting through screen, bottom cap broken, casing pulled, re-drilled to 20' inside 8" casing. SC=4400 µmhos/cm, pH=8.10, temp=14.3° C, yield= 2-4 gpm after development, still some fines through screen.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silty clay [Alluvium] Slightly moist, dark yellowish brown, loose, roots
3.0 - 10.0'	Silty clay, some sand [Alluvium] Wet, pale to moderate yellowish brown, soft, roots in top, non-plastic
10.0 - 15.0'	Clay, silty [Alluvium] Wet, pale yellowish brown, very soft, high plasticity, rolls to 1/16"
15.0 - 17.5'	Sand and gravel, poorly sorted Wet, multi-colors: pale to moderate reddish brown to olive gray, some light brown (5YR 5/6); sub-angular to sub-round with depth, clinker gravels and sandstone gravels, moderate yellowish brown sand to 50%
17.5 - 20.0'	Tagged bedrock, no samples

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Monitor Well Log

Hole Name: AVF2-6

Date Hole Started: 2/11/2011 Date Hole Finished: 2/11/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 33; N 485180.63, E 2815413.49
Location Description: AVF2 - south of cemetery
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 47

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	8" steel open bottom	+3-44
Surface Casing Used?	Y	8" steel	+3-44
Screen/Perforations?	N		
Sand Pack?	N		
Annular Seal?	Y	Bentonite Chips	annulus - drill/drive
Surface Seal?	N		

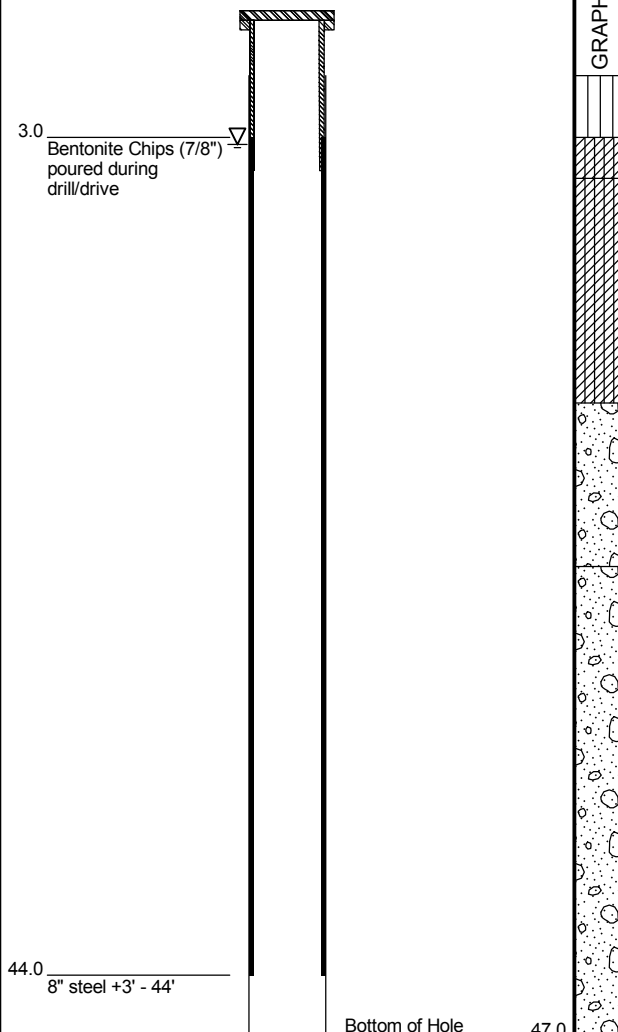
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 485180.63	Easting: 2815413.49
Static Water Level Below MP: 6.19	Surface Casing Height (ft): 2.86
Date: 2/11/2011	Riser Height (ft):
MP Description: Top of Steel	Ground Surface Elevation (ft): 3010.11
MP Height Above or Below Ground (ft): 2.86	MP Elevation (ft): 3012.97

Remarks: Drill and drive 8" steel casing to 44', 7 7/8" drag bit. SC=2000 μ mhos/cm, pH=8.13, temp=10.2°C, open hole yields ~150 gpm

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0' Silt [Colluvium] Dry, pale yellowish brown, moderately loose to weakly cemented, roots
3.0 - 5.0' Silty clay [Alluvium/Colluvium] Moist, medium gray and brownish gray with light brown (5YR 5/6) mottles, non-plastic, moderately dense
5.0 - 16.0' Silty, sandy, clay [Colluvium/Alluvium] Very moist to wet at 7', very plastic (rolls to 1/16") to moderately plastic with depth, becomes very sandy at 10', moderate yellowish brown with some light brown (5YR 5/6) and medium gray (N4) streaks
16.0 - 24.0' Gravel, sandy, clayey, poorly sorted [Alluvium] Wet, moderate to dark yellowish brown fines, clinker gravels with gravels to 1" at 16-24', very loose
24.0 - 47.0' Gravel, sandy Less sand (~5%) with depth, gravels to 3" at 24' - gravels = clinker, coal, sandstone; sub-rounded, low to moderate sphericity. Very sandy again at 36'-41', dark yellowish brown sand No sand at 40'-46', gravels to 6", hole stays open Bedrock at 46', claystone?, no sample returns, total depth at 47'

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Monitor Well Log

Hole Name: AVF3-1

Date Hole Started: 11/10/10 Date Hole Finished: 11/12/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15;
N470051.63 E2823451.75
Location Description: 50 yards East of Otter
Creek, 52.5 yards West of well C-4
Recorded By: AJH
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 103

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	6-inch Sch 40, PVC	+1-58
Surface Casing Used?	Y	8" steel	0-40
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	38-58
Sand Pack?	Y	natural and 10/20 silica sand	7-58
Annular Seal?	Y	Bentonite Chips	0-7
Surface Seal?	Y	Concrete Pad	

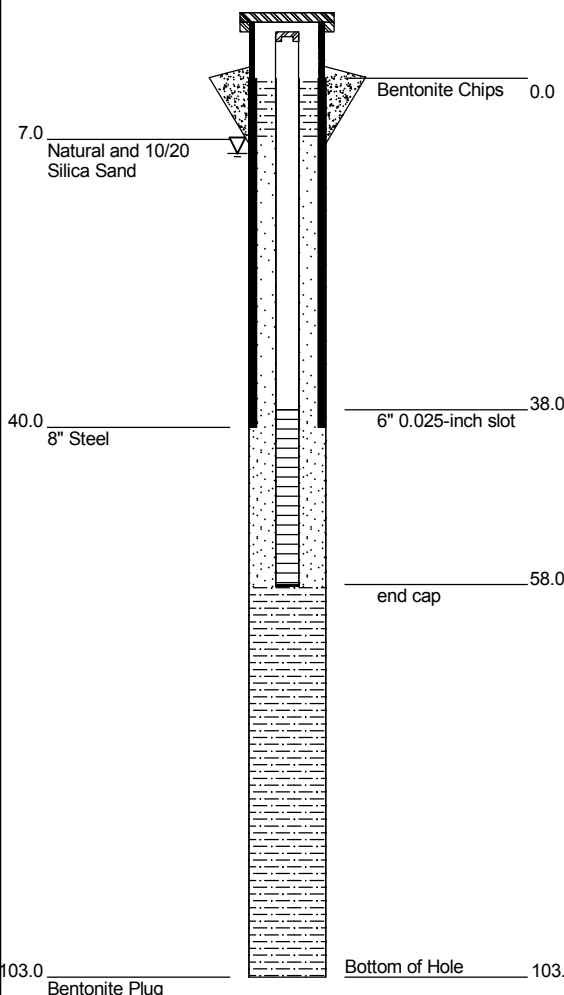
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Lift
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 470051.63	Easting: 2823451.75
Static Water Level Below MP: 9.8	Surface Casing Height (ft): 1.22
Date: 11/12/2010	Riser Height (ft): 1.18
MP Description: Top PVC	Ground Surface Elevation (ft): 3050.97
MP Height Above or Below Ground (ft): 1.18	MP Elevation (ft): 3052.14

Remarks: Drill to 10', drive 8" steel, advance 40', drilled out; add more steel drive to 59' bgs then to 79' then to 98'. Very high sediment load in cuttings, strong H2S odor; SC=2910 µmhos/cm, pH=8.56. Plug back pull casing to 60'. 30-40 gpm after completion

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silt, clayey [Topsoil] Dry to moist, moderate yellowish brown (10YR 5/4), calcareous, non-cohesive, few roots
3.0 - 7.0'	Clay, silty [Colluvium] Very moist, moderate yellowish brown (10YR 5/4), weakly cohesive, calcareous, very soft, no roots, rolls 1/8" thread
7.0 - 15.5'	Clay, some silt (5-10%) [Colluvium] Very moist to wet, dark yellowish brown (10YR 4/2), cohesive, rolls thread to 1/16", calcareous
15.5 - 27.0'	Sandy, silty gravel [Alluvium] Wet, variable colors, majority of gravel is angular to sub-rounded clinkers, some coal fragments, very gravelly, very poorly sorted, more sandy at 25', back to gravel at 27'
27.0 - 40.0'	Sandy, silty gravel [Alluvium] Wet, variable colors, rock fragments, sandstone, siltstone, and clinker, very poorly sorted, angular to well rounded
40.0 - 60.0'	Sandy, silty gravel [Alluvium] Wet, variable colors, 5% coal fragments, silt and clay increases at 47'-49', coal 10% up to 3" in length at 60', more angular cuttings
60.0 - 65.0'	Gravel mostly comprised of coal - 90%
65.0 - 85.0'	Sand, loose, silty [Alluvium] Flowing sand, very loose, liquifiable?, dark yellowish brown (10YR 4/2) cuttings contain 50% fine quartz sand and 50% coal flakes, quartz grain sub-angular to sub-rounded suggesting sandstone source
85.0 - 97.0'	Coal Cleated 3x, very soft, fragments to 3", may be in place, some sand
97.0 - 100.0'	Clay Olive black (5Y 2/1), fat, cohesive, very soft
100.0 - 101.0'	Claystone Greenish gray (5GY 6/1), soft, non-calcareous, well blowing 600gpm at 100-101

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Monitor Well Log

Hole Name: AVF3-2

Date Hole Started: 11/12/10 Date Hole Finished: 11/12/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15; N 470043.96, E 2823459.65
Location Description: 55 yards East of Otter Creek; 10' East of well AVF3-1
Recorded By: AJH
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 59

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-59
Surface Casing Used?	Y	8" steel	
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	37-57
Sand Pack?	Y	10/20 silica sand	41-56
Annular Seal?	Y	Bentonite Chips	0-16
Surface Seal?	Y	Concrete Pad	

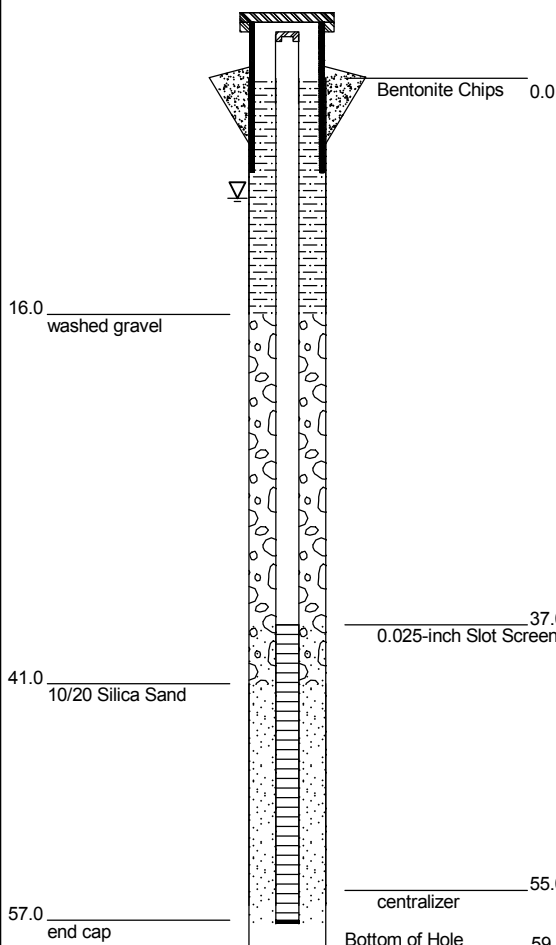
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Rotary
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 470043.96	Easting: 2823459.65
Static Water Level Below MP: 9.6	Surface Casing Height (ft): 1.69
Date: 11/12/2010	Riser Height (ft): 1.48
MP Description: Top PVC	Ground Surface Elevation (ft): 3051.15
MP Height Above or Below Ground (ft): 1.48	MP Elevation (ft): 3052.64

Remarks: Air lift develop 15 minutes, clear, SC stable at 4800 μ mhos/cm, pH 8.02, temp 9.3°C. Advanced steel to 60' by driving with casing hammer, drill out cuttings, install well, pull back steel.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0' Silt [Topsoil] Dry to very moist, moderate yellowish brown (10YR 5/4), calcareous, non-cohesive, few roots
3.0 - 15.0' Silty clay to clay [Colluvium] Very moist to wet at 8-9', moderate yellowish brown (10YR 5/4), cohesive, rolls 1/16" thread
15.0 - 48.0' Sandy, silty gravel Wet, color variable, fines pale yellowish brown (10YR 6/2), lots of clinker, sandstone, siltstone, some clay intervals but thin, calcareous, very poorly sorted, angular to rounded, rock fragments to 3" coal fragments increase below 40'
48.0 - 54.0' Sand with gravel [Alluvium] Wet, very soft, trace coal
54.0 - 55.0' Sandy clay Blue gray with black flakes, some clinker gravel, soft
55.0 - 58.0' Sandy gravel Variable color, very poorly sorted, rounded to angular, most rock fragments are flat

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Billings, Montana



Monitor Well Log

Hole Name: AVF3-3

Date Hole Started: 3/23/2011 Date Hole Finished: 3/23/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15; N 469949.41, E 2823931.81
Location Description: AVF3 on Otter Creek Alluvium; Easternmost well
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 11"(0-30'), 8"(30-65')
Total Depth Drilled (ft): 65

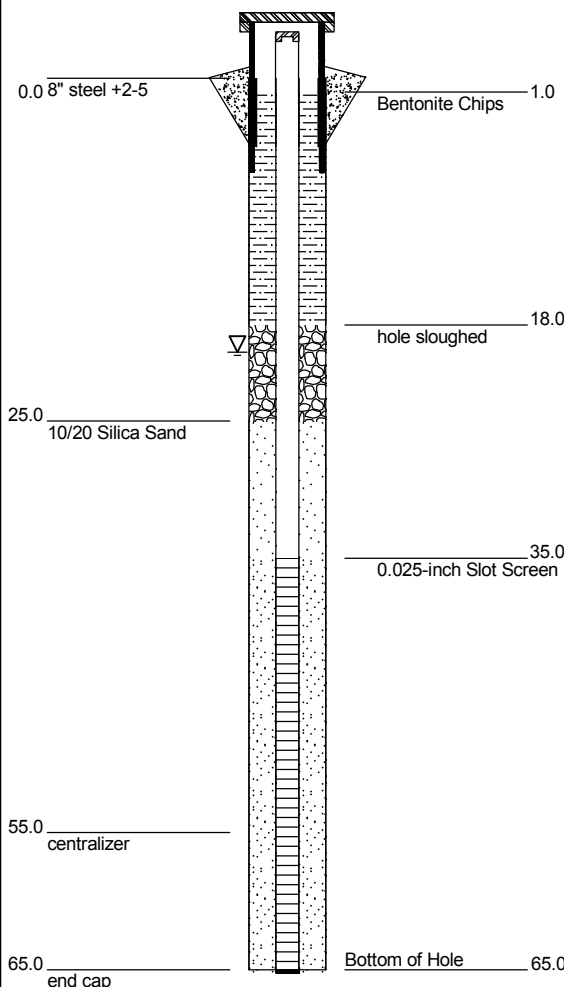
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-65
Surface Casing Used?	Y	8" steel	+2-5
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	35-65
Sand Pack?	Y	10/20 silica sand	25-65
Annular Seal?	Y	Bentonite Chips	+1-18
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 469949.41	Easting: 2823931.81	
Static Water Level Below MP: 21.55	Surface Casing Height (ft): 1.92	
Date: 3/23/2011	Riser Height (ft): 1.57	
MP Description: Top PVC	Ground Surface Elevation (ft): 3062.45	
MP Height Above or Below Ground (ft): 1.57	MP Elevation (ft): 3064.02	

Remarks: Drill to 30' with 7 7/8" bit, ream out with 12" bit, drive 8" steel to 58', drill out with 4" bit to 60', drive 8" steel to 65', bentonite poured with steel. Hole sloughed when steel pulled back from 18'-25' bgs, developed with rig air. After development SC=4290 μ mhos/cm, pH=8.03, temp=9.9° C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0' Silty clay [Topsoil] Moist, moderate yellowish brown, loose to moderately cohesive, roots of grass and shrubs
1.0 - 10.0' Silty clay [Colluvium] Dry, grayish orange, loose, non-plastic
10.0 - 15.0' Silty clay Slightly moist, pale to moderate yellowish brown, non-plastic
15.0 - 23.0' Clay, silty [Colluvium] Very moist, moderate yellowish brown, moderate to high plasticity with moisture increase, moisture increases with depth; wet at 18', trace of sand at 10', injecting water at 20'
23.0 - 25.0' Sand [Alluvium] fine to medium grained, wet, pale to moderate yellowish brown, very loose
25.0 - 51.0' Sand and gravel [Alluvium] poorly sorted (50/50), wet, pale to moderate yellowish brown sand with light brown and moderate orange pink gravel, gravel is clinker origin, flat, sub-angular to sub-round, hard
Gravels up to 3" at 35', less flat, medium sphericity Clay stringer at 50', fines (clay and sand) change color to dark yellowish brown
51.0 - 52.0' Gravel (sand 20%) [Alluvium] Wet, pale to dark yellowish brown and grayish orange sandstone gravels, light brown clinker gravels up to 3", cleaner than above
52.0 - 64.0' Sand, fine to medium, some silty clay [Alluvium] Moderate to pale yellowish brown, very loose, soft; coarse sand and gravels (up to 2") of sandstone origin at bedrock contact
64.0 - 65.0' Coal [Bedrock] Wet, black, hard, very cleated (Upper Knobloch?)

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Billings, Montana



Monitor Well Log

Hole Name: AVF3-4

Date Hole Started: 8/23/11 Date Hole Finished: 8/23/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15; N 470334.06, E 2822621.16
Location Description: AVF3 Battery near Badgett place
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Otter Creek Alluvium
Hole Diameter (in): 11" (0'-18'), 8" (18'-56')
Total Depth Drilled (ft): 56

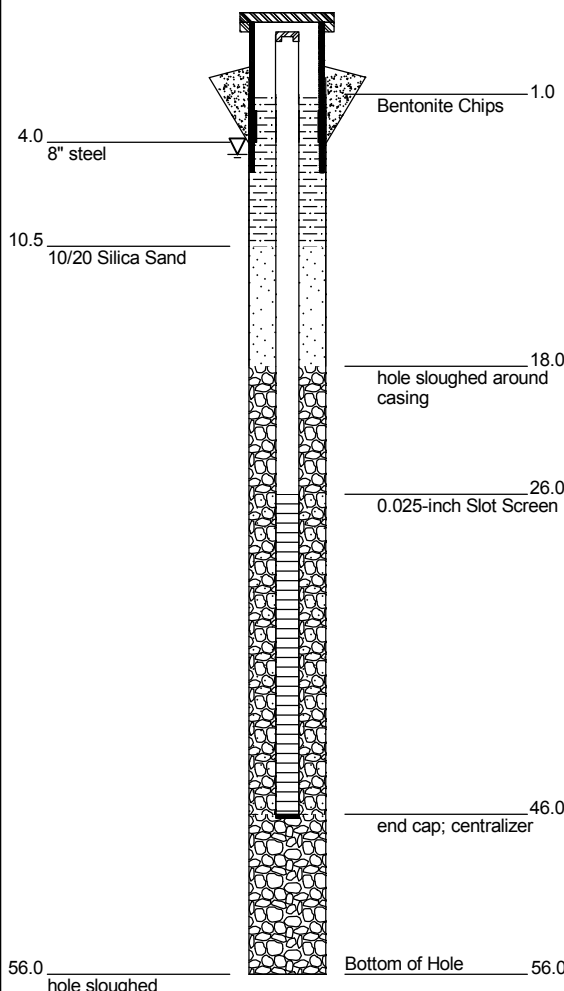
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-46
Surface Casing Used?	Y	8" steel	+2-4
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	26-46
Sand Pack?	Y	10/20 Silica Sand	10.5-18
Annular Seal?	Y	Bentonite Chips	+1-10.5
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 470334.06	Easting: 2822621.16	
Static Water Level Below MP: 6.79	Surface Casing Height (ft): 2.26	
Date: 9/13/2011	Riser Height (ft): 2.03	
MP Description: Top PVC	Ground Surface Elevation (ft): 3043.38	
MP Height Above or Below Ground (ft): 2.03	MP Elevation (ft): 3045.42	

Remarks: Drilled to 18' with 10 7/8" drag bit, set 51' of 8" steel. Drilled out with 7 7/8" bit to 56'. Pulled steel to complete well in alluvium. Hole sloughed from 46'-56' bgs below casing; and hole sloughed from 18'-46' around casing. Blow with rig air to develop; after development SC= 4800 μ mhos/cm, pH= 8.05, temp= 12.3°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 10.0'	Silty clay [Colluvium] Moist to wet, pale to moderate yellowish brown, loose to dense, plastic, roots; injecting water at 5' bgs
10.0 - 19.0'	Clay, silty/sandy, some gravels Wet, moderate yellowish brown, plastic, very loose
19.0 - 33.0'	Sand and gravel Wet, moderate yellowish brown fines with multi-colored (e.g. light brown, moderate reddish brown) clinker gravels and sandstone gravels (poorly sorted 50/50), very loose; gravels to 2" at 19', increase to 4" at 30'; some clay from 19'-25'
33.0 - 50.0'	Thermally altered shale [Clinker] Wet, moderate red and moderate reddish brown, some pale yellowish orange (10YR 8/6), in place very hard, cobble size to 6", sub-angular to angular. At 46'-50' very hard shale, light bluish gray, light brownish gray, and grayish purple
50.0 - 56.0'	Coal [Top of Knobloch Coal] Wet, black (N1), hard, cleated

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Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: AVF3-P1

Date Hole Started: 8/15/13 Date Hole Finished: 8/15/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15,
NW1/4; N 470024.461, E 2823417.91
Location Description:
Recorded By: RJJ
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 2 1/8"
Total Depth Drilled (ft): 12

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	3/4", flush threaded, Sch 40, PVC	+2.82-12
Surface Casing Used?	Y	4" steel	+2.82-2.18
Screen/Perforations?	Y	0.010-inch slot, 3/4" pre-pack	7-12
Sand Pack?	Y	20/30 Silica Sand	3-12
Annular Seal?	Y	3/8" Bentonite Chips	+1-3
Surface Seal?	Y	Concrete Pad	

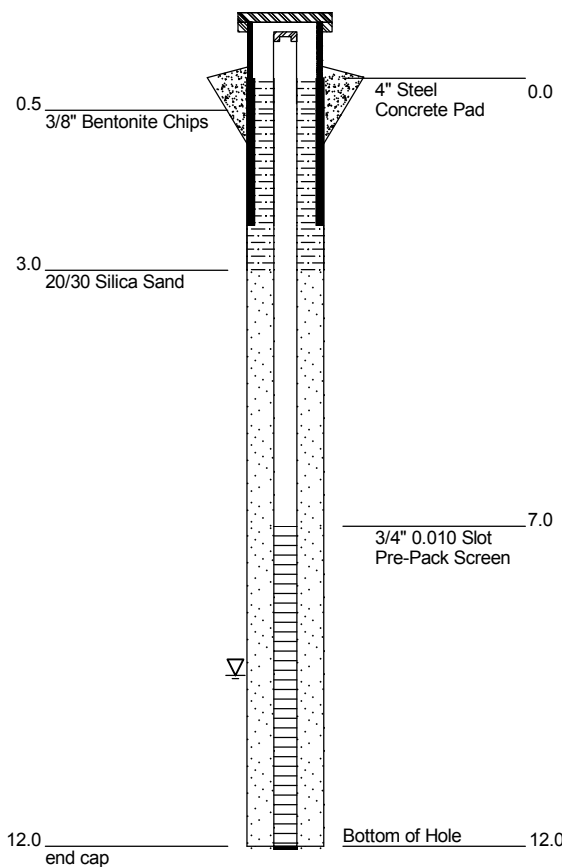
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 470024.461	Easting: 2823417.908
Static Water Level Below MP: 10.95	Surface Casing Height (ft): 2.82
Date: 8/28/2013	Riser Height (ft): 1.62
MP Description: Top PVC	Ground Surface Elevation (ft): 3050.069
MP Height Above or Below Ground (ft): 1.62	MP Elevation (ft): 3051.69

Remarks: Direct Pushed pilot hole to 14'. Tripped out and backfilled pilot hole with 3/8" bentonite chips. Moved ~ 5' and direct pushed to 12'. Used 10/20 silica sand to fill in around the 3/4 inch pre-pack screen. Interval for 10/20 sand pack is 3'-12'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0' **Clay**
dry; pale yellowish brown; moderately loose; trace sand; roots

4.0 - 13.0' **Silty Sandy Clay**
dry to very moist; moderate yellowish brown; loose; very sandy from 12'-13'

13.0 - 14.0' **Sandy Gravel**
wet; light brown to moderate yellowish brown; clinker gravel up to 3/4" in size

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: AVF3-P2

Date Hole Started: 8/15/13 Date Hole Finished: 8/15/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15,
NW1/4; N 470133.416, E 2823054.21
Location Description:
Recorded By: RJL
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/ Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4"
Total Depth Drilled (ft): 12

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	1-inch, flush threaded, Sch 40, PVC	+1.89-12
Surface Casing Used?	Y	4" steel	+1.89-3.11
Screen/Perforations?	Y	0.020-inch slot, 1"x 2" field pack	7-12
Sand Pack?	Y	10/20 Silica Sand	4-12
Annular Seal?	Y	3/8" Bentonite Chips	+1-4
Surface Seal?	Y	Concrete Pad	

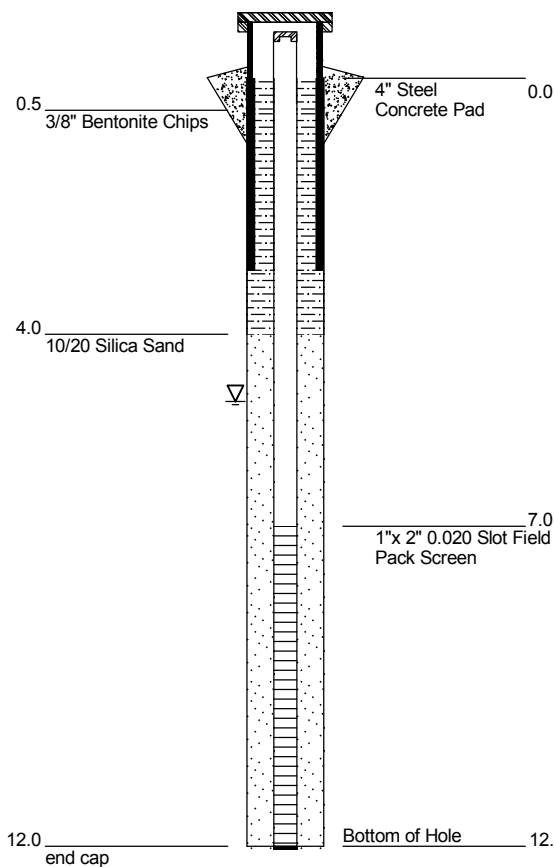
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 470133.416	Easting: 2823054.211
Static Water Level Below MP: 6.77	Surface Casing Height (ft): 1.89
Date: 8/28/2013	Riser Height (ft): 1.72
MP Description: Top PVC	Ground Surface Elevation (ft): 3045.329
MP Height Above or Below Ground (ft): 1.72	MP Elevation (ft): 3047.04

Remarks: Direct Pushed pilot hole to 12'. Tripped out and backfilled pilot hole with 3/8" bentonite chips. Moved ~ 3' and augered to 12'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 2.0'	Sandy Clay dry to moist; light yellowish brown; loose roots
2.0 - 4.0'	Clayey Sand very moist to wet; moderate yellowish brown; very loose
4.0 - 12.0'	Clayey Sand wet; moderate yellowish brown; very loose

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Monitor Well Log

Hole Name: AVF3-P3

Date Hole Started: 8/15/13 Date Hole Finished: 8/15/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15,
NW1/4; N 470379.922, E2822669.47
Location Description:
Recorded By: RJL
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/ Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4"
Total Depth Drilled (ft): 8

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	1-inch, flush threaded, Sch 40, PVC	+1.79-8.6
Surface Casing Used?	Y	4" steel	+1.79-3.21
Screen/Perforations?	Y	0.020-inch slot, 1"x 2" field pack	3.6-8.6
Sand Pack?	Y	10/20 Silica Sand	3-8
Annular Seal?	Y	3/8" Bentonite Chips	+1-3
Surface Seal?	Y	Concrete Pad	

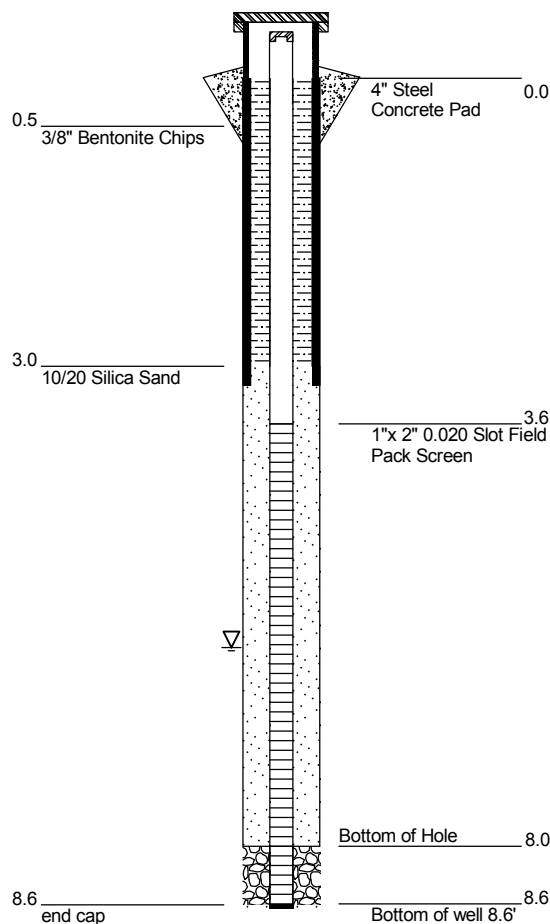
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 470379.922	Easting: 2822669.476
Static Water Level Below MP: 7.29	Surface Casing Height (ft): 1.79
Date: 8/28/2013	Riser Height (ft): 1.36
MP Description: Top PVC	Ground Surface Elevation (ft): 3043.64
MP Height Above or Below Ground (ft): 1.36	MP Elevation (ft): 3044.99

Remarks: Direct Pushed pilot hole to 8'. Tripped out and backfilled pilot hole with 3/8" bentonite chips. Moved ~ 3' and augered to 8'. Well pushed in and completed at 8.6' below ground surface due to soft clay.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Sandy Clayey Silt dry to moist; pale to moderate yellowish brown
4.0 - 8.0'	Clayey Sand wet; moderate yellowish brown; tagged gravel at 8'; 1/4" coal and clinker gravel
8.0 - 8.6'	No Core Logged well advanced passed the drilled depth

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Monitor Well Log

Hole Name: AVF4-1

Date Hole Started: 7/18/11 Date Hole Finished: 7/18/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 27, NE1/4; N 461327.91, E 2825333.13
Location Description: Immediately West of Otter Creek
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 35

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-34
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	21-34
Sand Pack?	Y	10/20 silica sand	20-35
Annular Seal?	Y	Bentonite Chips	0-9
Surface Seal?	N		

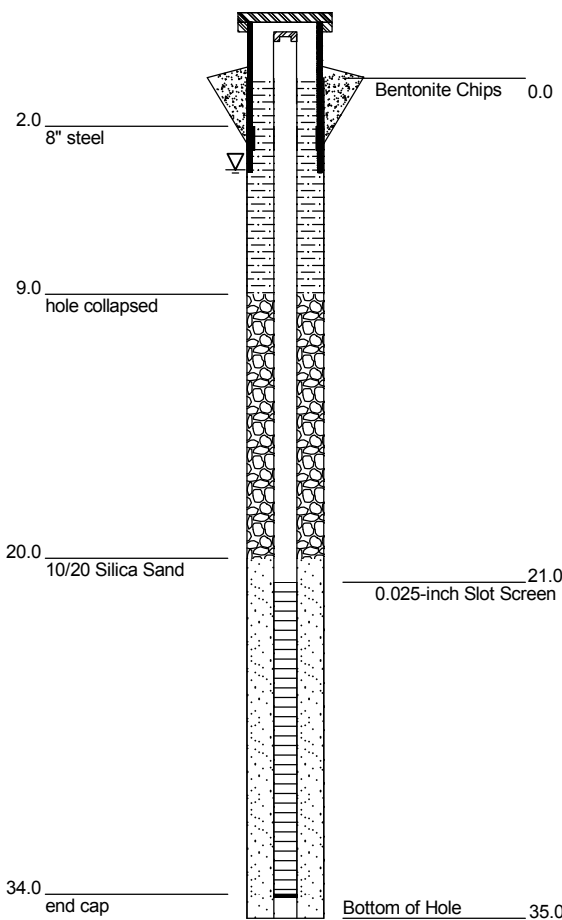
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 461327.91 Easting: 2825333.13
Static Water Level Below MP: 5.1 Surface Casing Height (ft): 1.84
Date: 7/18/2011 Riser Height (ft): 1.28
MP Description: Top PVC Ground Surface Elevation (ft): 3069.70
MP Height Above or Below Ground (ft): 1.28 MP Elevation (ft): 3070.98

Remarks: Hole collapsed at 9'-20'. Start air lift at 3:30 p.m., SC= 5350 μ mhos/cm at 3:32 p.m.; SC= 5430 μ mhos/cm at 3:40 p.m., slightly cloudy. Yield est. at 15-20 gpm.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 17.0' **Silty clay**
<5% fine sand (orange red); soft; dry to moist at 4', adding water; dark yellowish brown (10YR 4/2), silty layer at 10'-12', pale yellowish brown (10YR 6/2)

17.0 - 33.0' **Gravels** [Alluvium]
Multi-color; flaggy angular to sub-rounded, matrix is dark yellowish brown (10YR 4/2); clinker gravels and sandstone, rounded cobbles

33.0 - 34.0' **Weathered coal** [Bedrock]
Black, dusky brown, oxidized

34.0 - 35.0' **Coal** [Bedrock]
Hard, black cleated, glossy fracture planes

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Billings, Montana



Monitor Well Log

Hole Name: AVF4-2

Date Hole Started: 7/18/11

Date Hole Finished: 7/18/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 27, NE1/4; N 461411.75, E 2826300.08
Location Description: East end of AVF4 near mouth of Fortune Creek
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 55.5

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-51
Surface Casing Used?	Y	8" steel	+2-3'
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	31-51
Sand Pack?	Y	10/20 silica sand	16-26, 43-49
Annular Seal?	Y	Bentonite Chips	0-16
Surface Seal?	N		

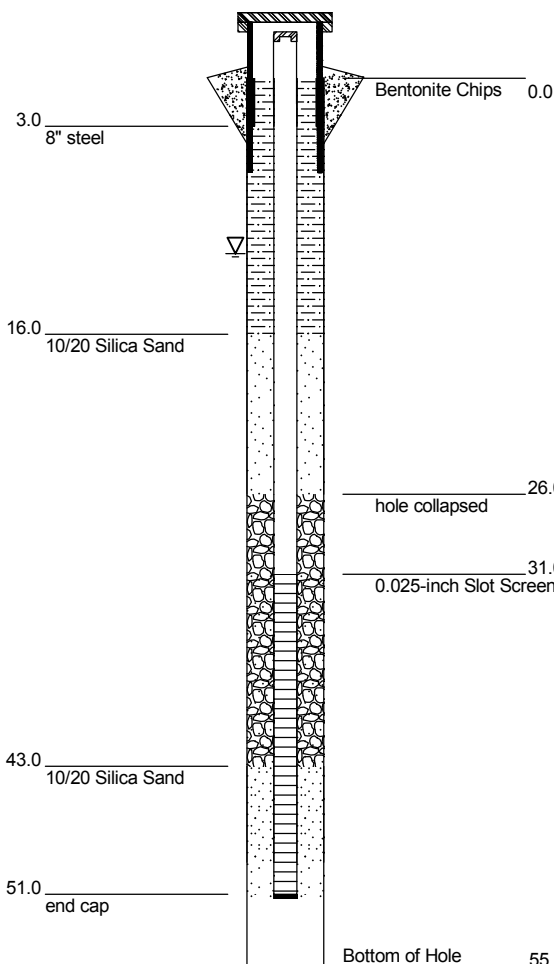
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 461411.75	Easting: 2826300.08
Static Water Level Below MP: 12.9	Surface Casing Height (ft): 2.06
Date: 7/18/2011	Riser Height (ft): 1.93
MP Description: Top PVC	Ground Surface Elevation (ft): 3076.20
MP Height Above or Below Ground (ft): 1.93	MP Elevation (ft): 3078.12

Remarks: Hole collapsed at 26'-43'. Gravels heaved to 49'. Start airlift at 6:00 p.m., SC=4250 µmhos/cm at 6:15p.m., stable.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 18.0'	Clayey silt Dry to 5', moist below, adding water; soft, moderate yellowish brown (10YR 5/4), orange oxidation staining at 5'-10'
18.0 - 26.0'	Silty clay [Alluvium] Slightly stiff, fine sand <10%, moderate yellowish brown (10YR 5/4) with medium gray layers
26.0 - 40.0'	Clayey gravels [Alluvium] Some coarse sand (~10%); clinker gravels red orange, multi-color, poorly sorted; flaggy angular coal chunks in gravels at 35' to 40'
40.0 - 55.0'	Gravel with sand (10-15%) [Alluvium] Multi-color (moderate reddish orange/dusky yellow/moderate brown), poorly sorted, flaggy, sub-rounded; clinker gravels, cobbles to 8" diameter, producing water
55.0 - 55.5'	Coal [Bedrock] Hard, black, cleated

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Billings, Montana



Monitor Well Log

Hole Name: AVF4-3

Date Hole Started: 7/19/11 Date Hole Finished: 7/19/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 27,
NE1/4; N 461198.56, E 2824564.14
Location Description: Just north of hay yard
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 32

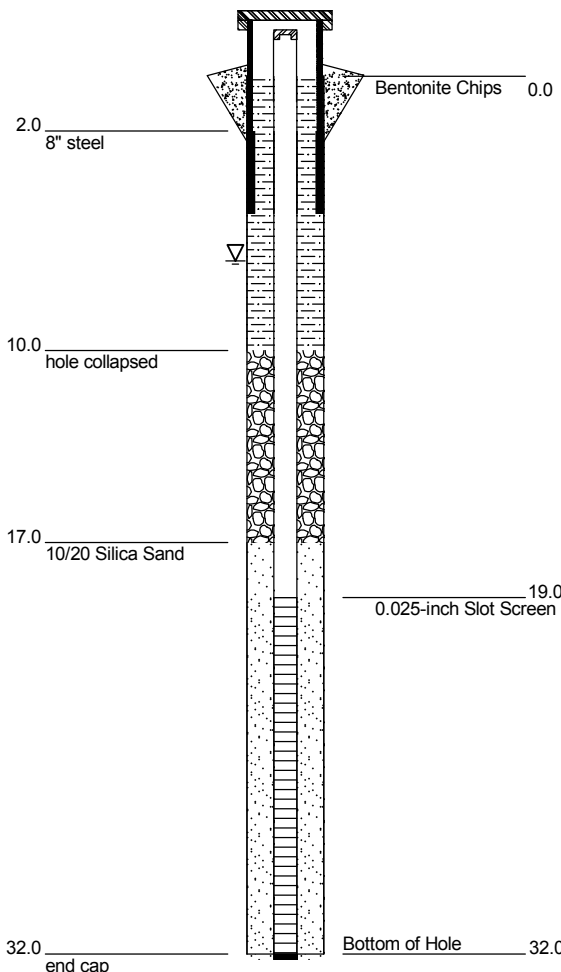
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-32
Surface Casing Used?	Y	8" steel	+2-5
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	19-32
Sand Pack?	Y	10/20 silica sand	17-32
Annular Seal?	Y	Bentonite Chips	0-10
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 461198.56	Easting: 2824564.14	
Static Water Level Below MP: 8.6	Surface Casing Height (ft): 2.09	
Date: 7/19/2011	Riser Height (ft): 1.87	
MP Description: Top PVC	Ground Surface Elevation (ft): 3073.23	
MP Height Above or Below Ground (ft): 1.87	MP Elevation (ft): 3075.1	

Remarks: Hole collapsed at 10'-17'. Start airlift at 10:10 a.m., SC=4260 µmhos/cm at 10:20 a.m., stable.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Silty clay	Dry at surface to moist at 3'; very moist at 4'; moderate yellowish brown (10YR 5/4), roots, minor very fine sand
4.0 - 15.0'	Clayey silt [Alluvium]	Very moist, some very fine sand, moderate yellowish brown, adding water at 5'
15.0 - 18.0'	Silty sand [Alluvium]	Coarse with very fine clinker gravels
18.0 - 21.0'	Sandy gravels [Alluvium]	Multi-color (blacks to reds); poorly sorted; flaggy, angular, up to 4" diameter; sand 15%+
21.0 - 23.0'	Clay [Alluvium]	Stiff, moderate olive brown (5Y 4/4)
23.0 - 31.0'	Gravels [Alluvium]	Multi-color, overall color dark reddish brown (10R 3/4); average 1/2", sorted; little sand <5%; flaggy, sub-rounded
31.0 - 32.0'	Coal [Bedrock]	Black, cleated, glossy

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Billings, Montana



Monitor Well Log

Hole Name: AVF4-4

Date Hole Started: 7/19/11 Date Hole Finished: 7/19/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 27,
NE1/4; N 461307.54, E 2825342.3
Location Description: 20 feet south of AVF4-1
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 34

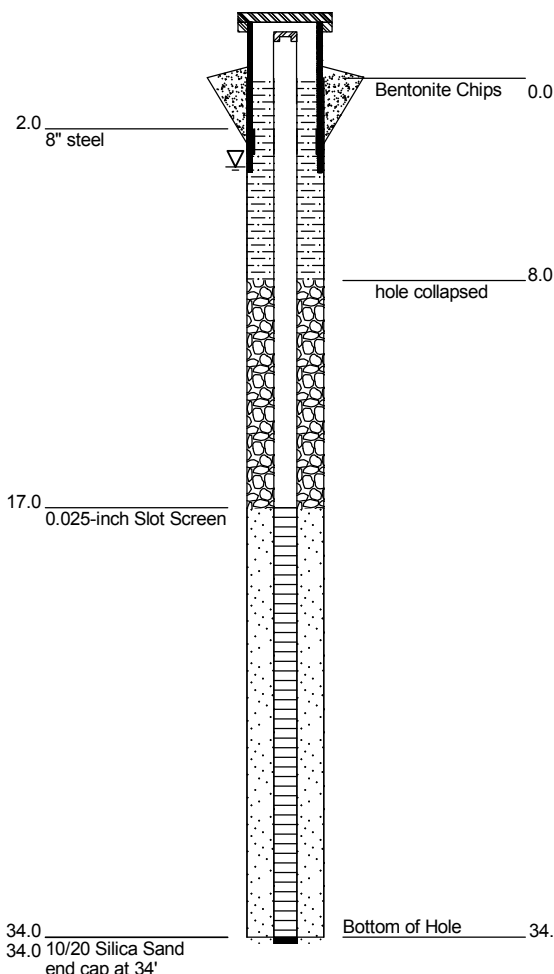
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	6" Sch 40, PVC	+2-34
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	17-34
Sand Pack?	Y	10/20 silica sand	17-34
Annular Seal?	Y	Bentonite Chips	0-8
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 461307.54	Easting: 2825342.3	
Static Water Level Below MP: 4.95	Surface Casing Height (ft): 1.72	
Date: 7/22/2011	Riser Height (ft): 1.44	
MP Description: Top PVC	Ground Surface Elevation (ft): 3069.45	
MP Height Above or Below Ground (ft): 1.44	MP Elevation (ft): 3070.89	

Remarks: Lithology based on well AVF4-1. After 10 minutes of development SC=6340 μ mhos/cm, pH= 7.7, temp= 12.2°C. Hole collapsed at 8'-17'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 17.0' **Silty Clay**
<5% fine sand (orange red); soft; dry to moist at 4', adding water; dark yellowish brown (10YR 4/2), silty layer at 10'-12', pale yellowish brown (10YR 6/2)

17.0 - 33.0' **Gravels** [Alluvium]
Multi-color; flaggy angular to sub-rounded, matrix is dark yellowish brown (10YR 4/2); clinker gravels and sandstone, rounded cobbles

33.0 - 34.0' **Weathered Coal** [Bedrock]
Black, dusky brown, oxidized

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Billings, Montana



Monitor Well Log

Hole Name: AVF4-P1

Date Hole Started: 8/16/13 Date Hole Finished: 8/16/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 27,
NE1/4; N 461128.44, E 2824540.89
Location Description: Near AVF4-3
Recorded By: RJL
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 2 1/8"
Total Depth Drilled (ft): 16

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	3/4"-inch, flush threaded, Sch 40, PVC	+3.13-16
Surface Casing Used?	Y	4" steel	+3.13-1.87
Screen/Perforations?	Y	0.010-inch slot, 3/4" pre-pack	11-16
Sand Pack?	Y	20/30 Silica Sand	5-16
Annular Seal?	Y	3/8 Bentonite Chips	+1-5
Surface Seal?	Y	Concrete Pad	

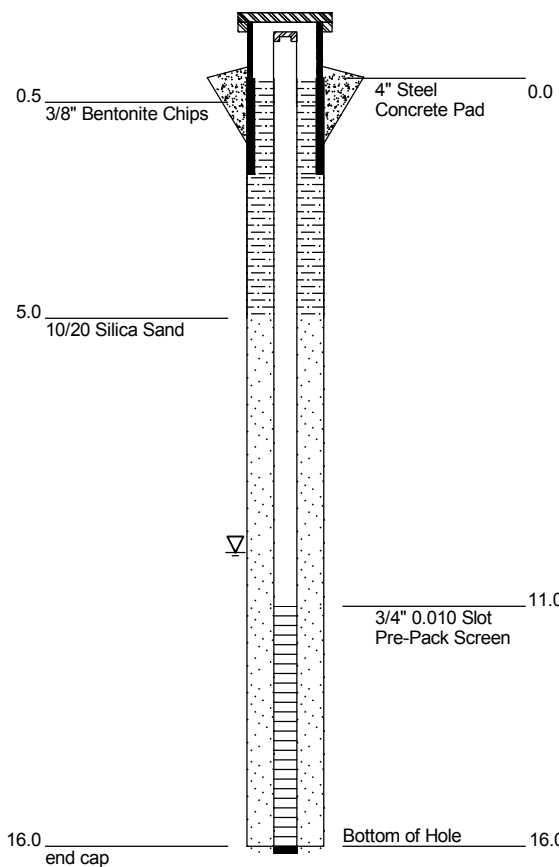
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 461128.447	Easting: 2824540.897
Static Water Level Below MP: 12.75	Surface Casing Height (ft): 3.13
Date: 8/28/2013	Riser Height (ft): 2.87
MP Description: Top PVC	Ground Surface Elevation (ft): 3074.143
MP Height Above or Below Ground (ft): 2.87	MP Elevation (ft): 3077.01

Remarks: Direct Pushed to 16'. Installed 3/4" well to 16'. Used 10/20 silica sand to fill in around the 3/4 inch pre-pack screen. Interval for 10/20 sand pack is 5'-16'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0' **Silty Clay**
dry; moderate yellowish brown to pale yellowish brown; roots

4.0 - 16.0' **Silty Clay**
moist to wet, moderate yellowish brown; trace sand (minor)

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Billings, Montana



Monitor Well Log

Hole Name: AVF4-P2

Date Hole Started: 8/16/13 Date Hole Finished: 8/16/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 27,
NE1/4; N 461288.85, E 2825354.32
Location Description: Near AVF4-1
Recorded By: RJJ
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/ Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4"
Total Depth Drilled (ft): 9

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	1-inch, flush threaded, Sch 40, PVC	+1.94-9
Surface Casing Used?	Y	4" steel	+1.94-3.06
Screen/Perforations?	Y	0.020-inch slot, 1"x 2" field pack	4-9
Sand Pack?	Y	10/20 Silica Sand	3.5-9
Annular Seal?	Y	3/8 Bentonite Chips	+1-3.5
Surface Seal?	Y	Concrete Pad	

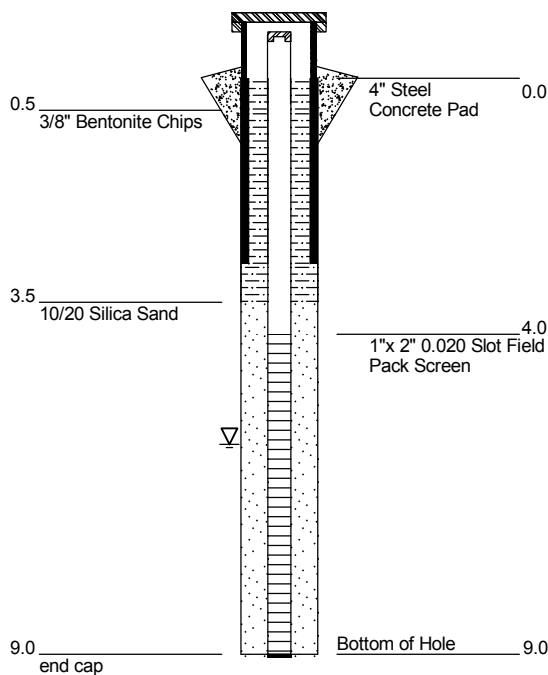
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 461288.857	Easting: 2825354.322
Static Water Level Below MP: 7.50	Surface Casing Height (ft): 1.94
Date: 8/28/2013	Riser Height (ft): 1.78
MP Description: Top PVC	Ground Surface Elevation (ft): 3069.489
MP Height Above or Below Ground (ft): 1.78	MP Elevation (ft): 3071.27

Remarks: Direct Pushed pilot hole to 12'. Tripped out and backfilled pilot hole with 3/8" bentonite chips. Moved ~ 5' and augered to 9'. Completed well at 9'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 12.0' **Silty Clay**
dry to wet; moderate yellowish brown; some sand; loose; roots in upper interval; tagged sand and gravel at 12'; poorly sorted fine gravels to coarse sands

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Monitor Well Log

Hole Name: AVF4-P3

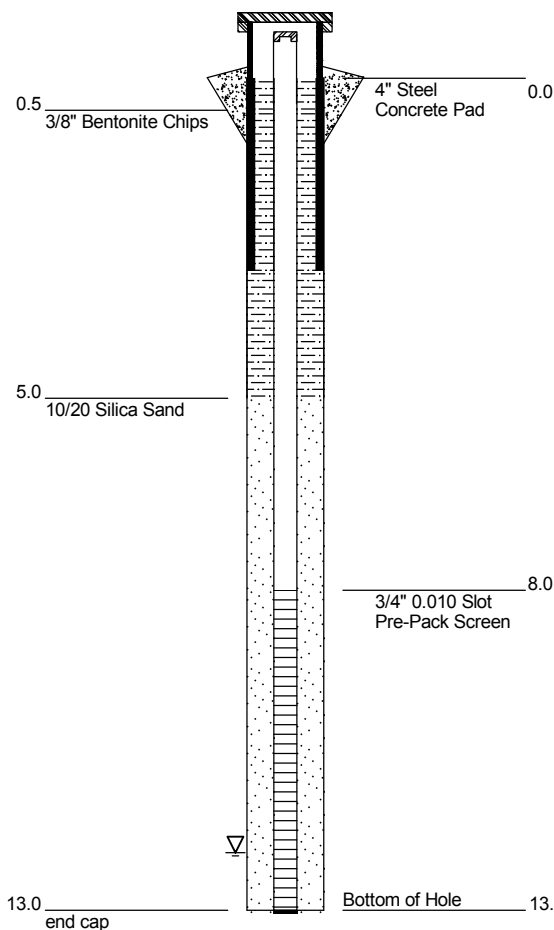
Date Hole Started: 8/16/13 Date Hole Finished: 8/16/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 27,
NE1/4; N 461404.08, E 2826287.52
Location Description: East end of AVF4 near
mouth of Fortune Creek
Recorded By: RJL
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4" (0'-3'); 2 1/8" (3'-13')
Total Depth Drilled (ft): 13

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	3/4"-inch, flush threaded, Sch 40, PVC	+2.73-13
Surface Casing Used?	Y	4" steel	+2.73-2.27
Screen/Perforations?	Y	0.010-inch slot, 3/4" pre-pack	8-13
Sand Pack?	Y	20/30 Silica Sand	5-13
Annular Seal?	Y	3/8 Bentonite Chips	+1-5
Surface Seal?	Y	Concrete Pad	
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Peristaltic Pump	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 461404.088		Easting: 2826287.521	
Static Water Level Below MP: 14.80		Surface Casing Height (ft): 2.73	
Date: 8/28/2013		Riser Height (ft): 2.70	
MP Description: Top PVC		Ground Surface Elevation (ft): 3075.858	
MP Height Above or Below Ground (ft): 2.70		MP Elevation (ft): 3078.56	

Remarks: Direct Pushed to 13'. Installed 3/4" well to 13'. Used 10/20 silica sand to fill in around the 3/4 inch pre-pack screen. Interval for 10/20 sand pack is 5'-13'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 13.0' **Silty Clay**
dry to wet; moderate yellowish brown

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Monitor Well Log

Hole Name: AVF5-1

Date Hole Started: 3/4/2011 Date Hole Finished: 3/4/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 28; N 490143.03, E 2819641.79
Location Description: Home Creek on Trusler property
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Home Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 34

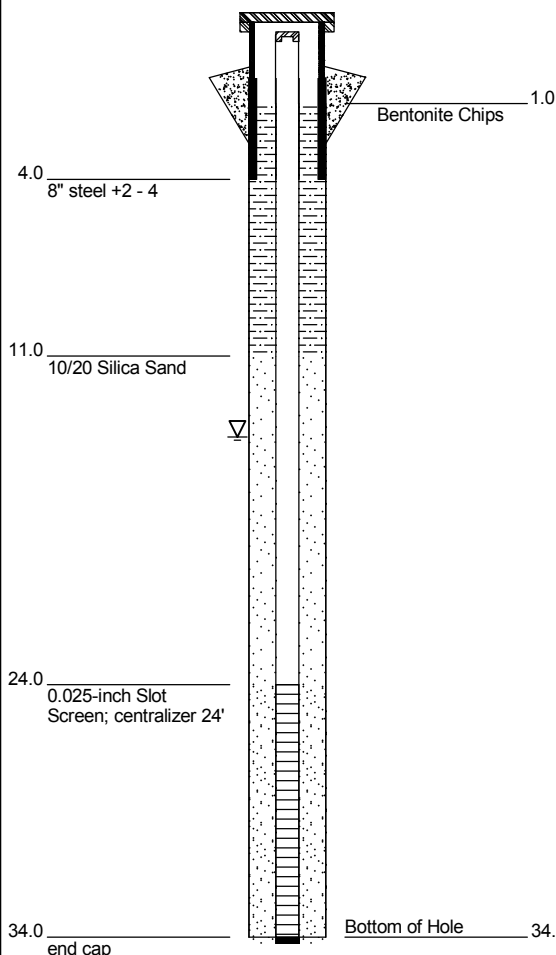
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-34
Surface Casing Used?	Y	8" steel	+2-4
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	24-34
Sand Pack?	Y	10/20 silica sand	11-34
Annular Seal?	Y	Bentonite Chips	+1-11
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 490143.03	Easting: 2819641.79	
Static Water Level Below MP: 15.85	Surface Casing Height (ft): 1.98	
Date: 3/4/2011	Riser Height (ft): 1.65	
MP Description: Top PVC	Ground Surface Elevation (ft): 3034.78	
MP Height Above or Below Ground (ft): 1.65	MP Elevation (ft): 3036.43	

Remarks: Drill to 20' with 7 7/8" drag bit, ream out with 9 7/8" drag bit, drive 8" steel to 34'. Yield ~7 gpm, developed with rig air for 20 minutes, SC=1540 µmhos/cm, pH=8.14, temp=12.7°C

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 10.0'	Silty clay and sand Dry to moist with depth, pale yellowish brown to moderate brown (5YR 3/4) with depth (color change at 4'); trace gravel at 5', increasing with depth, roots to 5', loose, trace white calcareous precipitates throughout
10.0 - 15.0'	Clayey, sandy, gravel Moist, fines are moderate brown (5YR 3/4), gravels multicolored: pale yellowish orange (10YR 8/6), dark yellowish orange (10YR 6/6), moderate orange pink (10R 7/9). Gravels clinker origin, hard to very hard, flat to spherical, sub-angular to sub-round, (50% gravel/50% sandy clay), wet making water at 12.5'
15.0 - 20.0'	Clayey, sandy, gravel As above, much less gravel, very loose/soft, possibly flowing
20.0 - 22.0'	Sand and gravel poorly sorted Wet, clinker gravels in moderate brown sand (55% sand) multicolored/hard
22.0 - 24.0'	Clay Wet, very plastic, very dense, trace small gravels and some very large cobbles at bottom of clay, some calcareous (one 7" cobble ejected from hole), mottled light gray (N7), light brown (5YR 6/4)
24.0 - 33.5'	Sand and gravel poorly sorted Wet, moderate brown sand (25% sand) with clinker gravels; gravels hard, multicolored: moderate reddish brown (10R 4/6), grayish brown (5YR 3/2), grayish orange (10YR 7/4), light brown (5YR 5/6). Baked shale and baked sandstone origin
33.5 - 34.0'	Siltstone [Bedrock] Dry, light olive gray (5Y 6/1), pale yellowish brown and dark yellowish orange with thin dark interbeds, laminated, non calcareous, soft to moderately firm, tagged coal, hard, black, in place at 34'

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Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: AVF5-2

Date Hole Started: 3/4/2011 Date Hole Finished: 3/4/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 28; N 489701.14, E 2819885.35
Location Description: AVF5 Section, Home Creek on Trusler property
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Home Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 71

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	6-inch Sch 40, PVC	+2-71
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	6" 100-slot screen	31-71
Sand Pack?	Y	10/20 silica sand	18-20
Annular Seal?	Y	Bentonite Chips	+1-18
Surface Seal?	N		

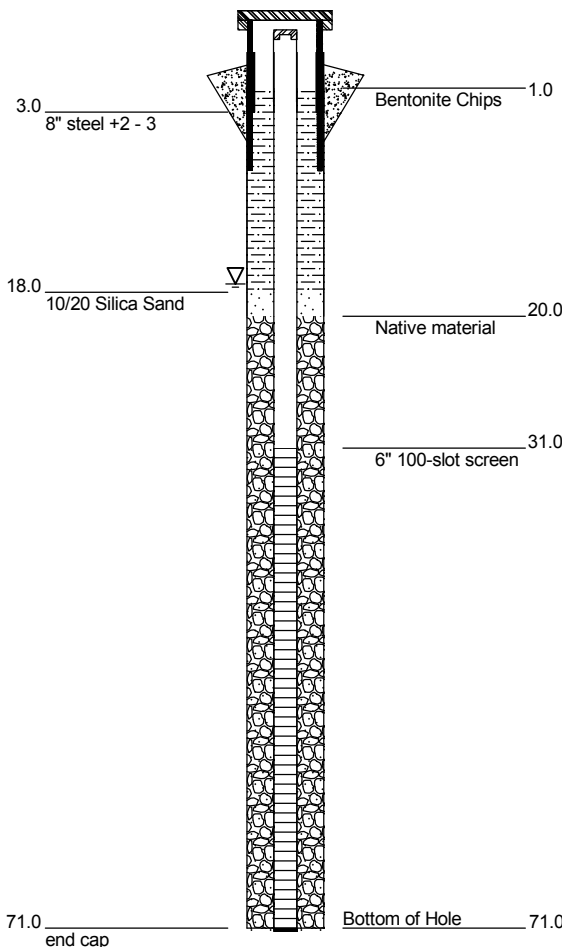
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 489701.14	Easting: 2819885.35
Static Water Level Below MP: 18.82	Surface Casing Height (ft): 1.94
Date: 7/6/2011	Riser Height (ft): 1.52
MP Description: Top PVC	Ground Surface Elevation (ft): 3039.83
MP Height Above or Below Ground (ft): 1.52	MP Elevation (ft): 3041.35

Remarks: Drill to 20' with 7 7/8" bit, drive 8" steel to 70', drill pilot with 4" bit, inject water at 20', drill out with 7 7/8" bit, no sand filter pack in annulus from 20'-71'; native gravel sloughed around screen, SC=1960 µmhos/cm, pH=8.33, yield ~200 gpm

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 9.0' Silty clay [Alluvium] Dry to slightly moist, moderate yellowish brown and pale yellowish brown, soft, loose
9.0 - 14.0' Sand [Alluvium] Slightly moist, very fine to fine with depth, trace clinker gravels, moderate yellowish brown to moderate brown, loose
15.0 - 19.0' Sand and gravel [Alluvium] Moist to very moist, sand loose, moderate brown, gravel to 25%, clinker origin, multicolored, hard, light brown, dark yellowish brown, flat, sub-angular
19.0 - 69.0' Sand and gravel (50/50) [Alluvium] Very moist to wet, moderate brown (5YR 4/4) sand, loose, light brown (5YR 5/6) clinker gravel, flat, sub-angular to sub-round, size up to 1.5", baked sandstone and baked shale origin, colors more diverse with depth, some yellowish gray. At 28' gravel fraction to 30% At 30' sand fraction to 10% At 35' more sand again (50%), gravel size increases to 3", colors more diverse with depth, some dark gray, some grayish red (5R 4/2). At 55' gravels to 5", sand fraction to ~2%, then grinding on large boulder at 57', some coal gravel at 65'-68'
69.0 - 70.0' Carbonaceous shale/junk coal Dry, medium gray to dark gray, moderately firm, non-plastic, non-reactive with HCl
70.0 - 71.0' Claystone [Bedrock] Dry, light olive gray to greenish gray, firm to stiff, moderately calcareous

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Billings, Montana



Monitor Well Log

Hole Name: AVF5-3

Date Hole Started: 3/9/2011 Date Hole Finished: 3/9/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Sec. 28; N 489716.27, E 2819885.12
Location Description: Adjacent to AVF5-2
Recorded By: LMJ
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Home Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 50

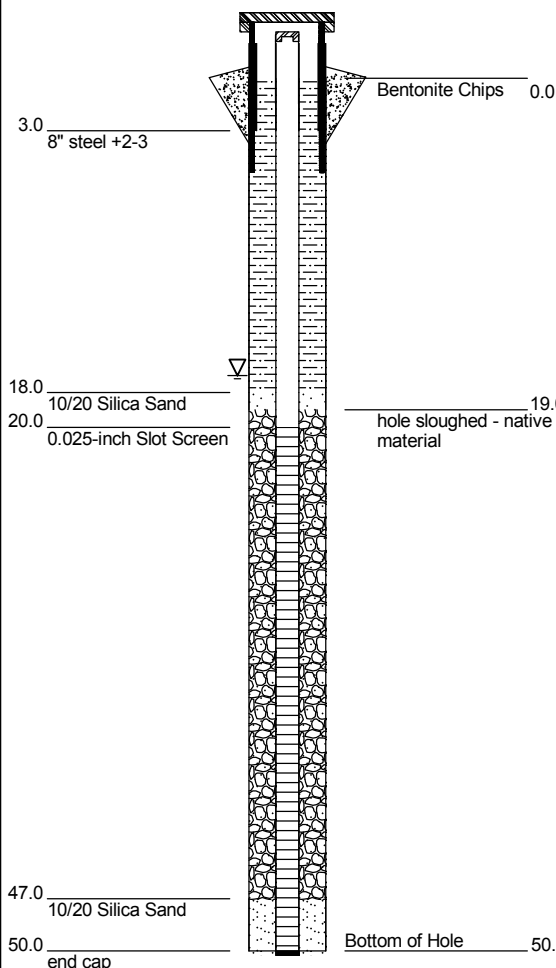
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-50
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	20-50
Sand Pack?	Y	10/20 silica sand	47-50, 18-19
Annular Seal?	Y	Bentonite Chips	0-18
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 489716.27	Easting: 2819885.12	
Static Water Level Below MP: 18.68	Surface Casing Height (ft): 1.91	
Date: 7/6/2011	Riser Height (ft): 1.64	
MP Description: Top PVC	Ground Surface Elevation (ft): 3039.59	
MP Height Above or Below Ground (ft): 1.64	MP Elevation (ft): 3041.23	

Remarks: Drill to 20', set 8" casing to 50' bsg, pull casing, hole caved to 19' bgs. Developed 30 minutes making ~25 gpm.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 9.0' Silty clay [Alluvium] Dry to slightly moist, moderate yellowish brown and pale yellowish brown, soft, loose
9.0 - 14.0' Sand [Alluvium] Slightly moist, very fine to fine with depth, trace clinker gravels, moderate yellowish brown to moderate brown, loose
14.0 - 19.0' Sand and gravel [Alluvium] Moist to very moist, sand loose, moderate brown, gravel to 25%, clinker origin, multicolored, hard, light brown, dark yellowish brown, flat, sub-angular; fine to medium grained sand with 10% flat clinker pebbles to 1/2" at 19'
19.0 - 50.0' Gravel, very coarse [Alluvium] Very moist to wet, moderate brown (5YR 4/4) sand, loose, light brown (5YR 5/6) clinker gravel, flat, sub-angular to sub-round, size up to 1.5", baked sandstone and baked shale origin, some rounded boulders to 4"

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Monitor Well Log

Hole Name: AVF5-4

Date Hole Started: 3/26/2011 Date Hole Finished: 3/26/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3, R45, Sec. 28; N 489376.30, E 2819988.69
Location Description: AVF battery near Trusler's dike
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Home Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 74

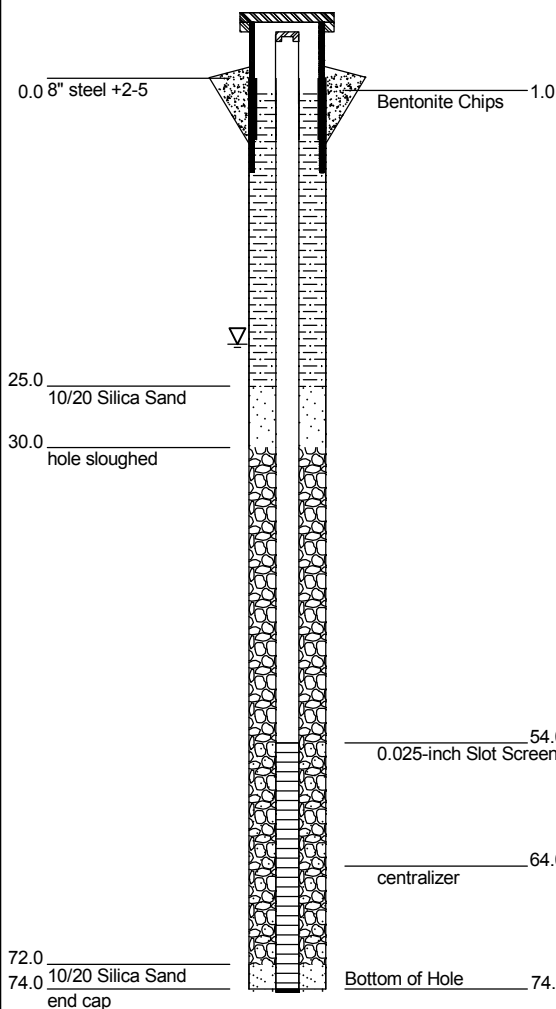
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-74
Surface Casing Used?	Y	8" steel	+2-5
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	54-74
Sand Pack?	Y	10/20 silica sand	25-30, 72-74
Annular Seal?	Y	Bentonite Chips	+1-25
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 489376.3	Easting: 2819988.69	
Static Water Level Below MP: 23.63	Surface Casing Height (ft): 2.31	
Date: 3/26/2011	Riser Height (ft): 2.02	
MP Description: Top PVC	Ground Surface Elevation (ft): 3043.26	
MP Height Above or Below Ground (ft): 2.02	MP Elevation (ft): 3045.28	

Remarks: Hole sloughed 30'-72' when steel pulled back, clean gravel. Developed with rig air, yield ~100 gpm.

WELL CONSTRUCTION



GEOLOGICAL DESCRIPTION

0.0 - 10.0'	Silty clay Dry to wet with depth, pale yellowish brown, plasticity none to slight with moisture and depth
10.0 - 25.0'	Sand, clayey, trace gravel with depth Wet, pale yellowish brown, moderately dense to dense
25.0 - 45.0'	Sand and gravel, poorly sorted, sand 50% to 20% with depth Wet, pale yellowish brown sand (fine to medium) with multi-colored clinker gravels, sub-round, up to 3"
45.0 - 71.0'	Gravel, some sand 20% to 2% with depth, sand from fine to coarse with depth [Alluvium] Wet, clinker origin to 5" and sandstone/shale origin; sub-round to sub-angular, flaggy to moderately spherical
71.0 - 74.0'	Shale [Bedrock] Dry, carbonaceous olive gray and olive black to non-carbonaceous medium light gray then light olive gray at Total Depth, firm

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Monitor Well Log

Hole Name: AVF5-4A

Date Hole Started: 3/9/2011 Date Hole Finished: 3/9/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Section 28;
N45.54254, E-106.17493
Location Description: South side Home Creek
Recorded By: LMJ
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Home Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 28

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	N		NA
Surface Casing Used?	N		NA
Screen/Perforations?	N		NA
Sand Pack?	N		NA
Annular Seal?	N		NA
Surface Seal?	Y	Bentonite Chips	0-28
DEVELOPMENT/SAMPLING			
Well Developed?	N		
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 489085.724		Easting: 2820071.376	
Static Water Level Below MP:		Surface Casing Height (ft):	
Date:		Riser Height (ft):	
MP Description:		Ground Surface Elevation (ft): 3047.031	
MP Height Above or Below Ground (ft):		MP Elevation (ft):	

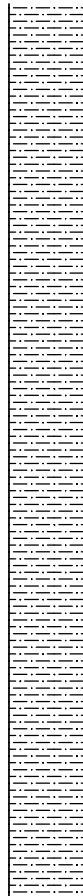
Remarks: Lost 20' of 8" steel down hole; rig slid off of jacks. ABANDONED HOLE, filled with 18 bags of 3/8" bentonite chips

WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 3/8" Bentonite Chips



Bottom of Hole 28.0

0.0 - 2.0' **Silt and Sand** [Alluvium]
dry, yellow brown

2.0 - 16.0' **Clay with Silt** [Alluvium]
moist, light brown, cuttings returned in balls

16.0 - 22.0' **Sand and Silt** [Alluvium]
(50/50), damp

22.0 - 28.0' **Silty Sand** [Alluvium]
wet

Sand and Gravel (10%) [Alluvium]
red brown clinker chips to 1", total depth before plugging and abandoning

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Monitor Well Log

Hole Name: AVF5-5

Date Hole Started: 3/9/2011 Date Hole Finished: 3/9/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: J. Trusler
Legal Description: T3S, R45E, Section 28; N 489085.72, E 2820071.38
Location Description: South end of AVF cross section, on south side of creek
Recorded By: LMJ
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Home Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 46

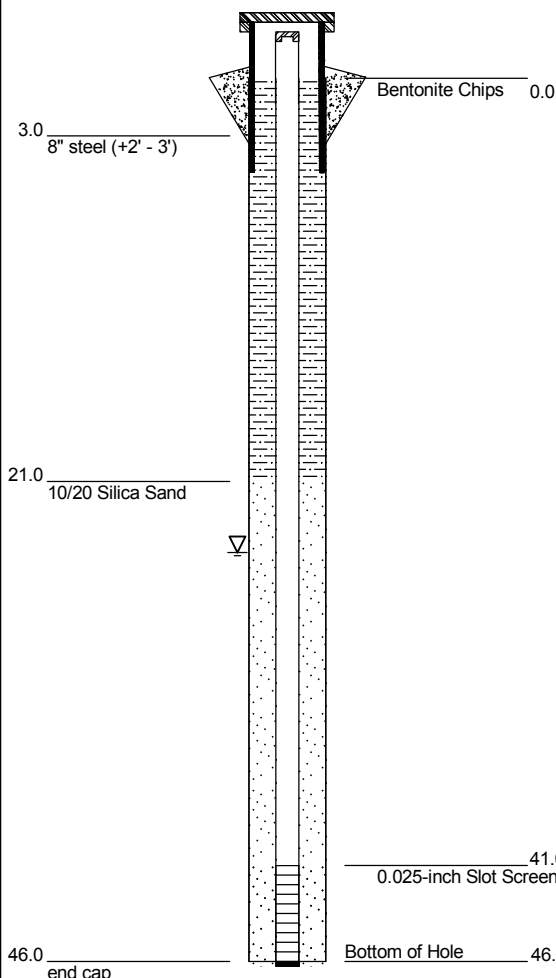
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-46
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	41-46
Sand Pack?	Y	10/20 silica sand	21-46
Annular Seal?	Y	Bentonite Chips	0-21
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 489085.72	Easting: 2820071.38	
Static Water Level Below MP: 26.19	Surface Casing Height (ft): 1.77	
Date: 7/6/2011	Riser Height (ft): 1.49	
MP Description: Top PVC	Ground Surface Elevation (ft): 3047.03	
MP Height Above or Below Ground (ft): 1.49	MP Elevation (ft): 3048.52	

Remarks: Set 5' screen (41'-46'), sand pack to 35', pull casing, sand settled to 38', add sand pack to 21', bentonite to 2'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 14.0'	Clayey silt with fine grained sand [Alluvium/Colluvium] Light brown
14.0 - 25.0'	Silt with fine grained sand dry, Light brown
25.0 - 38.5'	Sand Wet, medium grained, well sorted, first water at 25'
38.5 - 40.0'	Sand and gravel Medium grained sand (20%); rusty red, sub-angular, flat chips of shale gravel (60-80%)
40.0 - 44.5'	Gravel Sub-angular to sub-rounded clinker cobbles to 4" (>5%), medium grained sand (>10%) and flat rusty brown shale chips (70%)
44.5 - 46.0'	Mudstone [Bedrock] light gray, soft

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Billings, Montana



Monitor Well Log

Hole Name: AVF6-1

Date Hole Started: 8/18/11 Date Hole Finished: 8/18/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 10; N 477256.84, E 2822637.93
Location Description: AVF6 on old Gratwohl property on Three Mile Creek
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer:
Hole Diameter (in): 8"
Total Depth Drilled (ft): 50

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	8" steel open bottom	+2-40
Surface Casing Used?	Y	8" steel	+2-40

Screen/Perforations?	N
Sand Pack?	N
Annular Seal?	N
Surface Seal?	N

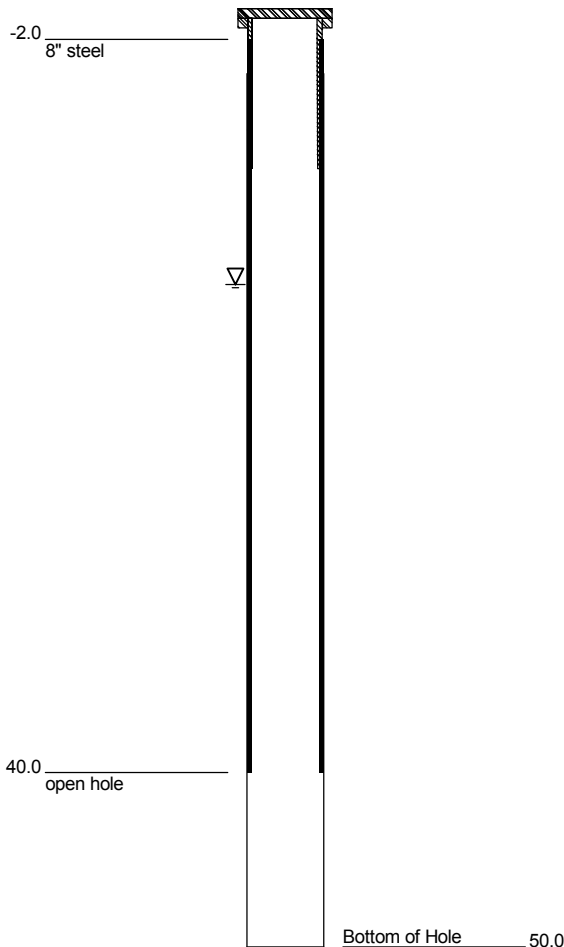
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 477256.84	Easting: 2822637.93
Static Water Level Below MP: 14.1	Surface Casing Height (ft):
Date: 8/18/2011	Riser Height (ft): 2.05
MP Description: Top of Steel	Ground Surface Elevation (ft): 3038.31
MP Height Above or Below Ground (ft): 2.05	MP Elevation (ft): 3040.36

Remarks: Drove 8" steel to 48', drilled to 36' with 4" bit. Drove 8" steel to 47', drilled out with 7 7/8" bit to 50'. Pulled steel back to 40' bgs. Developed with rig air at 20' bgs; SC=4000 μ mhos/cm, pH= 8.27, temp= 11.1°C, open hole yield= 100+ gpm. Blew on open hole at AVF6-2 approximately 10' away (~300 gpm), SWL dropped 0.4' - H_0 =14.1 and H_a =14.5

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0' Silt [Alluvium/Colluvium] Dry, moderate yellowish brown, loose, roots, Topsoil
3.0 - 10.5' Sand [Alluvium] Moist to very moist, moderate to dark yellowish brown and moderate brown at depth; silty/clayey from 3'-5', soft loose, fine-grained; trace gravel present at 10'
10.5 - 30.0' Sandy gravel [Alluvium] Very moist to wet with depth, moderate yellowish brown sand with light brown and reddish brown clinker gravels; poorly sorted (~50/50), gravels up to 2" at 10.5'-20' and up to 4" at 20'-30'; mostly flat, sub-angular, some spherical and/or sub-round; trace petrified bone t 25'
30.0 - 42.0' Clinker gravel [Alluvium/Clinker] Wet, very angular blochy, dark reddish brown, makes 100 gpm; trace sandstone gravel (mixture) at 30', size up to 6"; then grades to very angular clinker in place at 35'-42', thermally altered shale
42.0 - 43.0' Ash [Ash] Light olive gray, yellowish gray to white, loose to some cohesive
43.0 - 46.0' Coal remnant [Bedrock] Dusky brown to black, clayey, soft
46.0 - 50.0' Claystone [Bedrock] Medium light gray and moderate reddish brown, firm to stiff, non-carbonaceous, non-calcareous

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Billings, Montana



Monitor Well Log

Hole Name: AVF6-2

Date Hole Started: 8/19/11 Date Hole Finished: 8/19/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 10; N 477271.83, E 2822635.14
Location Description: AVF6 on old Gratwohl property on Three Mile Creek
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron and Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer:
Hole Diameter (in): 8"
Total Depth Drilled (ft): 40

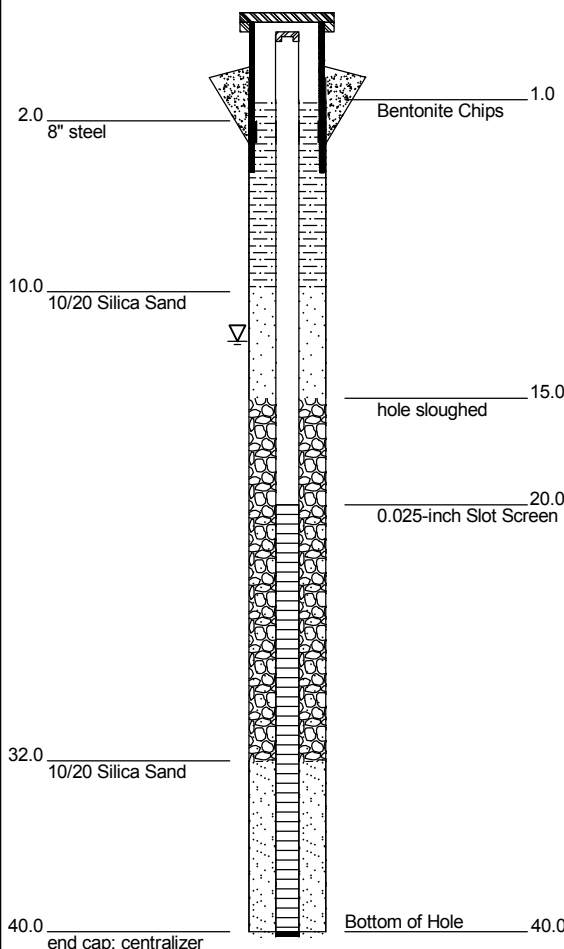
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-40
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	20-40
Sand Pack?	Y	10/20 Silica Sand	32-40, 10-15
Annular Seal?	Y	Bentonite Chips	+1-10
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 477271.83	Easting: 2822635.14	
Static Water Level Below MP: 14.07	Surface Casing Height (ft): 2.06	
Date: 8/18/2011	Riser Height (ft): 1.74	
MP Description: Top PVC	Ground Surface Elevation (ft): 3038.36	
MP Height Above or Below Ground (ft): 1.74	MP Elevation (ft): 3040.09	

Remarks: Lithology based on AVF6-1, cuttings verified in field. Open hole to 20' with 9 7/8" bit. Drive 8" steel to 40' bgs. Set 40' of 4.5" PVC (20' screen), pour sand (3 bags) around bottom of screen and pull 8" steel. Developed with rig air, SC= 2520 μ mhos/cm, pH= 8.25, temp= 13.2°C; SC rose to 3170 μ mhos/cm after 20 minutes blowing at 20' bgs.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0' Silt [Alluvium/Colluvium] Dry, moderate yellowish brown, loose, roots, Topsoil
3.0 - 10.5' Sand [Alluvium] Moist to very moist, moderate to dark yellowish brown and moderate brown at depth; silty/clayey from 3'-5', soft loose, fine-grained; trace gravel present at 10'
10.5 - 30.0' Sandy gravel [Alluvium] Very moist to wet with depth, moderate yellowish brown sand with light brown and reddish brown clinker gravels; poorly sorted (~50/50), gravels up to 2" at 10.5'-20' and up to 4" at 20'-30'; mostly flat, sub-angular, some spherical and/or sub-round; trace petrified bone t 25'
30.0 - 40.0' Clinker gravel [Alluvium/Clinker] Wet, very angular blochy, dark reddish brown, makes 100 gpm; trace sandstone gravel (mixture) at 30', size up to 6"; then grades to very angular clinker in place at 35'-42', thermally altered shale

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Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: AVF6-3

Date Hole Started: 8/19/11 Date Hole Finished: 8/22/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 10; N 477471.58, E 2822620.04
Location Description: AVF6 on old Gratwohl property on Three Mile Creek
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Three Mile Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 66

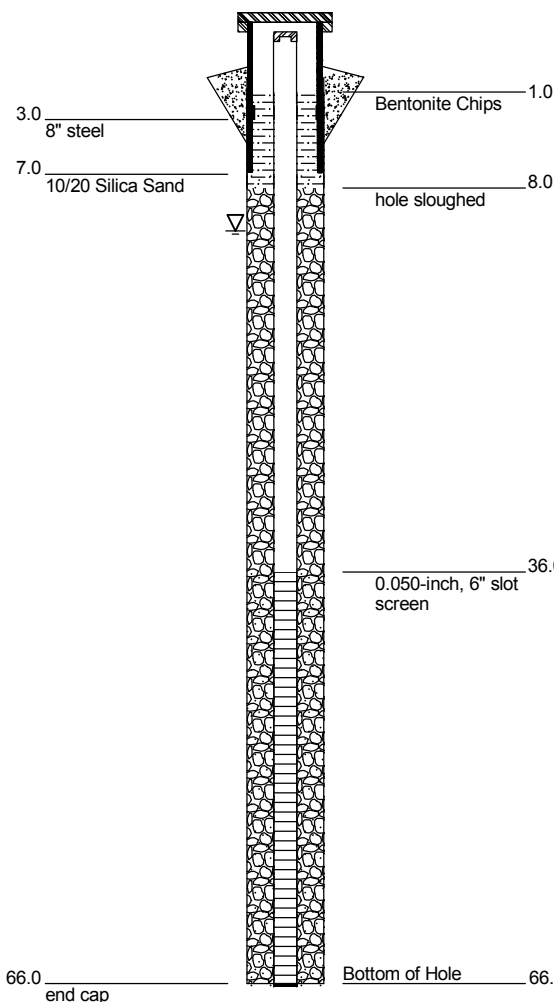
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	6-inch, Sch 40, PVC	+2-66
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.050-inch slot, 6" PVC	36-66
Sand Pack?	Y	10/20 Silica Sand	7-8
Annular Seal?	Y	Bentonite Chips	+1-8
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 477471.58	Easting: 2822620.04	
Static Water Level Below MP: 12.77	Surface Casing Height (ft): 1.94	
Date: 8/22/2011	Riser Height (ft): 1.64	
MP Description: Top PVC	Ground Surface Elevation (ft): 3036.94	
MP Height Above or Below Ground (ft): 1.64	MP Elevation (ft): 3038.58	

Remarks: Pulled 8" steel that was set during drilling; hole sloughed to 8' when pulled; set 6" PVC. Blew rig air to develop; SC= 3790 μ mhos/cm, pH= 8.2, temp= 11.3°C, yield estimate ~100+ gpm.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0'	Silty clay [Colluvium/Alluvium] Dry, pale yellowish brown (10YR 6/2), loose, soft, some roots
5.0 - 9.0'	Sand, trace gravel [Alluvium] Moist, moderate yellowish brown (10YR 5/4), loose, fine-grained
9.0 - 30.0'	Sand and gravel, poorly sorted (70% sand and 30% gravel) Moist, moderate yellowish brown (10YR 5/4) and moderate brown sand with light brown, dark yellowish orange (10YR 6/6) and moderate reddish orange (10R 6/6) gravel, loose, hard, clinker origin; grades 20% sand and 90% gravel at 15', gravels to 2", clinker and sandstone origin; sub-round, flat to medium sphericity, gravel to 6" at 20'
30.0 - 64.0'	Gravel/clinker and sandstone origin [Alluvium] Wet, pale yellowish brown (10YR 6/2), light brown, moderate reddish brown (10R 4/6) with light brownish gray (5YR 6/1) and grayish red purple (5RP 4/2) shale (altered shale). Increasing sandstone gravel at 35', sub-angular to sub-round, loose, flat to spherical
64.0 - 66.0'	Silty claystone [Bedrock] Pale yellowish brown (10YR 6/2) grades to light olive gray (5Y 6/1) and very light gray (N8), moderately firm, moderate plasticity, rolls to 1/8", calcareous

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Billings, Montana



Monitor Well Log

Hole Name: AVF6-4

Date Hole Started: 8/22/11 Date Hole Finished: 8/22/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 3; N 477789.43, E 2822602.67
Location Description: AVF6 on Three Mile Creek
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Three Mile Creek Alluvium
Hole Diameter (in): 8"
Total Depth Drilled (ft): 71

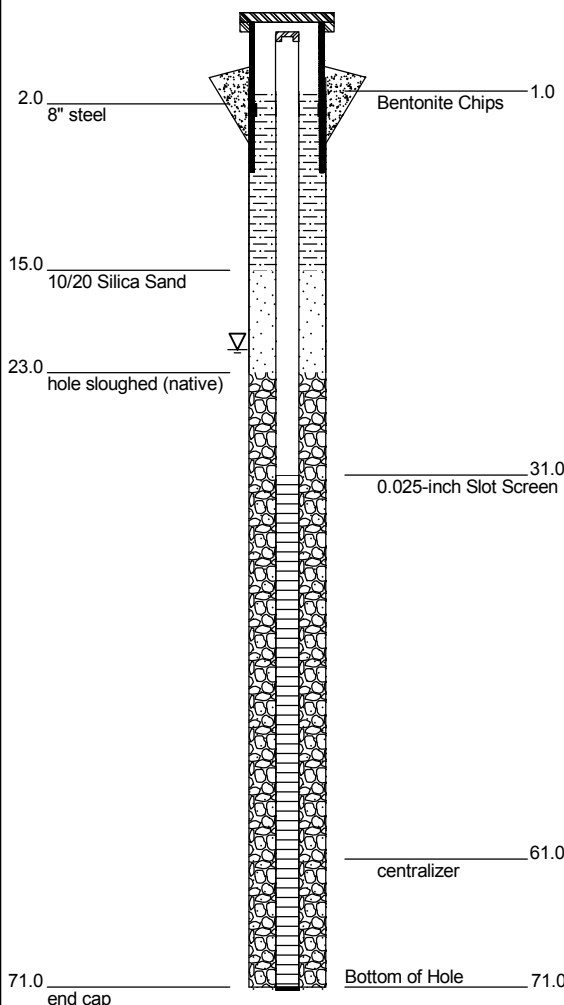
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-71
Surface Casing Used?	Y	8" steel	+2-3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	31-71
Sand Pack?	Y	10/20 Silica Sand	15-23
Annular Seal?	Y	Bentonite Chips	+1-15
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 477789.43	Easting: 2822602.67	
Static Water Level Below MP: 23.00	Surface Casing Height (ft): 2.06	
Date: 8/22/2011	Riser Height (ft): 1.81	
MP Description: Top PVC	Ground Surface Elevation (ft): 3046.46	
MP Height Above or Below Ground (ft): 1.81	MP Elevation (ft): 3048.27	

Remarks: Drill to 20' with 7 7/8" bit, drove 8" steel to 70', drill pilot with 3 7/8" bit. Ream out with 7 7/8" bit; 10/20 silica sand poured while driving 8" steel. Hole sloughed from 23'-71'. Developed with rig air; after development SC= 3770 μ mhos/cm, pH= 8.18, temp= 13°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0'	Silty clay [Colluvium/Topsoil] Dry, pale to moderate yellowish brown, roots, loose to moderately cohesive
5.0 - 10.0'	Silt, trace clay and very fine sand [Alluvium/Colluvium] Slightly moist, moderate yellowish brown, white precipitates, loose
10.0 - 15.0'	Sandy clay [Alluvium/Colluvium] Moist, dark yellowish brown, plastic, rolls to 1/16", white precipitates, loose
15.0 - 20.0'	Silty sandy clay, very fine gravel sand [Alluvium/Colluvium] Moist, moderate yellowish brown to moderate brown, loose, moderate plasticity
20.0 - 21.0'	Clayey sand and gravel, poorly sorted Wet, moderate yellowish brown fines, with light brown clinker gravels (80% fines 20% gravel), very fine-grain sand; injecting water at 20'
21.0 - 66.0'	Sand and gravel, poorly sorted [Alluvium] Wet, pale to medium yellowish brown sand with clinker and sandstone gravels (70% gravel 30% sand), gravels light brown, moderate reddish brown, and pale yellowish brown to dark gray, sub-angular to sub-round, medium sphericity to flat, gravels up to 6" (cobbles); sand decreases with depth <10%; clay stringer at 30'
66.0 - 70.0'	Siltstone/claystone [Bedrock] Dry, pale yellowish brown and light olive gray, dense, moderate firm to stiff, slightly plastic, calcareous

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Monitor Well Log

Hole Name: AVF6-5

Date Hole Started: 8/23/11 Date Hole Finished: 8/23/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 10; N 477463.64, E 2822619.16
Location Description: AVF6 on old Gratwohl prop. on ThreeMile Creek paired with AVF6-3
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer:
Hole Diameter (in): 11" (0'-18'), 12" (18'-30')
Total Depth Drilled (ft): 30

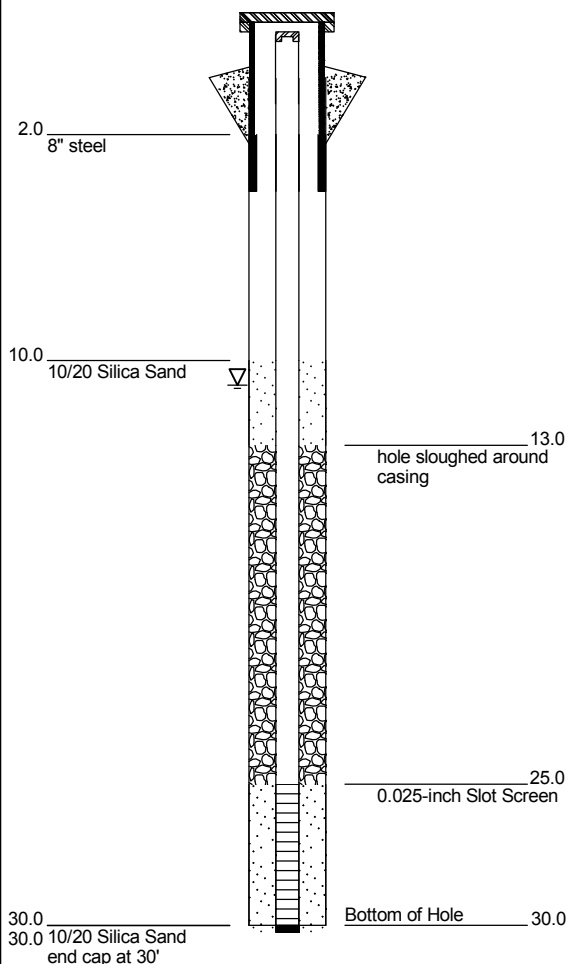
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-30
Surface Casing Used?	Y	8" steel	+2-4
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	25-30
Sand Pack?	Y	10/20 Silica Sand	25-30, 10-13
Annular Seal?	Y	Bentonite Chips	
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 477463.64	Easting: 2822619.16	
Static Water Level Below MP: 12.55	Surface Casing Height (ft): 2.14	
Date: 9/15/2011	Riser Height (ft): 1.68	
MP Description: Top PVC	Ground Surface Elevation (ft): 3036.69	
MP Height Above or Below Ground (ft): 1.68	MP Elevation (ft): 3038.37	

Remarks: Lithology based on well AVF6-3, cuttings verified in field. Drill to 18' with 10 7/8" drag bit, set 30' of 8" steel casing. Drill out with 7 7/8" drag bit. Hole sloughed around casing at 13'-25'. Blew with rig air once completed; after development SC= 3600 µmhos/cm, pH= 8.1, temp= 15.0°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0'	Silty clay [Colluvium/Alluvium] Dry, pale yellowish brown (10YR 6/2), loose, soft, some roots
5.0 - 9.0'	Sand, trace gravel [Alluvium] Moist, moderate yellowish brown (10YR 5/4), loose, fine-grained
9.0 - 30.0'	Sand and gravel, poorly sorted (70% sand and 30% gravel) Moist, moderate yellowish brown (10YR 5/4) and moderate brown sand with light brown, dark yellowish orange (10YR 6/6) and moderate reddish orange (10R 6/6) gravel, loose, hard, clinker origin; grades 20% sand and 90% gravel at 15', gravels to 2", clinker and sandstone origin; sub-round, flat to medium sphericity, gravel to 6" at 20'

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Monitor Well Log

Hole Name: AVF6-PH1

Date Hole Started: 8/22/11 Date Hole Finished: 8/22/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 3; N 478147.3, E 2822469.1
Location Description: AVF6 on Three Mile Creek
Recorded By: RJJ
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Define Alluvial Valley Floor
Target Aquifer: Three Mile Creek Alluvium
Hole Diameter (in): 11" (0'-18'), 8" (18'-45')
Total Depth Drilled (ft): 45

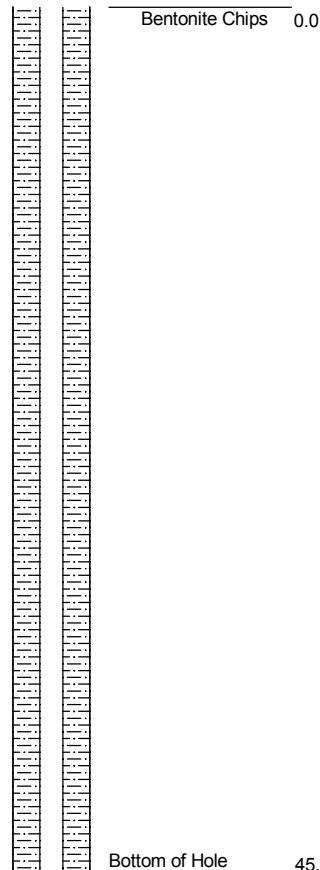
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	N		NA
Surface Casing Used?	N		NA
Screen/Perforations?	N		NA
Sand Pack?	N		NA
Annular Seal?	N		NA
Surface Seal?	Y	Bentonite Chips	0-45

DEVELOPMENT/SAMPLING

Well Developed?	N
Water Samples Taken?	N
Boring Samples Taken?	N
Northing: 478147.3	Easting: 2822469.1
Static Water Level Below MP:	Surface Casing Height (ft): NA
Date:	Riser Height (ft): NA
MP Description:	Ground Surface Elevation (ft): 3047.46
MP Height Above or Below Ground (ft):	MP Elevation (ft):

Remarks: Open hole with 10 7/8" bit to 18', drive 8" steel to 45', pulled steel, plugged hole with 3/8" bentonite chips.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 10.0'	Silty clay [Colluvium] Dry to moist at 3', pale yellowish brown to grayish orange, moderate plasticity, rolls to 1/8", loose to trace cemented, roots; trace white precipitates at 5'-10', becomes sandy at 10', very fine-grain
10.0 - 19.0'	Sand, silty clayey [Colluvium] Moist, moderate yellowish brown, trace coarse sand or fine gravel size clinker fragments; loose, sand is fine-grain
19.0 - 26.0'	Sand and gravel, poorly sorted Moist, moderate yellowish brown to moderate brown fines, with light brown and moderate reddish brown clinker gravels, flat, sub-angular to sub-round (80 % fines, 20% gravel at 19')
26.0 - 40.0'	Gravel, some sand <10% [Alluvium] Wet, multi-colored: pale yellowish brown, dark gray, light brown, cobble size up to 8", clinker and sandstone origin; sub-angular, moderate sphericity
40.0 - 45.0'	Siltstone, clayey [Bedrock] Dry, pale yellowish brown to light olive gray, dense, moderately firm to stiff, non-plastic to mild plasticity with depth, calcareous; trace sand at 41'-45'. No SC from open hole, blew with rig air at 20', very muddy

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Monitor Well Log

Hole Name: AVF7-P1

Date Hole Started: 8/14/13 Date Hole Finished: 8/14/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 9, NE1/4;
N 476126.85, E 2819323.30
Location Description:

Recorded By: RJJ
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/ Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4"
Total Depth Drilled (ft): 14

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	1-inch, flush threaded, Sch 40, PVC	+2.09-14
Surface Casing Used?	Y	4" steel	+2.34-2.66
Screen/Perforations?	Y	0.020-inch slot, 1"x 2" field pack	9-14
Sand Pack?	Y	10/20 Silica Sand	7-14
Annular Seal?	Y	3/8 Bentonite Chips	+2-7
Surface Seal?	Y	Concrete Pad	

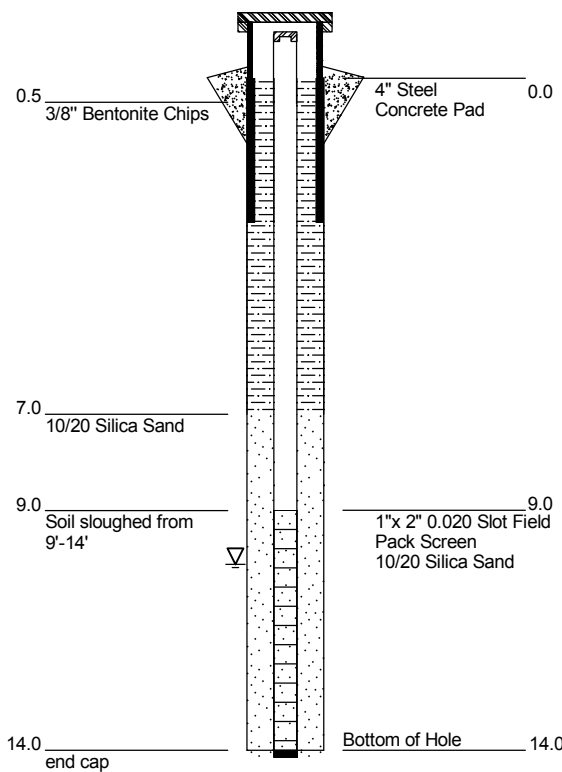
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 476126.859	Easting: 2819323.308
Static Water Level Below MP: 12.22	Surface Casing Height (ft): 2.34
Date: 8/28/2013	Riser Height (ft): 2.09
MP Description: Top PVC	Ground Surface Elevation (ft): 3035.06
MP Height Above or Below Ground (ft): 2.09	MP Elevation (ft): 3037.15

Remarks: Wet at 11' bgs. Direct Push to 19' no gravel. Tripped out and moved rig ~2'. 2 1/4" Direct Push hole collapsed to 9' when tools were pulled. Piezometer was pushed to 14' through sloughed soils.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 11.0' **Silty Clay**
dry to moist at 7'; moderate yellowish brown; non plastic to moderately plastic w/ depth trace sand at 9'

11.0 - 14.0' **Sand with Silt and Clay**
wet; moderate yellowish brown; loose

14.0 - 18.0' **Sand**
as above, less fines with depth

18.0 - 19.0' **Sand and Gravel**
loose; moderate yellowish brown to light brown; gravel is clinker in origin and up to 1/4" in size.

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Monitor Well Log

Hole Name: AVF7-P2

Date Hole Started: 8/14/13 Date Hole Finished: 8/14/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 9, NE1/4;
N 476095.23, E 2818915.08
Location Description:

Recorded By: RJL
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 2 1/8"
Total Depth Drilled (ft): 16

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	3/4"-inch, flush threaded, Sch 40, PVC	+3.08-14
Surface Casing Used?	Y	4" steel	+3.08-1.92
Screen/Perforations?	Y	0.010-inch slot, 3/4" pre-pack	9-14
Sand Pack?	Y	20/30 Silica Sand	6-14
Annular Seal?	Y	3/8 Bentonite Chips	+1-6
Surface Seal?	Y	Concrete Pad	

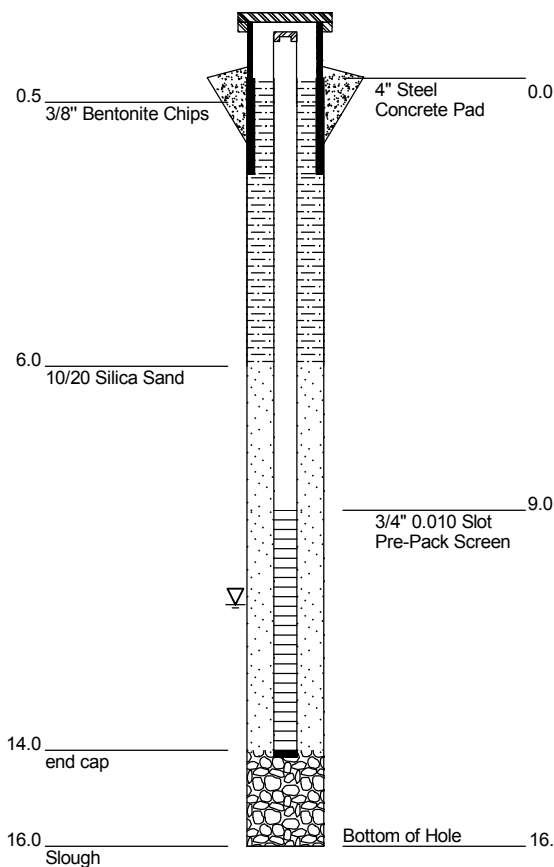
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 476095.232	Easting: 2818915.087
Static Water Level Below MP: 13.68	Surface Casing Height (ft): 3.08
Date: 8/28/2013	Riser Height (ft): 2.71
MP Description: Top PVC	Ground Surface Elevation (ft): 3035.33
MP Height Above or Below Ground (ft): 2.71	MP Elevation (ft): 3038.04

Remarks: Direct Push to 16'. Hole sloughed to 14', set 3/4" well to 14'. Used 10/20 silica sand to fill in around the 3/4 inch pre-pack screen. Interval for 10/20 sand pack is 6'-14'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 10.0' **Silty Clay**
dry to moist with depth; moderate yellowish brown to moderate brown; roots to 5'; some sand at depth

10.0 - 16.0' **Silt, Sand, and Clay**
moist to wet; moderate yellowish brown; loose; some coarse sand from 12'-16'

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Monitor Well Log

Hole Name: AVF7-P3

Date Hole Started: 8/14/13 Date Hole Finished: 8/14/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 9, NE1/4;
N 476190.12, E 2819849.76
Location Description:

Recorded By: RJL

Drilling Company: Hydrometrics, Inc

Driller: Larry Johnson and Carl Lanz

Drilling Method: Auger/ Direct Push

Drilling Fluids Used: None

Purpose of Hole: Install Monitor Well

Target Aquifer: Root Zone Ground Water

Hole Diameter (in): 6 1/4"

Total Depth Drilled (ft): 11

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	1-inch, flush threaded, Sch 40, PVC	+1.45-11
Surface Casing Used?	Y	4" steel	+1.78-3.22
Screen/Perforations?	Y	0.020-inch slot, 1"x 2" field pack	6-11
Sand Pack?	Y	10/20 Silica Sand	3.5-11
Annular Seal?	Y	3/8 Bentonite Chips	+1-3.5
Surface Seal?	Y	Concrete Pad	

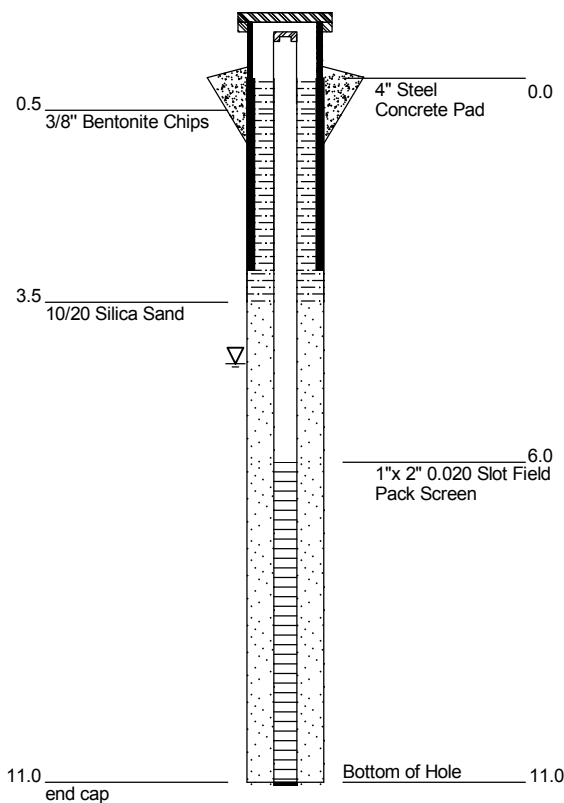
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 476190.121	Easting: 2819849.76
Static Water Level Below MP: 5.91	Surface Casing Height (ft): 1.78
Date: 8/28/2013	Riser Height (ft): 1.45
MP Description: Top PVC	Ground Surface Elevation (ft): 3029.089
MP Height Above or Below Ground (ft): 1.45	MP Elevation (ft): 3030.54

Remarks: Direct Pushed pilot hole to 12'. Tripped out and backfilled pilot hole with 3/8" bentonite chips. Moved ~ 3' and augered to 11'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0' **Silty Clay**
dry to moist with depth; very fine sand with depth; loose soft (roots)

4.0 - 5.0' **Silty Sand**
slightly moist; moderate yellowish brown

5.0 - 12.0' **Sand**
wet; moderate yellowish brown; loose to very loose; poorly sorted very fine to medium sand, some silt and clay to lots of fines at depth

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Billings, Montana



Monitor Well Log

Hole Name: AVF7-P4

Date Hole Started: 8/15/13 Date Hole Finished: 8/15/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 9, NE1/4;
N 476220.01, E 2820263.05
Location Description:

Recorded By: RJJ
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/ Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4"
Total Depth Drilled (ft): 9

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	1-inch, flush threaded, Sch 40, PVC	+2.29-9
Surface Casing Used?	Y	4" steel	+2.39-2.25
Screen/Perforations?	Y	0.020-inch slot, 1"x 2" field pack	4-9
Sand Pack?	Y	10/20 Silica Sand	3.5-9
Annular Seal?	Y	3/8 Bentonite Chips	+1-3.5
Surface Seal?	Y	Concrete Pad	

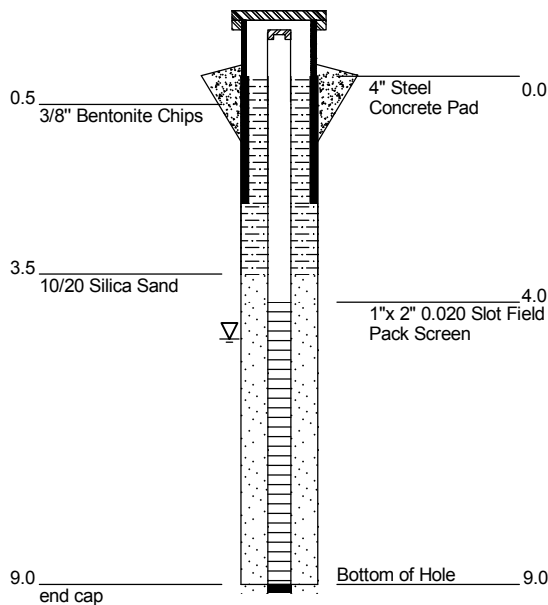
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 476220.018	Easting: 2820263.055
Static Water Level Below MP: 6.94	Surface Casing Height (ft): 2.39
Date: 8/28/2013	Riser Height (ft): 2.29
MP Description: Top PVC	Ground Surface Elevation (ft): 3029.119
MP Height Above or Below Ground (ft): 2.29	MP Elevation (ft): 3031.41

Remarks: Direct Pushed pilot hole to 16'. Tripped out and backfilled pilot hole with 3/8" bentonite chips. Moved ~ 3' and augered to 9'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Silt dry; pale yellowish brown; trace clay and fine sand; loose, roots
4.0 - 8.0'	Sandy Clay to clayey sand; dry to very moist at 5'; moderate yellowish brown; very soft;
8.0 - 12.0'	Sandy Clay as above; wet
12.0 - 16.0'	Sandy Gravel wet; moderate yellowish brown sand to light brown clinker gravel; sub-angular up to 3/4"

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Monitor Well Log

Hole Name: AVF8-P1

Date Hole Started: 8/15/13 Date Hole Finished: 8/15/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 22,
NW1/4; N 464455.85, E 2823411.65
Location Description:
Recorded By: RJL
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 2 1/2"
Total Depth Drilled (ft): 16

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	3/4"-inch, flush threaded, Sch 40, PVC	+1.59-16
Surface Casing Used?	Y	4" steel	+2.28-2.72
Screen/Perforations?	Y	0.010-inch slot, 3/4" pre-pack	11-16
Sand Pack?	Y	20/30 Silica Sand	8.5-16
Annular Seal?	Y	3/8 Bentonite Chips	+1-8.5
Surface Seal?	Y	Concrete Pad	

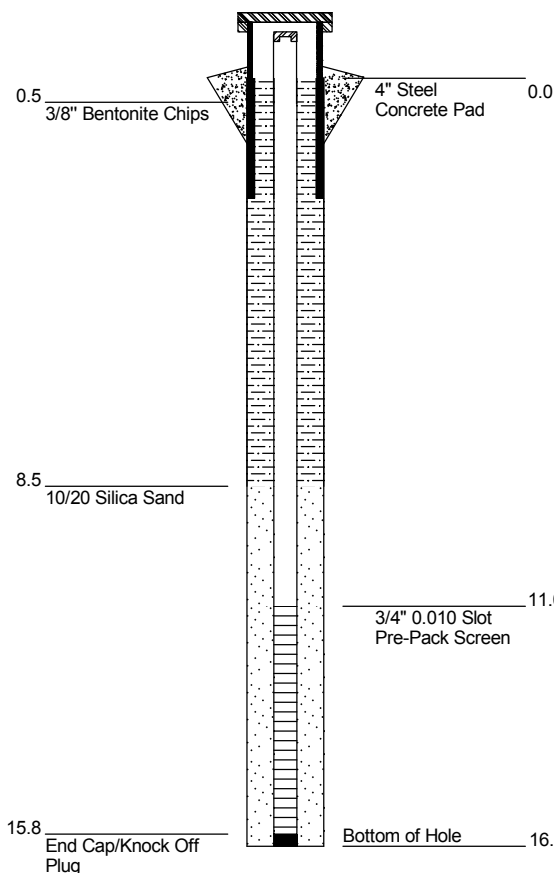
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 464455.857 Easting: 2823411.658
Static Water Level Below MP: Dry at 17.38' Surface Casing Height (ft): 2.28
Date: 8/28/2013 Riser Height (ft): 1.59
MP Description: Top PVC Ground Surface Elevation (ft): 3070.862
MP Height Above or Below Ground (ft): 1.59 MP Elevation (ft): 3072.45

Remarks: Direct Pushed to 16'. Completed 3/4" well inside of 2 1/8" rods. Used 2 1/2" outside diameter steel knock off plug at bottom. Used 10/20 silica sand to fill in around the 3/4 inch pre-pack screen. Interval for 10/20 sand pack is 8.5'-16'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Silt w/ Fine Sand dry; pale yellowish brown; soft loose roots
4.0 - 8.0'	Silt, Sand Gravel dry; pale yellowish brown; w/ multicolored (brown to reddish brown) sub-angular to sub-rounded clincker gravels about 15% gravels up to 3/4" in size
8.0 - 12.0'	Sand and Gravel dry to slightly moist; medium yellowish brown; clincker and shale gravels, shale gravels at 10', gravels up to +1" in size
12.0 - 15.0'	Gravel dry; multicolored; clincker and sandstone in origin; large up to cobble sized; sub-angular to angular
15.0 - 16.0'	Clay moist; weathered claystone

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Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: AVF8-P2

Date Hole Started: 8/15/13 Date Hole Finished: 8/15/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 22,
NW1/4; N 464789.38, E 2823283.66
Location Description:
Recorded By: RJJ
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4" (0'-2'); 2 1/8" (2'-16')
Total Depth Drilled (ft): 16

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	3/4"-inch, flush threaded, Sch 40, PVC	+2.97-16
Surface Casing Used?	Y	4" steel	+2.97-2.03
Screen/Perforations?	Y	0.010-inch slot, 3/4" pre-pack	11-16
Sand Pack?	Y	20/30 Silica Sand	6-16
Annular Seal?	Y	3/8 Bentonite Chips	+1-6
Surface Seal?	Y	Concrete Pad	

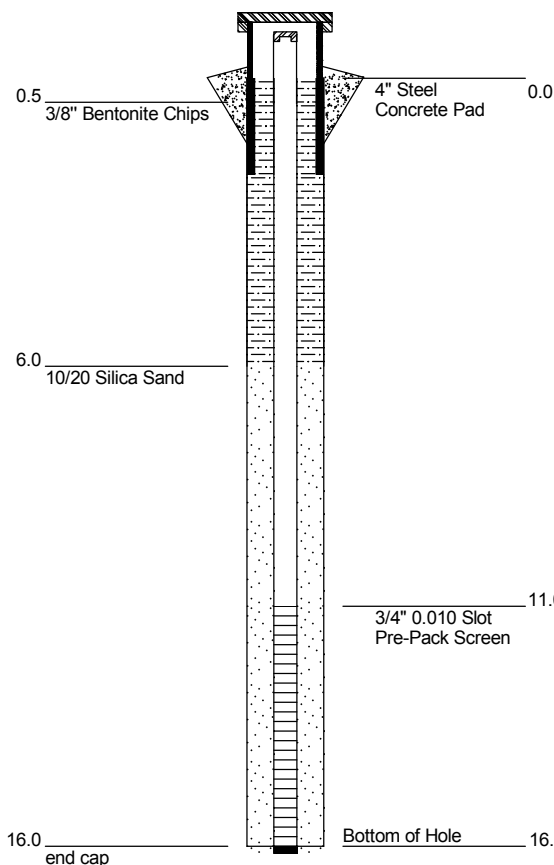
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 464789.386	Easting: 2823283.667
Static Water Level Below MP: Dry at 17.84'	Surface Casing Height (ft): 2.97
Date: 8/28/2013	Riser Height (ft): 2.54
MP Description: Top PVC	Ground Surface Elevation (ft): 3073.524
MP Height Above or Below Ground (ft): 2.54	MP Elevation (ft): 3076.06

Remarks: Direct Pushed pilot hole to 16', didn't tag gravel, installed 3/4" well to 16' in pilot hole. Used 10/20 silica sand to fill in around the 3/4 inch pre-pack screen. Interval for 10/20 sand pack is 6'-16'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Silt and Clay very dry; pale yellow to moderate yellowish brown; very dense; white salt precipitate; roots throughout
4.0 - 8.0'	Silty Clay as above; more coarse w/ depth
8.0 - 12.0'	Silty Sand dry to slightly moist; trace gravel <5%
12.0 - 16.0'	Sandy Clay slightly moist; moderate yellowish to moderate yellowish brown [10YR 4/4]

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Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: AVF8-P3

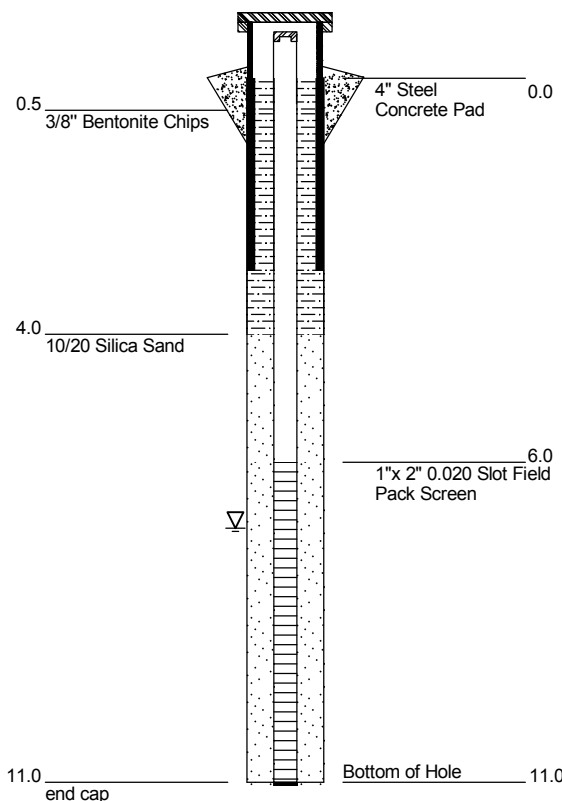
Date Hole Started: 8/15/13 Date Hole Finished: 8/15/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 22,
NE1/4; N 464492.40, E 2824386.72
Location Description:
Recorded By: RJL
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/ Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4"
Total Depth Drilled (ft): 11

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	1-inch, flush threaded, Sch 40, PVC	+1.90-11.8
Surface Casing Used?	Y	4" steel	+1.90-3.10
Screen/Perforations?	Y	0.020-inch slot, 1"x 2" field pack	6-11
Sand Pack?	Y	10/20 Silica Sand	4-11
Annular Seal?	Y	3/8 Bentonite Chips	+1-4
Surface Seal?	Y	Concrete Pad	
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Peristaltic Pump	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 464492.404		Easting: 2824386.727	
Static Water Level Below MP: 8.61		Surface Casing Height (ft): 1.90	
Date: 8/28/2013		Riser Height (ft): 1.58	
MP Description: Top PVC		Ground Surface Elevation (ft): 3060.353	
MP Height Above or Below Ground (ft): 1.58		MP Elevation (ft): 3061.92	

Remarks: Direct Pushed pilot hole to 12'. Tripped out and backfilled pilot hole with 3/8" bentonite chips. Moved ~ 3' and augered to 11'.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Silt dry; pale yellowish brown [10YR 5/4]; soft; moderately loose, roots
4.0 - 10.0'	Silt to Clayey Sand dry to very moist; moderate yellowish brown; more clayey sand with depth
10.0 - 11.8'	Sandy Clay to Clayey Sand wet; moderate yellowish brown;
11.8 - 12.0'	Gravel 1/4" clinker and sand poorly sorted

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Billings, Montana



Monitor Well Log

Hole Name: AVF8-P4

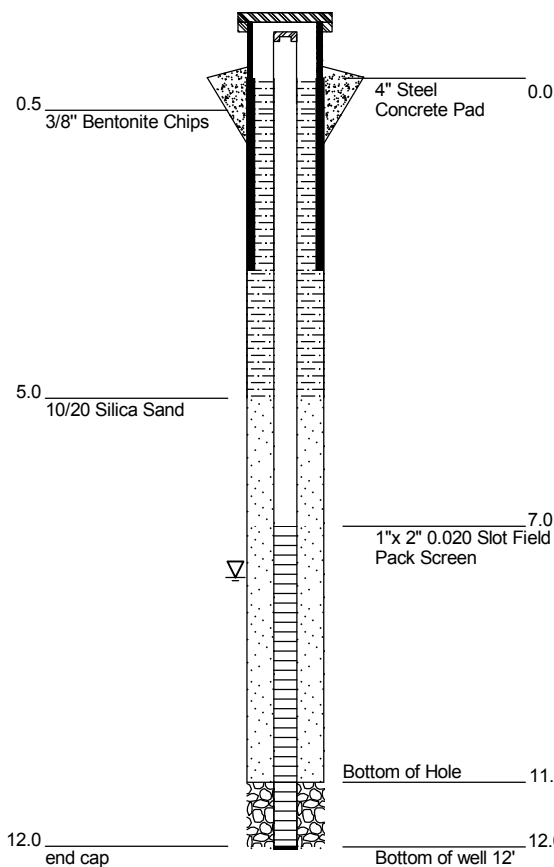
Date Hole Started: 8/16/13 Date Hole Finished: 8/16/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 22,
NE1/4; N 464810.33, E 2824900.74
Location Description:
Recorded By: RJJ
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/ Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4"
Total Depth Drilled (ft): 11

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	1-inch, flush threaded, Sch 40, PVC	+1.60-12
Surface Casing Used?	Y	4" steel	+1.88-3.22
Screen/Perforations?	Y	0.020-inch slot, 1"x 2" field pack	7-12
Sand Pack?	Y	10/20 Silica Sand	5-11
Annular Seal?	Y	3/8 Bentonite Chips	+1-5
Surface Seal?	Y	Concrete Pad	
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Peristaltic Pump	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 464810.332		Easting: 2824900.743	
Static Water Level Below MP: 9.40		Surface Casing Height (ft): 1.88	
Date: 8/28/2013		Riser Height (ft): 1.60	
MP Description: Top PVC		Ground Surface Elevation (ft): 3060.169	
MP Height Above or Below Ground (ft): 1.60		MP Elevation (ft): 3061.77	

Remarks: Direct Pushed pilot hole to 11'. Tripped out and augered to 11'. Well pushed in and completed at 12' below ground surface due to soft clay.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 4.0'	Silt, Sand and Clay dry to slightly moist; pale to moderate yellowish brown; loose, roots
4.0 - 7.0'	Sand and Gravel dry to slightly moist; pale reddish brown to moderate yellowish brown; multicolored gravels sub-angular to 3/4"
7.0 - 11.0'	Sandy Clay to Clayey Sand very moist to wet; very soft, loose; less clay to no clay at 10' - 12' and fine to moderately fine
11.0 - 12.0'	No Core Logged well advanced passed the drilled depth into soft clay

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Billings, Montana



Monitor Well Log

Hole Name: AVF8-P5

Date Hole Started: 8/16/13 Date Hole Finished: 8/16/13

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 22,
NE1/4; N 465061.70, E 2825528.65
Location Description:
Recorded By: RJL
Drilling Company: Hydrometrics, Inc
Driller: Larry Johnson and Carl Lanz
Drilling Method: Auger/ Direct Push
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Root Zone Ground Water
Hole Diameter (in): 6 1/4" (0'-3'); 2 1/8" (3'-16')
Total Depth Drilled (ft): 14

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	3/4"-inch, flush threaded, Sch 40, PVC	+2.36-14
Surface Casing Used?	Y	4" steel	+2.36-2.64
Screen/Perforations?	Y	0.010-inch slot, 3/4" pre-pack	9-14
Sand Pack?	Y	20/30 Silica Sand	9-14
Annular Seal?	Y	3/8 Bentonite Chips	+1-3
Surface Seal?	Y	Concrete Pad	

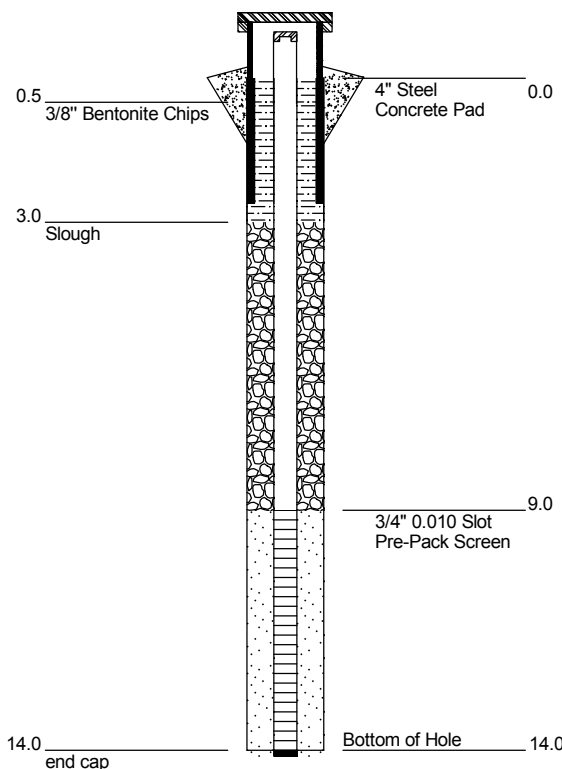
DEVELOPMENT/SAMPLING

Well Developed?	Y	Peristaltic Pump
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 465061.707	Easting: 2825528.645
Static Water Level Below MP: Dry at 16.15'	Surface Casing Height (ft): 2.36
Date: 8/28/2013	Riser Height (ft): 2.24
MP Description: Top PVC	Ground Surface Elevation (ft): 3067.358
MP Height Above or Below Ground (ft): 2.24	MP Elevation (ft): 3069.59

Remarks: Direct Pushed pilot hole to 16'. Tripped out and augered hole for steel casing to 3' with 6 1/4" auger. Directed pushed well hole to 14'. Installed 3/4" well at 14'. Used 10/20 silica sand to fill in around the 3/4 inch pre-pack screen. Interval for 10/20 pre-pack is 9'-14', hole sloughed from 3'-9',

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silty Clay dry to slightly moist; moderate to dark yellowish brown; loose, roots
3.0 - 9.0'	Silty Sandy Clay slightly moist; moderate yellowish brown; moderate plasticity; loose
9.0 - 16.0'	Clayey Sand and Sandy Clay slightly moist to very moist w/ depth; soft, loose

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Billings, Montana



Monitor Well Log

Hole Name: B10-KL

Date Hole Started: 3/3/2011 Date Hole Finished: 3/3/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T5S, R45E, Sec. 3, Tract SW 1/4; N 447884.96, E 2822243.99
Location Description: B10 battery, Lower Knobloch well
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Lower Knobloch
Hole Diameter (in): 8"
Total Depth Drilled (ft): 147

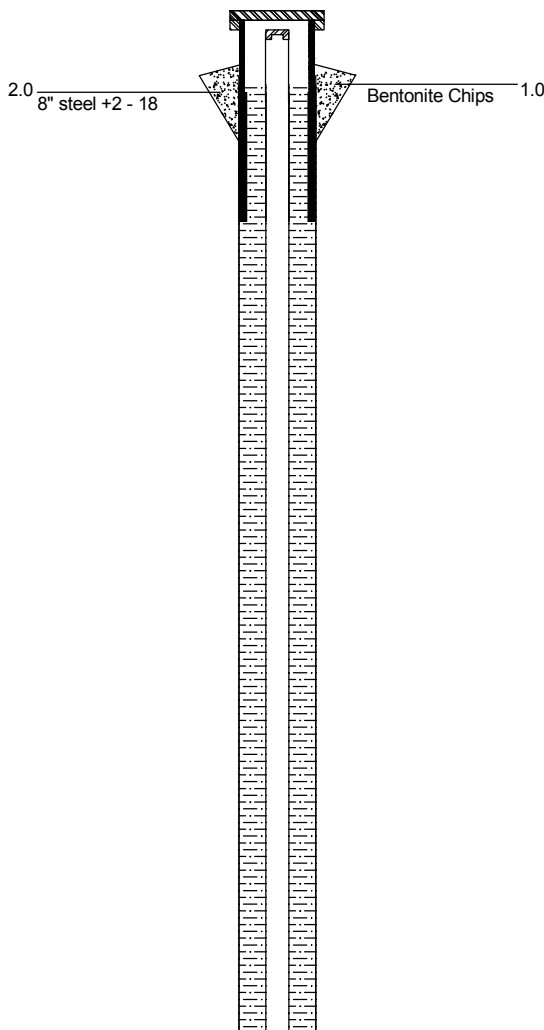
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-147
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	137-147
Sand Pack?	Y	10/20 silica sand	135-147
Annular Seal?	Y	Bentonite Chips	+1-135
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 447884.96	Easting: 2822243.99	
Static Water Level Below MP: 108.2 (rising)	Surface Casing Height (ft): 2.00	
Date: 3/3/2011	Riser Height (ft): 1.66	
MP Description:	Ground Surface Elevation (ft): 3177.85	
MP Height Above or Below Ground (ft): 1.66	MP Elevation (ft): 3179.51	

Remarks: Lithology based on well B10-U, checked cuttings for verification. Injecting water at 35'. Start development with bailer, yield is ~2-2.5 gpm, removed ~60 gallons total. Upon well completion water medium dark brown, turbid, frothy, SC=4280 µmhos/cm, pH=7.52, temp=11.5°C.

WELL CONSTRUCTION



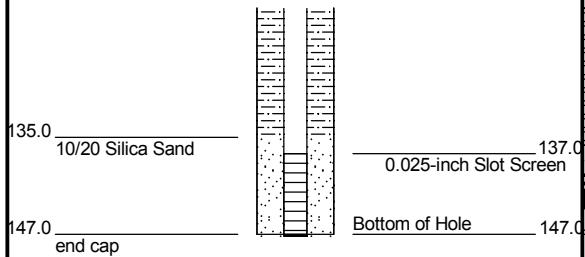
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silty clay [Colluvium]	Slightly moist (frost), moderate to dark yellowish brown, moderately cohesive, non-plastic, roots
3.0 - 4.0'	Silty clay, trace sand with depth [Colluvium]	Dry, moderate yellowish brown, loose to dense, roots
4.0 - 5.0'	Sand, some gravel (2%) [Colluvium]	Dry, moderate yellowish brown, loose
5.0 - 8.0'	Clay, sandy, silty [Colluvium]	Dry, moderate yellowish brown, soft, white calcareous nodules/precipitates
8.0 - 15.0'	Clayey sand (clay & sand) [Alluvium/Colluvium]	Dry, moderate yellowish brown, loose to moderately dense, thickly interlayered, trace gravel (1-2%), clinker flat, light brown, major sand layers at 8'-11' and at 14'-15'
15.0 - 30.0'	Claystone, very silty, interbedded siltstone [Bedrock]	Dry to very moist with depth, multicolored pale and moderate yellowish brown, light olive gray and grayish orange (10YR 7/4), mild reaction to HCl (calcareous), most very hard, some soft with moderate plasticity, rolls to 1/8" when wet
30.0 - 33.5'	Coal	Wet, makes ~5 gpm, injecting water; black (N1), moderately weathered, cleated on multiple planes, moderately firm
33.5 - 36.0'	Carbonaceous shale	Dry, brownish gray (5YR 4/1) to olive gray (5Y 4/1), firm to stiff
36.0 - 40.0'	Shale	Dry, light brownish gray (5YR 6/1) and light olive gray (5Y 6/1) to brownish black (5YR 2/1), carbonaceous, firm
40.0 - 66.5'	Coal [Knobloch]	Wet, black, hard, cleated multiple times, no visible impurities
66.5 - 69.0'	Shale	Olive gray (5Y 4/1), firm, non-plastic
69.0 - 76.5'	Coal [Middle Knobloch]	Black, hard, cleated multiple times, no visible impurities
76.5 - 79.5'	Shale	Light olive gray (5Y 5/2), moderate plasticity, soft to moderately firm
79.5 - 80.0'	Coal	Black, thin stringer, cleated multiple times, hard
80.0 - 97.0'	Siltstone	Dry, light olive gray (5Y 5/2) to medium light gray (N6), mostly moderate firm with intercalated, hard, yellowish gray (5Y 7/2), mildly calcareous, some fine sandstone at 80'-82'
97.0 - 119.0'	Sandstone	Medium light gray, light olive gray, soft to stiff at 97'-110', then very soft. Moderately fine grained interbedded shale, yellowish gray (5Y 7/2), hard calcareous layers at (97'-103'), and (115'-116'). Blew with rig air - yield ~5 gpm



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

119.0 - 136.0' Claystone/siltstone

Light olive gray (5Y 6/1), soft to moderately firm; moderately fine grained interbedded shale, yellowish gray (5Y 7/2), hard

136.0 - 146.5' Coal [Lower Knobloch]

Wet, making water, black, cleated on multiple planes, hard

146.5 - 147.0' Siltstone [Bedrock]

Medium light gray, firm to moderately stiff

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B10-KU

Date Hole Started: 3/3/2011 Date Hole Finished: 3/3/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T5S, R45E, Sec. 3; N
447896.91, E 2822243.93
Location Description:
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Upper Knobloch
Hole Diameter (in): 8"
Total Depth Drilled (ft): 77

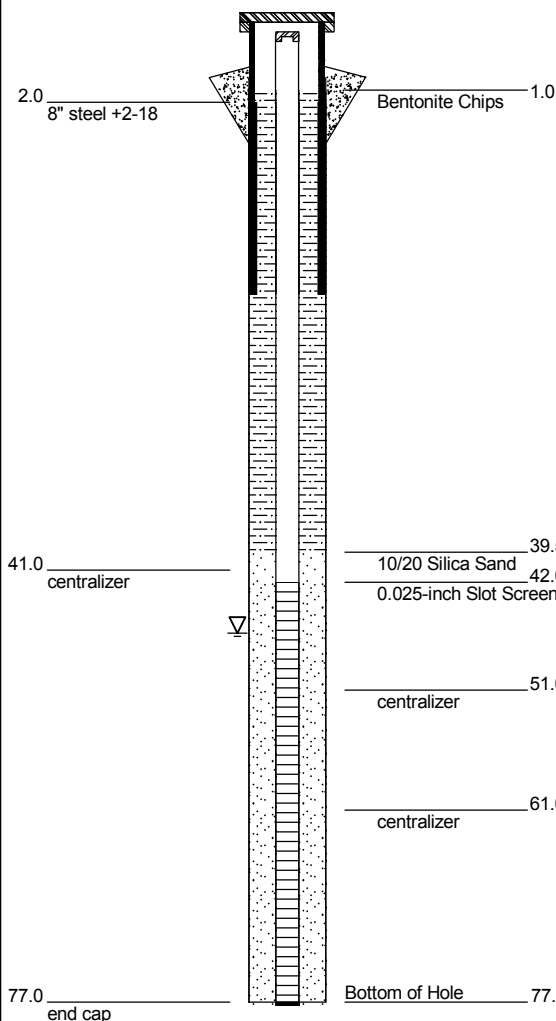
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-77
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	42-77
Sand Pack?	Y	10/20 silica sand	39.5-77
Annular Seal?	Y	Bentonite Chips	+1-39.5
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 447896.91	Easting: 2822243.93	
Static Water Level Below MP: 47.76	Surface Casing Height (ft): 1.96	
Date: 3/3/2011	Riser Height (ft): 1.53	
MP Description: Top PVC	Ground Surface Elevation (ft): 3177.98	
MP Height Above or Below Ground (ft): 1.53	MP Elevation (ft): 3179.51	

Remarks: Lithology based on well B10-U, checked cuttings for verification. Drill to 20' with 9 7/8" drag bit, drive 8" steel to 20', injecting water at 35'. Yield is 1-2 gpm, removed ~48 gallons total. Upon well completion very turbid, dark brown color, SC=4930 µmhos/cm, pH=7.75, temp=11.1°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silty clay [Colluvium]	Slightly moist (frost), moderate to dark yellowish brown, moderately cohesive, non-plastic, roots
3.0 - 4.0'	Silty clay, trace sand with depth [Colluvium]	Dry, moderate yellowish brown, loose to dense, roots
4.0 - 5.0'	Sand, some gravel (2%) [Colluvium]	Dry, moderate yellowish brown, loose
5.0 - 8.0'	Clay, sandy, silty [Colluvium]	Dry, moderate yellowish brown, soft, white calcareous nodules/precipitates
8.0 - 15.5'	Clayey sand (clay & sand) [Alluvium/Colluvium]	Dry, moderate yellowish brown, loose to moderately dense, thickly interlayered, trace gravel (1-2%), clinker flat, light brown, major sand layers at 8'-11' and at 14'-15'
15.5 - 30.5'	Claystone, very silty, interbedded siltstone [Bedrock]	Dry to very moist with depth, multicolored pale and moderate yellowish brown, light olive gray and grayish orange (10YR 7/4), mild reaction to HCl (calcareous), most very hard, some soft with moderate plasticity, rolls to 1/8" when wet
30.5 - 34.0'	Coal	Wet, makes ~5 gpm, injecting water; black (N1), moderately weathered, cleated on multiple planes, moderately firm
34.0 - 40.0'	Carbonaceous shale	Dry, brownish gray (5YR 4/1) to olive gray (5Y 4/1), firm to stiff
40.0 - 66.0'	Coal [Upper Knobloch]	Wet, black, hard, cleated multiple times, no visible impurities
66.0 - 71.0'	Shale	Olive gray (5Y 4/1), firm, non-plastic
71.0 - 76.5'	Coal [Upper/Middle Knobloch ??]	Black, hard, cleated multiple times, no visible impurities
76.5 - 77.0'	Shale	Light olive gray (5Y 5/2), moderate plasticity, soft to moderately firm

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Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B10-O

Date Hole Started: 3/3/2011 Date Hole Finished: 3/3/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T5S, R45E, Sec. 3, Tract SW 1/4; N 447907.40, E 2822242.97
Location Description: B10 battery overburden in Denson meadow
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Overburden above Knobloch coal
Hole Diameter (in): 8"
Total Depth Drilled (ft): 35

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-35
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	30-35
Sand Pack?	Y	10/20 silica sand	28-35
Annular Seal?	Y	Bentonite Chips	+1-28
Surface Seal?	N		

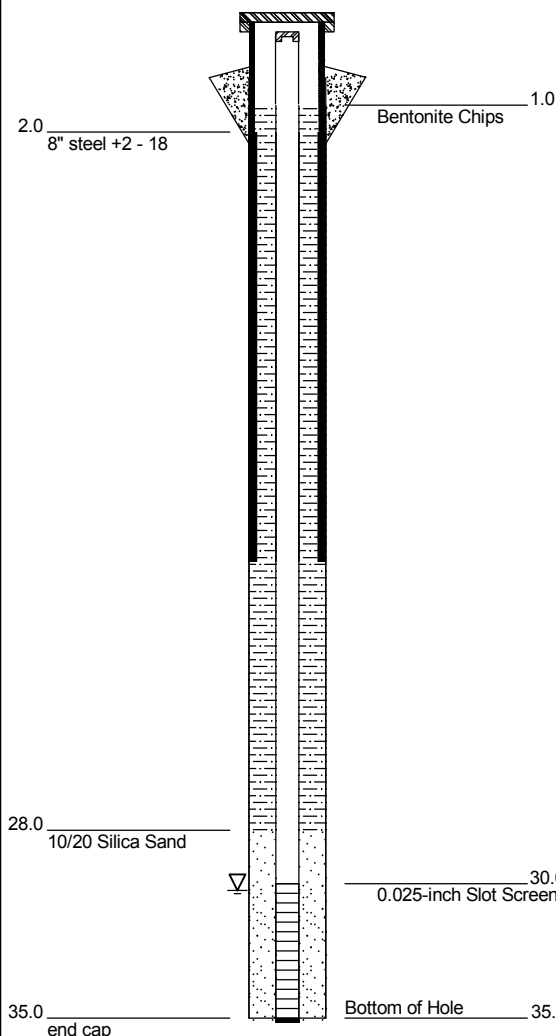
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Bailer
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 447907.4	Easting: 2822242.97
Static Water Level Below MP: 32.00	Surface Casing Height (ft): 1.92
Date: 3/3/2011	Riser Height (ft): 1.76
MP Description: Top PVC	Ground Surface Elevation (ft): 3177.80
MP Height Above or Below Ground (ft): 1.76	MP Elevation (ft): 3179.56

Remarks: Lithology based on well B10-U, checked cuttings for verification. Drill to 20' with 7 7/8" bit, ream with 9 7/8" bit, drive 8" steel, no drilling fluids used, developed with rig bailer. Yield is ~2-3 gpm. Removed ~25 gallons with rig bailer; upon completion very turbid, frothy rich dark brown color, did not clear, SC=2140 µmhos/cm, pH=6.09, temp=10.1°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silty clay [Colluvium] Slightly moist (frost), moderate to dark yellowish brown, moderately cohesive, non-plastic, roots
3.0 - 4.0'	Silty clay, trace sand with depth [Colluvium] Dry, moderate yellowish brown, loose to dense, roots
4.0 - 5.0'	Sand, some gravel (2%) [Colluvium] Dry, moderate yellowish brown, loose
5.0 - 8.0'	Clay, sandy, silty [Colluvium] Dry, moderate yellowish brown, soft, white calcareous nodules/precipitates
8.0 - 15.0'	Clayey sand (clay & sand) [Alluvium/Colluvium] Dry, moderate yellowish brown, loose to moderately dense, thickly interlayered, trace gravel (1-2%), clinker flat, light brown, major sand layers at 8'-11' and at 14'-15'
15.0 - 30.0'	Claystone, very silty, interbedded siltstone [Bedrock] Dry to very moist with depth, multicolored pale and moderate yellowish brown, light olive gray and grayish orange (10YR 7/4), mild reaction to HCl (calcareous), most very hard, some soft with moderate plasticity, rolls to 1/8" when wet
30.0 - 33.5'	Coal Wet, makes ~5 gpm, injecting water; black (N1), moderately weathered, cleated on multiple planes, moderately firm
33.5 - 35.0'	Carbonaceous shale Dry, brownish gray (5YR 4/1) to olive gray (5Y 4/1), firm to stiff

Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: B10-U

Date Hole Started: 2/28/2011 Date Hole Finished: 2/28/2011

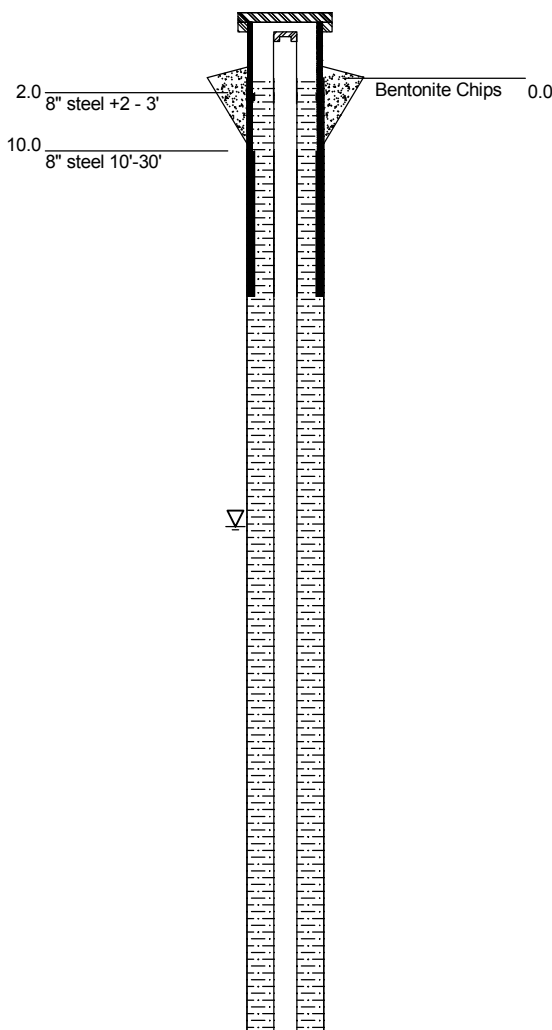
Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T5S, R45E, Sec. 3, Tract
SW 1/4; N 447919.60, E 2822245.02
Location Description: B10 battery in Denson
meadow
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Underburden
Hole Diameter (in): 8"
Total Depth Drilled (ft): 460

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-460
Surface Casing Used?	Y	8" steel	+2-3 and 10-30
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	380-460
Sand Pack?	Y	10/20 silica sand	350-460
Annular Seal?	Y	Bentonite Chips	0-350
Surface Seal?	N		
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Rig Air	
Water Samples Taken?	N		
Boring Samples Taken?	N		

Northing: 447919.6 Easting: 2822245.02
Static Water Level Below MP: 63.19 Surface Casing Height (ft): 1.81
Date: 3/2/2011 Riser Height (ft): 1.56
MP Description: Top PVC Ground Surface Elevation (ft): 3177.64
MP Height Above or Below Ground (ft): 1.56 MP Elevation (ft): 3179.2

Remarks: Drill to 20' with 7 7/8" bit, ream with 10' bit, drive 20' steel casing (8"). Lost 20' steel down open hole, backfilled with bentonite seal. Static water level in casing lower than open hole, seal ok. Removed approximately 1170 gallons with rig air; upon well completion slightly turbid, SC=1437 μ mhos/cm, pH=8.70, temp=15.3°C.

WELL CONSTRUCTION



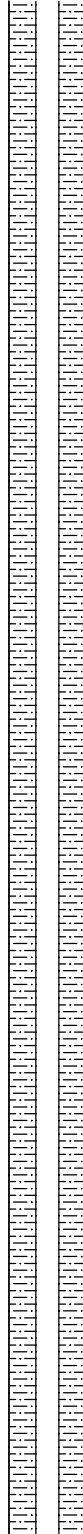
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silty clay [Colluvium] Slightly moist (frost), moderate to dark yellowish brown, moderately cohesive, non-plastic, roots
3.0 - 4.0'	Silty clay, trace sand with depth [Colluvium] Dry, moderate yellowish brown, loose to dense, roots
4.0 - 5.0'	Sand, some gravel (2%) [Colluvium] Dry, moderate yellowish brown, loose
5.0 - 8.0'	Clay, sandy, silty [Colluvium] Dry, moderate yellowish brown, soft, white calcareous nodules/precipitates
8.0 - 15.0'	Clayey sand (clay & sand) [Alluvium/Colluvium] Dry, moderate yellowish brown, loose to moderately dense, thickly interlayered, trace gravel (1-2%), clinker flat, light brown, major sand layers at 8'-11' and at 14'-15'
15.0 - 30.0'	Claystone, very silty, interbedded siltstone [Bedrock] Dry to very moist with depth, multicolored pale and moderate yellowish brown, light olive gray and grayish orange (10YR 7/4), mild reaction to HCl (calcareous), most very hard, some soft with moderate plasticity, rolls to 1/8" when wet
30.0 - 33.5'	Coal Wet, makes ~5 gpm, injecting water; black (N1), moderately weathered, cleated on multiple planes, moderately firm
33.5 - 36.0'	Carbonaceous shale Dry, brownish gray (5YR 4/1) to olive gray (5Y 4/1), firm to stiff
36.0 - 40.0'	Shale Dry, light brownish gray (5YR 6/1) and light olive gray (5Y 6/1) to brownish black (5YR 2/1), carbonaceous, firm
40.0 - 66.5'	Coal [Knobloch] Wet, black, hard, cleated multiple times, no visible impurities
66.5 - 69.0'	Shale Olive gray (5Y 4/1), firm, non-plastic
69.0 - 76.0'	Coal [Middle Knobloch] Black, hard, cleated multiple times, no visible impurities
76.0 - 79.5'	Shale Light olive gray (5Y 5/2), moderate plasticity, soft to moderately firm
79.5 - 80.0'	Coal Black, thin stringer, cleated multiple times, hard
80.0 - 97.0'	Siltstone Dry, light olive gray (5Y 5/2) to medium light gray (N6), mostly moderate firm with intercalated, hard, yellowish gray (5Y 7/2), mildly calcareous, some fine sandstone at 80'-82'
97.0 - 119.0'	Sandstone Medium light gray, light olive gray, soft to stiff at 97'-110', then very soft. Moderately fine grained interbedded shale, yellowish gray (5Y 7/2), hard calcareous layers at (97'-103') and (115'-116')
119.0 - 123.0'	Claystone Light olive gray (5Y 6/1), soft to moderately firm
123.0 - 124.0'	Shale Moderately fine grained interbedded shale, yellowish gray (5Y 7/2), hard



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

124.0 - 135.0' **Siltstone**
Light olive gray (5Y 6/1), moderately firm

135.0 - 146.0' **Coal** [Lower Knobloch]
Wet, making water, black, cleated on multiple planes, hard

146.0 - 153.0' **Fine sandstone/siltstone** [Bedrock]
Medium light gray, firm to moderately stiff

153.0 - 154.0' **Sandstone** [Bedrock]
Medium light gray, hard, rig chattering at 153'

154.0 - 188.0' **Siltstone/shale**
Dry, interbedded fine sandstone, very stiff to hard at 175'-177'. Colors from medium light gray to medium dark gray with depth, shale becomes carbonaceous with depth, firm to stiff

188.0 - 189.5' **Sandstone**
Very hard, rig chattering, slow to advance

189.5 - 197.0' **Siltstone/interbedded sandstone**
Greenish gray to medium light gray, soft to moderately firm

197.0 - 204.0' **Sandstone**
Medium light gray, very soft to moderately firm, moderately fine grained

204.0 - 207.0' **Coal**
Black, hard cuttings ground, appears cleated

207.0 - 214.0' **Siltstone, sandy**
Olive gray (5Y 4/1), moderately firm

214.0 - 221.5' **Coal**
Black, hard, cuttings ground

221.5 - 320.0' **Siltstone**
Light gray to light olive gray (5Y 6/1)
240' very thin coal stringer
250'-253' very hard cemented interval, rig chattering/slow to advance, medium light gray to light gray, calcareous
280'-281.5' carbonaceous shale, medium dark gray
281.5' very thin coal stringer
285'-290' soft, advanced very quickly
296' sandstone stringer
305' coal stringer
310' very sandy from 310'-315'

320.0 - 324.0' **Coal**
Black, cleated on multiple planes

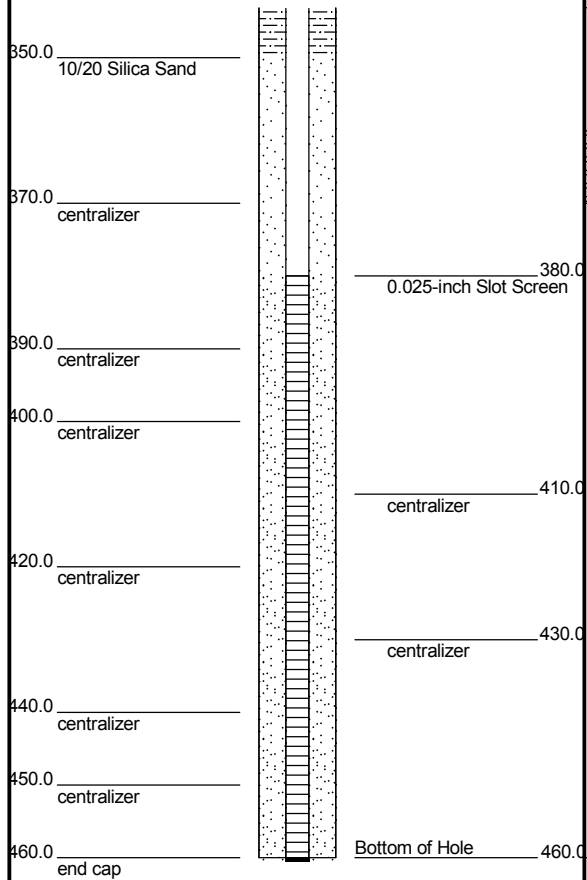
324.0 - 360.0' **Siltstone/shale**
Light gray to light olive gray, some yellowish gray (5Y 7/2) shale, intercalated, mildly calcareous, hard, otherwise only firm.
326' very hard cemented layer, thin



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



360.0 - 370.0' **Shale**
Olive gray to olive black, mildly carbonaceous, firm

370.0 - 460.0' **Sandstone**
Medium light gray, very soft, gravels coarser with depth, fine to moderately fine grain; making ~20 gpm

Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: B11-K

Date Hole Started: 11/4/10

Date Hole Finished: 11/4/10

Client: Arch Coal

Project: Otter Creek Mine Permit (10068)

County: Powder River State: Montana

Property Owner: Great Northern Properties

Legal Description: T4S, R45E, Sec. 23;

N467914.49, E 2829529.76

Location Description: B11 Battery East Center

Proposed Mine Area

Recorded By: ajh

Drilling Company: Askin Drilling

Driller: Ron Askin

Drilling Method: Air Rotary

Drilling Fluids Used:

Purpose of Hole: Install Monitor Well

Target Aquifer: Knobloch Coal

Hole Diameter (in): 7 7/8"

Total Depth Drilled (ft): 313

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-313
Surface Casing Used?	Y	8" steel	+2-18.5
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	243-313
Sand Pack?	Y	10/20 Silica Sand	232-313
Annular Seal?	Y	Bentonite Chips	0-232
Surface Seal?	Y	Concrete Pad	

DEVELOPMENT/SAMPLING

Well Developed? Y Bailed

Water Samples Taken? N

Boring Samples Taken? N

Northing: 467914.49

Easting: 2829529.76

Static Water Level Below MP: 190.77

Surface Casing Height (ft): 1.70

Date: 11/8/2010

Riser Height (ft): 0.99

MP Description: Top PVC

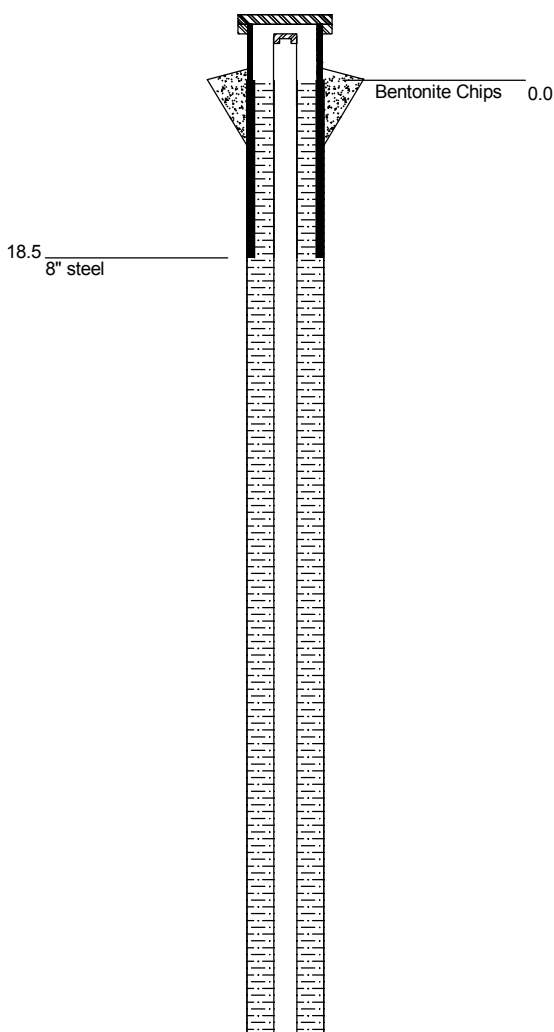
Ground Surface Elevation (ft): 3250.18

MP Height Above or Below Ground (ft): 0.99

MP Elevation (ft): 3251.17

Remarks: Open hole 20-25gpm (est.); SC 1,382 μ mhos/cm & 1,442 μ mhos/cm. Blew hole with rig air 135-147.5' test for add'l water; makes 1-2gpm including 36' interval which was making 1/4gpm, this interval sealed off but completed as B11-O in different bore hole.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0'	Clayey Silt [Topsoil] Dry, grayish orange (10YR 7/4), non-cohesive, calcareous
1.0 - 2.0'	Silt, Clayey, grading to shale Dry, grayish orange (10YR 7/4), non-cohesive, calcareous
2.0 - 5.0'	Shale [Fort Union Formation] Slightly moist to dry, moderate brown (5YR 3/4), grades to carbonaceous shale
5.0 - 7.0'	Coal Dry, dusky brown (5YR 2/2), very soft, weathered, trace pyrite, sulfur
7.0 - 13.0'	Claystone Moist, grayish orange (10YR 7/4), mottled gray, calcareous, shell fragments
13.0 - 15.5'	Siltstone, Clayey [Fort Union Formation] Moist, greenish gray (5GY 6/1), soft, calcareous, laminated
15.5 - 23.0'	Claystone grading to shale Moist, dark yellowish orange (10YR 6/6), calcareous, soft, iron oxide mottled at 17'
23.0 - 24.5'	Siltstone Moist, medium dark gray (N4), soft, weakly calcareous; carbonaceous shale at 24.5-25'
24.5 - 25.0'	Carbonaceous Shale Brownish gray (5YR 4/1), soft
25.0 - 27.0'	Shale Dry, medium light gray (N6), calcareous cemented at base, soft to moderately hard
27.0 - 30.0'	Siltstone Moist, light olive gray (5Y 6/1), calcareous, soft, appears massive
30.0 - 66.0'	Shale Dry but wet zone (1-2" only) on top of CaCO ₃ cemented zone (hard) that exists 36.5 - 37', light brown gray to medium gray (N5), makes 1/4 to 1/2gpm with rig air. Note: no springs observed around perimeter of hill. Carbonaceous shale (non
66.0 - 67.0'	Silty Sandstone Moist, light olive gray, soft, non-calcareous
67.0 - 70.5'	Shale, carbonaceous Dry, brownish gray (5YR 4/1), soft
70.5 - 72.0'	Sandstone, silty, very fine Moist, non-calcareous, soft
72.0 - 102.0'	Shale, carbonaceous to regular Brownish gray to gray, contains silty stringer, calcareous hard stringer at 86.5', becomes fissile at 95'

Hard CaCO₃ cemented shale at 87.5-87.8'+/-; hard zone at 100 to 100.5'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION

102.0 - 106.0' **Coal**

Dry to moist at bottom, cleated 2x, brownish black (5YR 2/1), soft

106.0 - 110.5' **Shale**

Dry, medium dark gray (N4)

110.5 - 116.0' **Shale, carbonaceous**

Dry, brownish gray (5YR 4/1) to gray, soft

116.0 - 123.0' **Shale, carbonaceous, but silty**

Dry, brownish gray (5YR 4/1) to gray, soft

123.0 - 127.0' **Coal**

Dry, black, cleated 3x

127.0 - 135.0' **Shale**

Dry, brownish gray (5YR 4/1), carbonaceous shale at top; less at base

135.0 - 147.5' **Siltstone, clayey**

Moist, light olive gray (5Y 6/1), soft, calcareous, very moist at 140' but no free water at connection, interval yields .5 to 1.5 gpm with rig air

147.5 - 179.5' **Shale**

Dry, brownish gray (5YR 4/1), soft, hard calcareous cemented layer at 147.5-148' and 152-152.5', coal flakes at 159', carbonaceous shale streaks at 169', coal stringer at 176-176.5'

Hard, cemented shale, CaCO₃ at 147.5-148'
Siltstone at 177-178'179.5 - 181.0' **Coal**

Black (N1), soft

181.0 - 187.5' **Shale**

Dark gray (N3), soft, carbonaceous

187.5 - 189.0' **Siltstone grading to silty fine sandstone**

Olive gray, non calcareous, soft

189.0 - 201.0' **Shale**

Brownish gray (5YR 4/1), carbonaceous

201.0 - 206.0' **Shale with minimal siltstone**206.0 - 238.0' **Shale**Light brownish gray (5YR 6/1), soft, more carbonaceous at 215', CaCO₃ cemented at 216.5-217', harder also at 223-223.24', hard at 231', carbonaceous at 233'238.0 - 313.0' **Coal** [Knobloch Coal]

Black (N1), cleated 3x, dense, making 10gpm +/- at 300' with rig air, claystone 1 cm to 1 ft at 292-293', no pyrite observed but sulphur odor

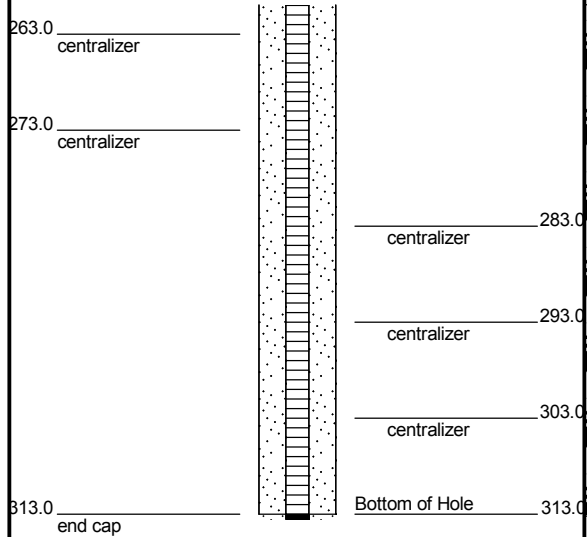
232.0
10/20 Silica Sand243.0
0.025-inch Slot Screen253.0
centralizer



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



313.0 - 313.2' **Claystone, silty**
Light olive gray, very soft, non-calcareous

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B11-O

Date Hole Started: 11/8/10 Date Hole Finished: 11/8/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 23; N 467902.65, E 2829525.74
Location Description: B11 Battery
Recorded By: ajh
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Overburden
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 151

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	141-151
Surface Casing Used?	Y	8" steel	+1.5 to -3
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	141-151
Sand Pack?	Y	10/20 Silica Sand	138-151
Annular Seal?	Y	Bentonite Chips	0-138
Surface Seal?	Y	Concrete Pad	

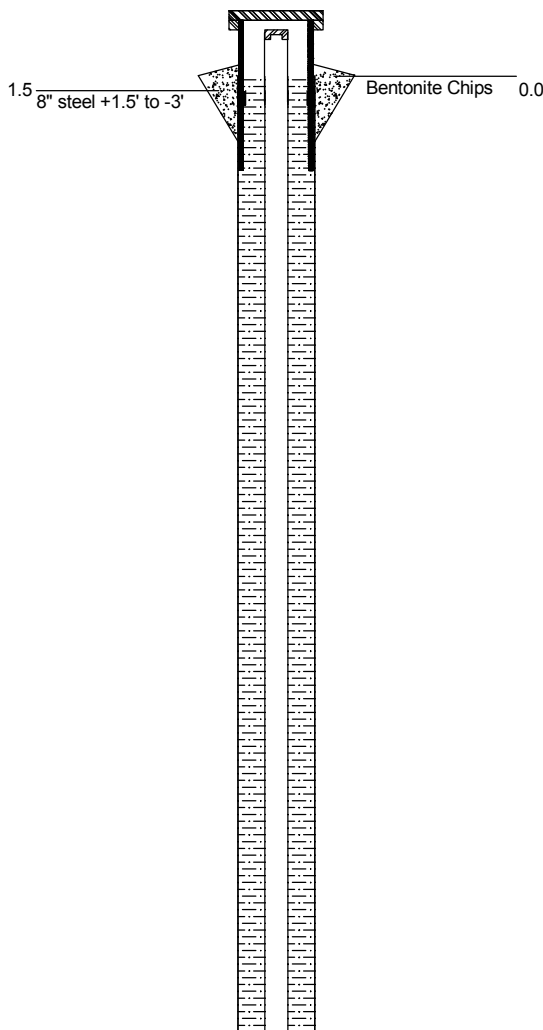
DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailed
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 467902.65	Easting: 2829525.74
Static Water Level Below MP: 142 & Rising	Surface Casing Height (ft): 1.95
Date: 11/8/2010	Riser Height (ft): 1.56
MP Description: Top PVC	Ground Surface Elevation (ft): 3250.54
MP Height Above or Below Ground (ft): 1.56	MP Elevation (ft): 3252.09

Remarks: Set 20' steel through upper weathered deposits (-18.5'). Developed with bailer, bailed dry, yield at 1 minute intervals +/- 1/2gpm; SC of last bail 7500 µmhos/cm, pH=8.26, temp 11.7°C, water level 142 and rising BMP

WELL CONSTRUCTION



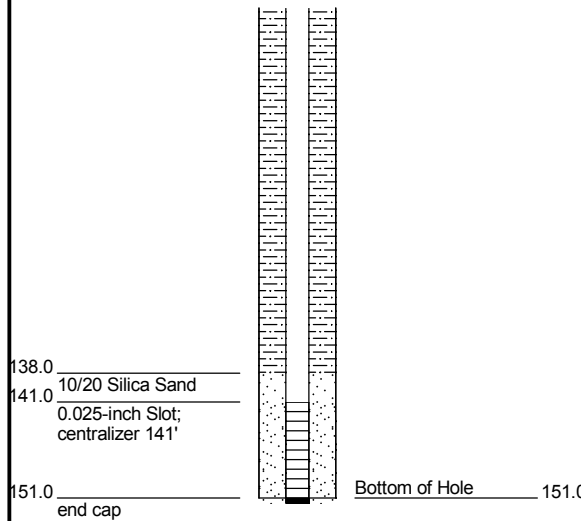
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0' Clayey Silt [Topsoil] Dry, grayish orange (10YR 7/4), non-cohesive, calcareous
1.0 - 2.0' Silt, Clayey, grading to shale Dry, grayish orange (10YR 7/4), non-cohesive, calcareous
2.0 - 5.0' Shale [Fort Union Formation] Slightly moist to dry, moderate brown (5YR 3/4), grades to carbonaceous shale
5.0 - 7.0' Coal Dry, dusky brown (5YR 2/2), very soft, weathered, trace pyrite, sulfur
7.0 - 13.0' Claystone Moist, grayish orange (10YR 7/4), mottled gray, calcareous, shell fragments
13.0 - 15.5' Siltstone, Clayey [Fort Union Formation] Moist, greenish gray (5GY 6/1), soft, calcareous, laminated
15.5 - 23.0' Claystone Moist to very moist, dark yellowish orange (10YR 6/6), calcareous, soft, balls on bit
23.0 - 25.0' Siltstone Moist, medium dark gray (N4), soft, weakly calcareous; carbonaceous shale at 24.5-25'
25.0 - 26.0' Carbonaceous Shale Brownish gray (5YR 4/1), soft
26.0 - 27.0' Shale Dry, medium light gray (N6), calcareous cemented at base, soft to moderately hard
27.0 - 30.0' Siltstone Moist, light olive gray (5Y 6/1), calcareous, soft, appears massive
30.0 - 66.0' Shale Hard CaCO ₃ layer at 37-37.5', makes less than 1/4gpm, injection at 40'. Hard CaCO ₃ layer at 43'; CaCO ₃ cemented siltstone at 55-61' numerous calcite crystals
66.0 - 68.0' Silty Sandstone Moist, light olive gray, soft, non-calcareous
68.0 - 71.0' Carbonaceous shale Dry, brownish gray (5YR 4/1), soft; no siltstone layer
71.0 - 72.0' Sandstone, silty, very fine Moist, non-calcareous, soft
72.0 - 103.0' Shale, carbonaceous to regular Brownish gray to gray, contains silty stringer, calcareous hard stringer at 86.5', becomes fissile at 95'; hard layers at 68' and 87'



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION



103.0 - 107.0' **Coal**

Dry to moist at bottom, cleated 2x, brownish black (5YR 2/1), soft



107.0 - 110.5' **Shale**

Dry, medium dark gray (N4)



110.5 - 116.0' **Shale, carbonaceous**

Dry, brownish gray (5YR 4/1) to gray, soft



116.0 - 124.0' **Shale, carbonaceous, but silty**

Dry, brownish gray (5YR 4/1) to gray, soft



124.0 - 129.0' **Coal**

Dry, black, cleated, clay stringer at 127-127.5'



129.0 - 138.0' **Shale**

Dry, brownish gray (5YR 4/1), carbonaceous shale at top; less at base



138.0 - 141.0' **Siltstone, clayey**

Moist, light olive gray (5Y 6/1), soft, calcareous, very moist at 140' but no free water at connection



141.0 - 151.0' **Siltstone**

Medium light gray (N4), hard layer at 148-151', CaCO₃, makes little water 1gpm

Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: B11-U

Date Hole Started: 11/3/10

Date Hole Finished: 11/3/10

Client: Arch Coal

Project: Otter Creek Mine Permit (10068)

County: Powder River State: Montana

Property Owner: Great Northern Properties

Legal Description: T4S, R45E, Sec. 23; N
467927.58, E 2829534.34

Location Description: B11 Battery

Recorded By: ajh

Drilling Company: Askin Drilling

Driller: Ron Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water Injection

Purpose of Hole: Install Monitor Well

Target Aquifer: Knobloch Underburden

Hole Diameter (in): 7 7/8"

Total Depth Drilled (ft): 380.5

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-380
Surface Casing Used?	Y	8" steel	+1.32-38.5
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	360-380
Sand Pack?	Y	10/20 Silica Sand	358-380
Annular Seal?	Y	Bentonite Chips	0-358
Surface Seal?	Y	Concrete Pad	

DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailed
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 467927.58

Easting: 2829534.34

Static Water Level Below MP: 178.20

Surface Casing Height (ft): 1.55

Date: 11/8/2010

Riser Height (ft): 1.39

MP Description: Top PVC

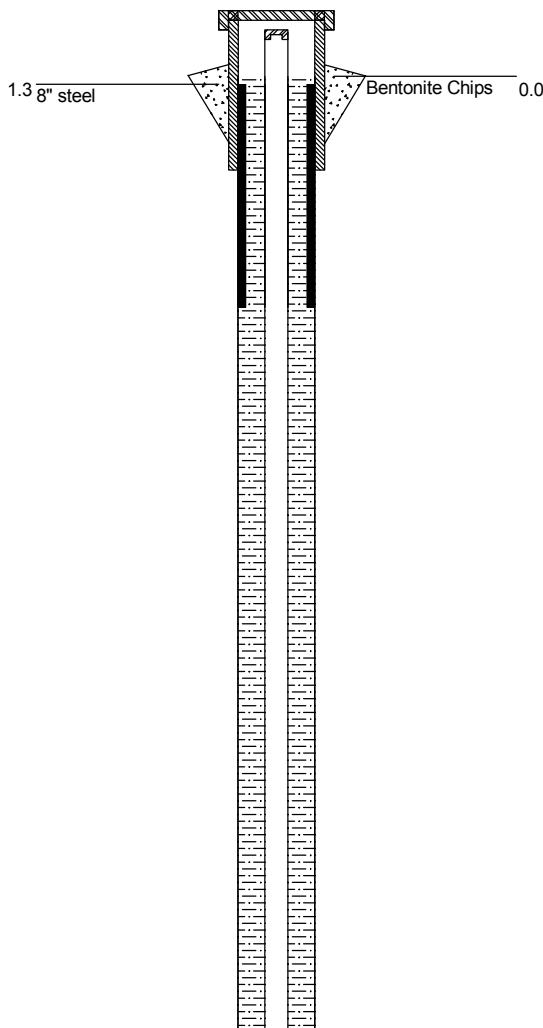
Ground Surface Elevation (ft): 3249.71

MP Height Above or Below Ground (ft): 1.39

MP Elevation (ft): 3251.09

Remarks: Inject at 36'; pull steel, set thru upper perched water zone. TDS exceeds 5000ppm, 8" steel to 38.5' bgs. Total est. vol. from open hole ~20gpm during develop, SC combined 1180µmhos/cm, well yield est. +/- 6gpm at 370' water level with bailer in completed well.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

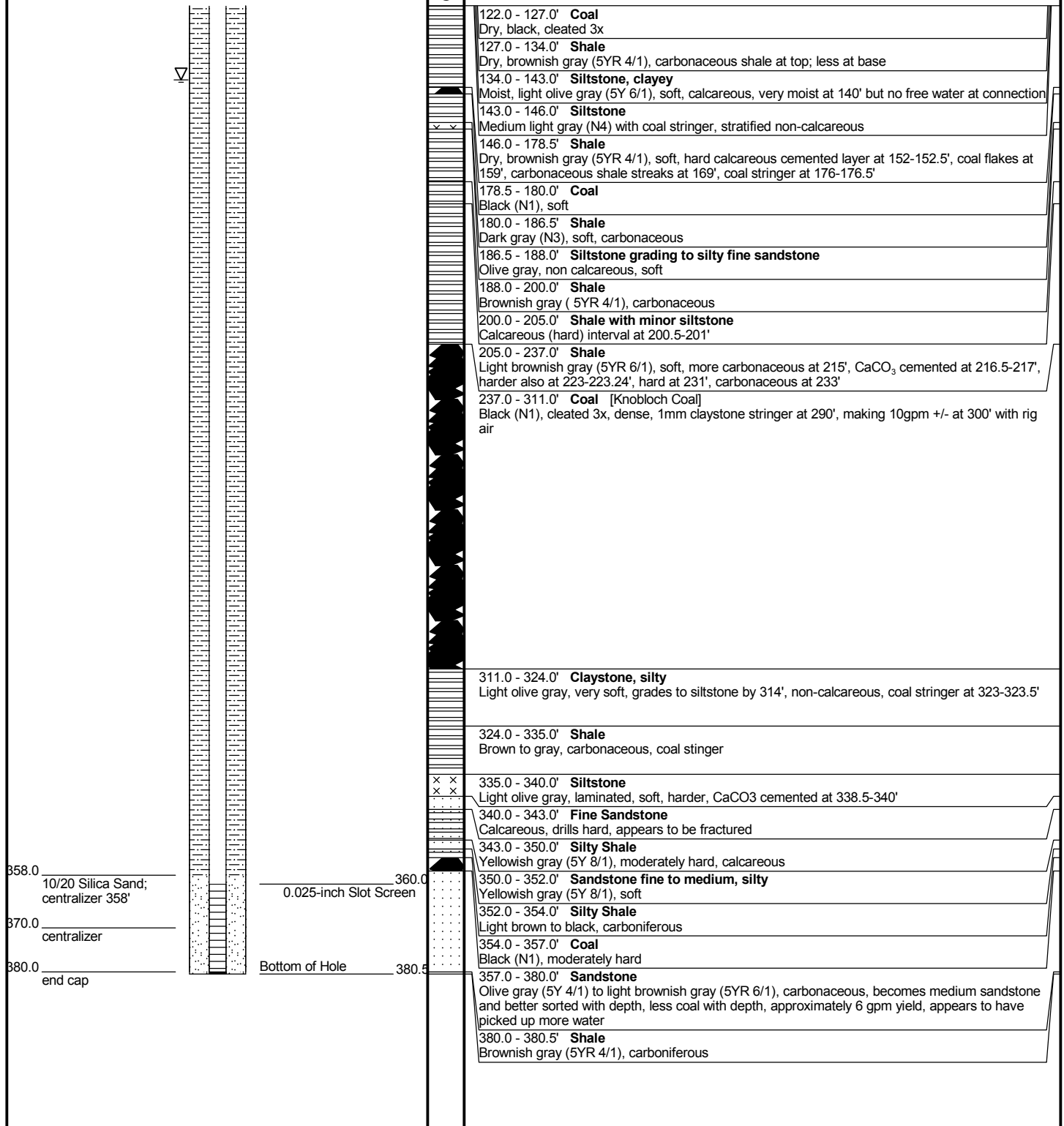
0.0 - 1.0'	Silt, Clayey [Topsoil] Dry, grayish orange (10YR 7/4), non-cohesive, calcareous
1.0 - 2.0'	Silt, Clayey, grading to shale Dry, grayish orange (10YR 7/4), non-cohesive, calcareous
2.0 - 4.0'	Shale [Fort Union Formation] Slightly moist to dry, moderate brown (5YR 3/4), grades to carbonaceous shale at base of interval
4.0 - 6.0'	Coal Dry, dusky brown (5YR 2/2), very soft, weathered, trace pyrite, sulfur
6.0 - 12.0'	Claystone Moist, grayish orange (10YR 7/4), mottled gray, calcareous, contains shell fragments
12.0 - 14.5'	Siltstone, Clayey [Fort Union Formation] Moist, greenish gray (5GY 6/1), soft, calcareous, laminated
14.5 - 22.0'	Claystone grading to shale Moist, dark yellowish orange (10YR 6/6), calcareous, soft
22.0 - 24.0'	Siltstone Moist, medium dark gray (N4), soft, weakly calcareous
24.0 - 24.5'	Shale, carbonaceous Brownish gray (5YR 4/1), soft
24.5 - 26.0'	Shale Dry, medium light gray (N6), calcareous cemented at base, soft to moderately hard
26.0 - 29.0'	Siltstone Moist, light olive gray (5Y 6/1), calcareous, soft, appears massive
29.0 - 65.0'	Shale Dry but wet zone (1-2" only) on top of CaCO ₃ cemented zone (hard) that exists 35 - 35.5', light brown gray to medium gray (N5), makes 1/4 to 1/2 gpm with rig air. Note: no springs observed around perimeter of hill. Carbonaceous shale (non
65.0 - 66.0'	Silty Sandstone Moist, light olive gray, soft, non-calcareous
66.0 - 69.5'	Shale, carbonaceous Dry, brownish gray (5YR 4/1), soft
69.5 - 71.0'	Sandstone, silty, very fine Moist, non-calcareous, soft
71.0 - 101.0'	Shale, carbonaceous to regular Brownish gray to gray, contains silty stringer, calcareous hard stringer at 86.5', becomes fissile at 95'
101.0 - 105.0'	Coal Dry to moist at bottom, cleated 2x, brownish black (5YR 2/1), soft
105.0 - 109.5'	Shale Dry, medium dark gray (N4)
109.5 - 115.0'	Shale, carbonaceous Dry, brownish gray (5YR 4/1) to gray, soft
115.0 - 122.0'	Shale, carbonaceous, but silty Dry, brownish gray (5YR 4/1) to gray, soft



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B12-CO

Date Hole Started: 6/4/14

Date Hole Finished: 6/5/14

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: U.S.F.S.
Legal Description: T4S, R46E, S31 NESENE
Location Description: B12 Battery near Coal Creek
Recorded By: JS
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Potable Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Colluvium/Overburden
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 40

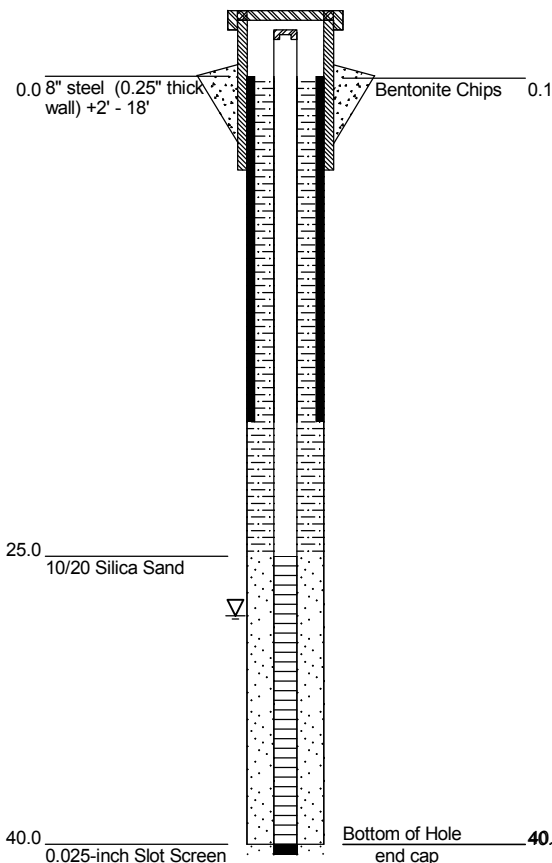
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.25" Sch 40, PVC	+1.37'AGL - 40'
Surface Casing Used?	Y	8" steel 0.250" wall	+2'AGL - 18'
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	25'-40'
Sand Pack?	Y	10/20 Silica Sand	25'-40'
Annular Seal?	Y	Bentonite Chips	0'-25'
Surface Seal?	Y	Bentonite around steel csg	

DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailed 30 min.
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 454435.2	Easting: 2842000	
Static Water Level Below MP: 29.47	Surface Casing Height (ft): 2.00	
Date: 6/10/2014	Riser Height (ft): 1.37	
MP Description: BMP (TOPVC)	Ground Surface Elevation (ft): 3258.531	
MP Height Above or Below Ground (ft): 1.37	MP Elevation (ft): 3259.9	

Remarks: Approximately 2.0 to 2.5 gpm; 39 bails/30 minutes; SC= 5,340 μ mhos/cm.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 20.0'	Silty clayey sand loam [Colluvium] Dry to slightly moist; reddish gray - reddish brown; mixed sand, clay, silt, clinker chips to <3/4"; sub-angular, flat; loose, soft, no plasticity/no cohesiveness; coarse grain to very coarse grain; at 20' increase in moisture - damp
20.0 - 30.0'	Silty clayey sand loam [Colluvium] Damp; reddish gray - reddish brown; mixed sand, clay, silt, clinker chips to <3/4"; sub-angular, flat; loose, soft, no plasticity/no cohesiveness; coarse grain to very coarse grain 33' first groundwater (driller)
30.0 - 40.0'	Silty clayey sand loam [Colluvium] Wet - saturated at 33'; reddish gray - reddish brown; mixed sand, clay, silt, clinker chips to <3/4"; sub-angular to flat; loose, soft, no plasticity/no cohesiveness; coarse grain to very coarse grain. No pea gravels/no alluvium as was present in B12-U

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B12-LK

Date Hole Started: 6/3/14

Date Hole Finished: 6/3/14

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: U.S.F.S.
Legal Description: T4S, R46E, S31 NESENE
Location Description: B12 Battery near Coal Creek
Recorded By: JS
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Potable Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Lower Knobloch Coal
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 240

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.25" Sch 40, PVC	+1.09' AGL - 240'
Surface Casing Used?	Y	8" steel 0.250" wall	+1.60' AGL - 38'
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	223'-240'
Sand Pack?	Y	10/20 Silica Sand	221'-240'
Annular Seal?	Y	Bentonite Chips	0'-221'
Surface Seal?	Y	Bentonite around steel csg	

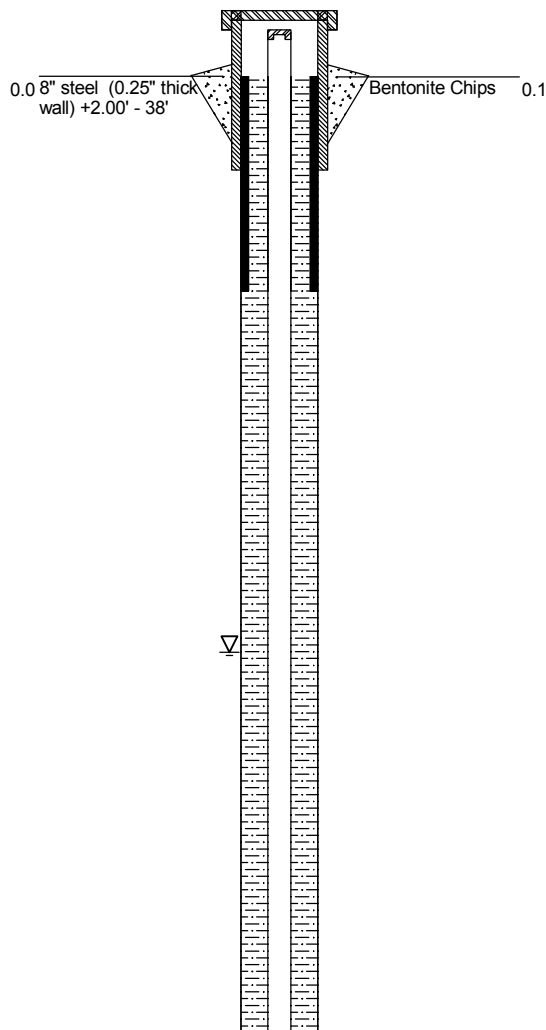
DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailed 32 min.
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 454392	Easting: 2842007
Static Water Level Below MP: 103.07	Surface Casing Height (ft): 1.60
Date: 6/10/2014	Riser Height (ft): 1.09
MP Description: BMP (TOPVC)	Ground Surface Elevation (ft): 3258.738
MP Height Above or Below Ground (ft): 1.09	MP Elevation (ft): 3259.828

Remarks: Bailed 32 minutes - 49 bails = ~343 gallons; water level at 54' BTOSC prior to development; driller measured yield ~10 gpm. Water level at 170' BTOSC immediately after development; TDS = 3,129. Well recovery after development ~5.1'/minute. Surface casing pilot hole 11" diameter to 18' below ground level (bgl). Centralizers (2): 7 ft. above screen bottom and top of screen.

WELL CONSTRUCTION



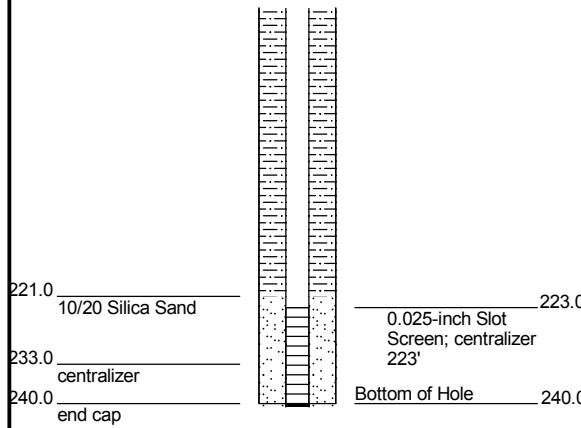
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 26.0'	Clinker gravel [Alluvium & Colluvium] Pale red; mix of clinker, clay-silt loam, sand; angular sub-round pieces to 1.25" and less. Moisture increases with depth
26.0 - 32.0'	Sandstone, large blocks (1"x6" max) Red-orange-tan clinker gravel with high clay-sand percentage 32' first groundwater (driller)
32.0 - 38.0'	Sandstone [Colluvium] Wet, saturated; no large sandstone blocks
38.0 - 45.0'	Weathered bedrock [Bedrock] Gray silt; slightly sandy; damp
45.0 - 66.0'	Coal [Upper Knobloch (2)]
66.0 - 80.0'	Clay shale Bluish-gray; becoming more silty about 75'
80.0 - 95.0'	Shale Bluish-gray; minor cohesion; moderately dense; brittle; silty; at 90' seems to be softer less dense with depth
95.0 - 96.5'	Coal
96.5 - 108.0'	Shale Greenish-gray, fissile, soft to medium hard to soft; minor brittleness; non-plastic, non-cohesive; medium density
108.0 - 110.0'	Hard silty sandstone Olive brown; very fine grain
110.0 - 128.0'	Shale Brownish, greenish-gray to bluish-gray
128.0 - 136.0'	Siltstone-mudstone Dark yellowish-brown; no bedding; fractured into flakes 3/8"
136.0 - 137.0'	Coal
137.0 - 140.0'	Silty shale Gritty minor sand content
140.0 - 152.0'	Coal [Upper Knobloch (1)]
152.0 - 160.0'	Shale Greenish-gray, sandy-silty toward 155-160'; very fine grain; silty, gritty feel; stiff; minor fissility; dense
160.0 - 163.0'	Silty sandy shale



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

163.0 - 203.0'	Sandstone Bluish-gray; silty; stiff; very fine grain; dense; becoming less dense (less stiff) with depth; increase in shale content below 178'; sandstone, very weak, silty, very fine grain; salt and pepper texture, light bluish-gray; becoming loose sand with depth
203.0 - 205.0'	Mudstone Grayish-yellow; very hard
205.0 - 207.0'	Sandstone with calcite (yellow) Healed Fracture (?) Frac-face; large crystals encrusted onto bluish-gray sandstone; hard
207.0 - 208.0'	Mudstone/Sandstone Mixed brown chert, yellowish-gray mudstone; bluish-gray sandstone; hard
208.0 - 220.0'	Silty sandstone Bluish-gray with minor coal
220.0 - 223.0'	Carbonaceous shale Brownish-black; moderately dense; non-plastic-no cohesion; stiff
223.0 - 239.0'	Coal [Lower Knobloch] Black
239.0 - 240.0'	Shale Bluish-gray; moderately dense - soft; low cohesiveness

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B12-U

Date Hole Started: 6/2/14

Date Hole Finished: 6/2/14

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: U.S.F.S.
Legal Description: T4S, R46E, S31 NESENE
Location Description: B12 Battery near Coal Creek
Recorded By: JS
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Potable Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Lower Knobloch Sand
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 300

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	SDR17 PVC/5" OD, 4.25" ID	+1.27'AGL - 300'
Surface Casing Used?	Y	8" steel 0.250" wall	+1.90'AGL - 44'
Screen/Perforations?	Y	SDR17 PVC/0.0.25" slot	260'-285'
Sand Pack?	Y	10/20 Silica Sand	250'-285'
Annular Seal?	Y	Bentonite Chips	0'-250'
Surface Seal?	Y	Bentonite around steel csg	

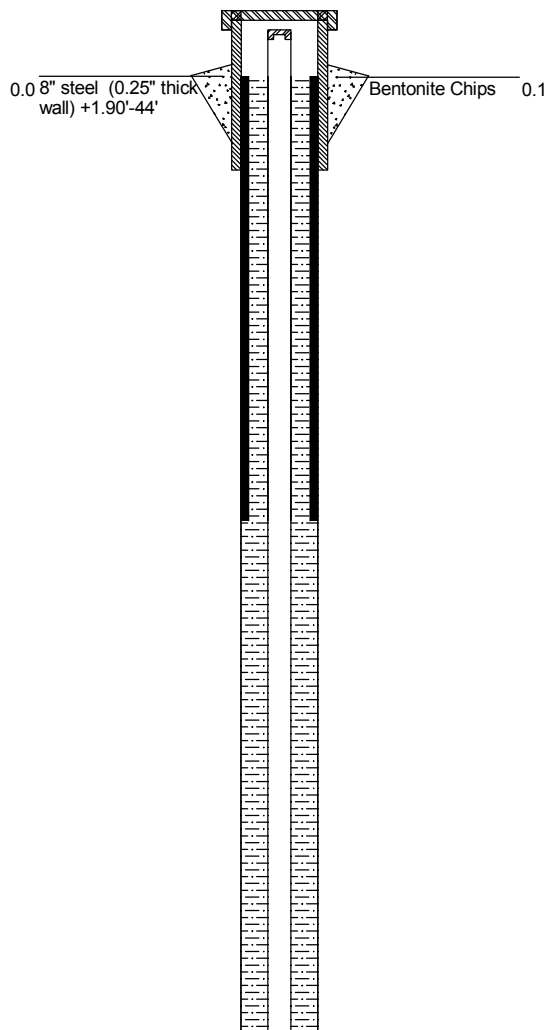
DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailed
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 454380.8	Easting: 2842009
Static Water Level Below MP: 113.5	Surface Casing Height (ft): 1.90
Date: 6/10/2014	Riser Height (ft): 1.27
MP Description: BMP (TOPVC)	Ground Surface Elevation (ft): 3258.829
MP Height Above or Below Ground (ft): 1.27	MP Elevation (ft): 3260.099

Remarks: At 10:38 a.m. began drilling with kelly rod. Well development: seven (7) gallons/bail x 42 bails = 294 gallons, 30 minutes bailing. Water level at start of development (100.74' BTOSC), end of development water level at 214' BTOSC, rising 6' per minute, TDS = 966 ppm

WELL CONSTRUCTION



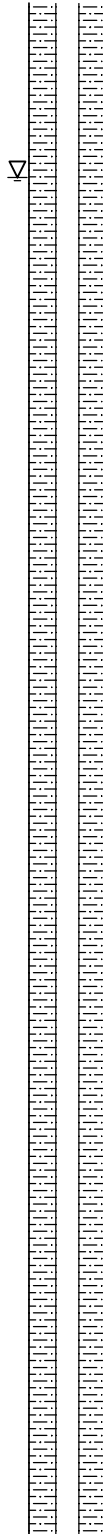
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 2.0'	Clayey silt Moderately brown; moist; minor sand
2.0 - 6.0'	Silty sand, Very fine to fine Moderately brown; moist; non-cohesive; non plastic
6.0 - 10.0'	Sedimentary clinker gravel Orange platy clinker to 1"; silty sand; no rounded gravels; sub-round clinker and medium grain and sandstone blocks to 3"
10.0 - 13.0'	As above with sandstone blocks to 1" x 6" Grayish-yellow; medium grain; cohesive; consolidated
13.0 - 25.0'	Silty sand, clayey Yellowish-gray; slightly moist; clinker chips to 1"; platy; minor consolidated; sandstone (<1" x 2")
25.0 - 30.0'	Silty sand, clayey Wet; clay silty with clinker gravel and light gray silty sandstone; plastic 30' first groundwater (driller)
30.0 - 35.0'	Clinker and bedrock (sandstone) gravel Wet; sub-round - round; unconsolidated; fragments to <1"; non-plastic, non-cohesive; pea size gravel
35.0 - 40.0'	Silty clay [Weathered Bedrock] Bluish- green; slightly moist; cohesive; fine grained; soft; minor plasticity and minor cohesion, weathered
40.0 - 45.0'	Silty clay Bluish- green; slightly moist; cohesive; fine grained; soft; minor plasticity and minor cohesion
45.0 - 50.0'	Coal [Upper Knobloch (2)] Wet; black with orange stain on frac face; fractured with cleats to 1"; hole making water, began rig injection (potable water)
50.0 - 66.0'	Coal [Upper Knobloch (2)] Wet; black without orange stain; fine fractures <1/4"; hole making 4 to 5 gpm; conductivity 2,870 umhos (maximum)
66.0 - 67.0'	Clay Bluish-gray - slight greenish; fissile; cohesive; moderately stiff - minor plastic (low)
67.0 - 70.0'	Shale Bluish-gray; cohesive; fissile; stiff; non-plastic; cuttings to 1" typical
70.0 - 85.0'	Siltstone Light bluish-gray; very fine grained; brittle; silty-sandy
85.0 - 95.0'	Shale Bluish-gray; light cohesion, non-plastic; becoming silty with depth



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

95.0 - 96.0'	Coal
96.0 - 113.0'	Shale Greenish-gray; fissile; non-plastic; brittle; silty sand streak at 106' - 107'
113.0 - 115.0'	Shale Brownish-gray; hard
115.0 - 130.0'	Shale Greenish-gray; fissile; brittle; non-plastic, non-cohesive; stiff
130.0 - 135.0'	Mudstone Pale yellowish-brown; hard; brittle
135.0 - 136.0'	Shale Greenish-gray; fissile; brittle; non-plastic, non-cohesive; stiff
136.0 - 136.5'	Coal
136.5 - 140.5'	Silty sand Pale yellowish-brown; fissile; hard; brittle
140.5 - 153.0'	Coal [Upper Knobloch (1)] Black; brittle
153.0 - 157.0'	Shale Greenish-gray
157.0 - 157.5'	Sandstone Yellowish-gray; fine grain to medium grain; hard
157.5 - 160.0'	Shale Bluish-gray; fissile; non-plastic, non-cohesive; stiff
160.0 - 180.0'	Shale, silty Bluish-gray; fissile; non-plastic, non-cohesive; stiff; at 167' slight increase in sandy content
180.0 - 215.0'	Sand Bluish-gray; very fine grain to medium grain; loose; silty; at 270' and 290' hard mudstone; at 205' petrified tree material
215.0 - 220.0'	Sand Moderate yellowish brown; thin streaks of hard mudstone; calcareous
220.0 - 238.0'	Coal [Lower Knobloch] Black
238.0 - 257.0'	Shale Light bluish-gray; platy; fissile; non-cohesive, non-plastic; soft

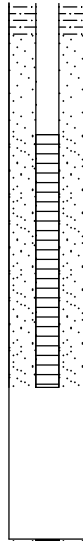


WELL CONSTRUCTION

250.0
10/20 Silica Sand

295.0
centralizer

300.0
end cap



SDR17 PVC/0.025"
slot

centralizer

centralizer

Bottom of Hole

GRAPHICS

GEOLOGICAL DESCRIPTION

257.0 - 258.0' **Coal**

258.0 - 275.0' **Sand**

Wet; dark yellowish-brown; medium grain; loose; not consolidated

275.0 - 278.0' **Mixed sand and coal**

Wet; dark yellowish-brown; medium grain; loose; not consolidated

278.0 - 285.0' **Silty sandstone**

Moderately stiff

285.0 - 300.0' **Silty shale**

Bluish-gray; silty; stiff; increase in silty toward 300'; at 285' to 300' mixed coal and shale

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Billings, Montana



Monitor Well Log

Hole Name: B12-UK1

Date Hole Started: 6/3/14

Date Hole Finished: 6/4/14

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: U.S.F.S.
Legal Description: T4S, R46E, S31 NESENE
Location Description: B12 Battery near Coal Creek
Recorded By: JS
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Potable Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Upper Knobloch 1 Coal
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 151

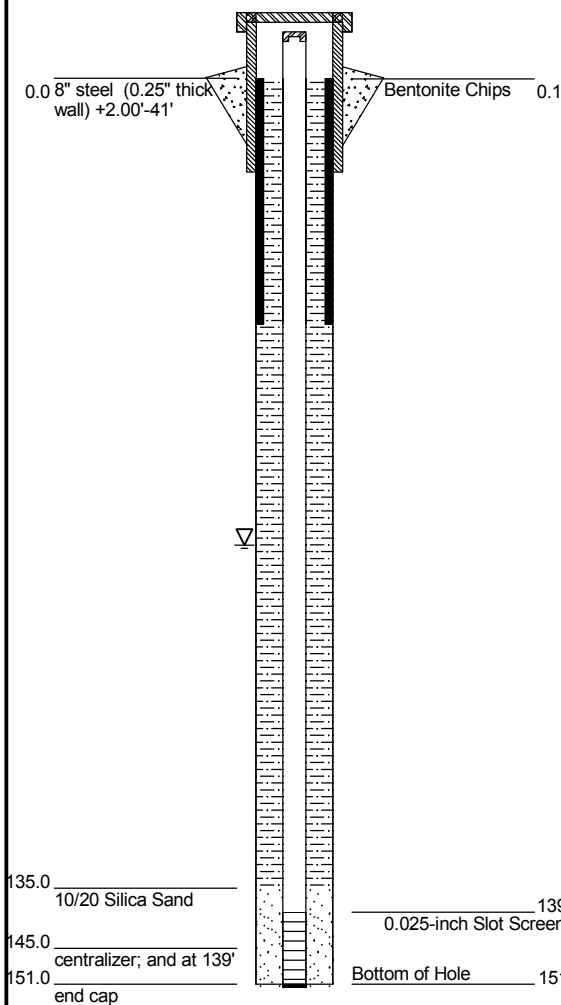
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+1.54'AGL - 151'
Surface Casing Used?	Y	8" steel 0.250" wall	+2.00'AGL - 41'
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	139'-151'
Sand Pack?	Y	10/20 Silica Sand	135'-151'
Annular Seal?	Y	Bentonite Chips	0'-135'
Surface Seal?	Y	Bentonite around steel csg	

DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailed
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 454404.3	Easting: 2842005	
Static Water Level Below MP: 79.34	Surface Casing Height (ft): 2.00	
Date: 6/10/2014	Riser Height (ft): 1.54	
MP Description: BMP (TOPVC)	Ground Surface Elevation (ft): 3258.451	
MP Height Above or Below Ground (ft): 1.54	MP Elevation (ft): 3259.991	

Remarks: Bailed 37 minutes, ~32 bails estimate 156 gallons; water level at start of development 59.5' BTOSC; water level immediately after development 137.5' BTOSC; water quality at 4,664 µmhos/cm; well making ~3 gpm; surface casing pilot hole 11" diameter to 19' below ground level (bgl) - 14 bags Hole Plug in annulus

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 2.0'	Sandy silty loam
2.0 - 20.0'	Clinker, clay, silt, sand [Colluvium] Pale red - grayish red; dry; fragments <1/4 to ~1" diameter; angular to sub-angular
20.0 - 35.0'	Clinker gravel (1/4 to 3/4") Wet - nearly saturated; grayish red; clayey silty
30'	first groundwater (driller)
35.0 - 44.0'	Silty shale [Weathered Bedrock] Bluish-gray; not saturated - damp
44.0 - 65.0'	Coal [Upper Knobloch (2)]
65.0 - 75.0'	Shale Light to dark olive gray; fissile; medium dense; non-plastic, no cohesion; becoming bluish-gray with depth
75.0 - 80.0'	Silty shale Bluish-gray; becoming more silty; gritty feel
80.0 - 94.0'	Shale Yellowish-bluish-gray; dry; stiff; fissile; non-plastic, non-cohesive
94.0 - 95.0'	Coal
95.0 - 104.0'	Shale Bluish-gray to greenish-gray; more sand/silt with depth
104.0 - 105.0'	Sandstone Olive gray; very hard, stiff; very fine grain
105.0 - 135.0'	Shale, slightly silty Olive gray to greenish-gray; dry; medium dense; brittle; fissile; no plasticity, no cohesion; At 130' an increase in silt (fine sand?)
135.0 - 136.0'	Coal
136.0 - 139.0'	Siltstone, shaley Greenish gray; dry; medium dense; becoming yellowish-brown
139.0 - 150.5'	Coal [Upper Knobloch]
150.5 - 151.0'	Silty shale Greenish-gray; medium dense; fissile; no plasticity, no-cohesion

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Monitor Well Log

Hole Name: B12-UK2

Date Hole Started: 6/4/14

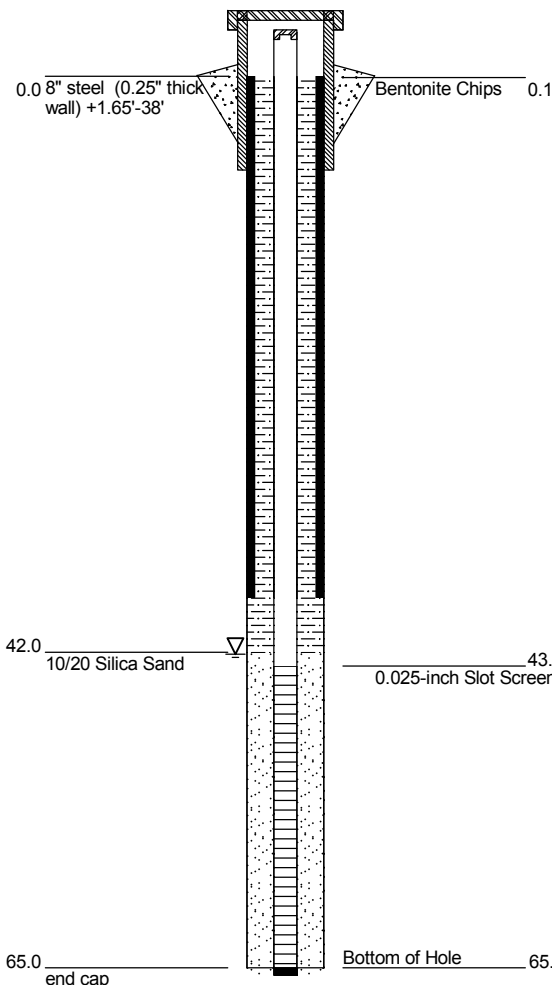
Date Hole Finished: 6/4/14

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: U.S.F.S.
Legal Description: T4S, R46E, S31 NESENE
Location Description: B12 Battery near Coal Creek
Recorded By: JS
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Potable Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Upper Knobloch 2 Coal
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 65

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+1.05'AGL - 65'
Surface Casing Used?	Y	8" steel 0.250" wall	+1.65'AGL - 38'
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	43'-65'
Sand Pack?	Y	10/20 Silica Sand	42'-65'
Annular Seal?	Y	Bentonite Chips	0'-42'
Surface Seal?	Y	Bentonite around steel csg	
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Bailed	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 454420.5		Easting: 2842003	
Static Water Level Below MP: 43.20		Surface Casing Height (ft): 1.65	
Date: 6/10/2014		Riser Height (ft): 1.05	
MP Description: BMP (TOPVC)		Ground Surface Elevation (ft): 3258.413	
MP Height Above or Below Ground (ft): 1.05		MP Elevation (ft): 3259.463	

Remarks: Bailed for 30 minutes, 17 bails, <1/2 gallon per minute; centralizers installed; however not recorded. Water level prior to development 54.3' BTOSC on June 4, 2014 at 1:30 p.m.; water level at 44.30' BTOSC on June 5, 2014 at 8:35 a.m.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 2.0'	Sandy, silty loam
2.0 - 43.0'	Mixture of clay, sand, silt, clinker [Colluvium] Reddish-brown - grayish-red; dry to moist; clinker chips to 1/2"; chips flat; sub-angular; loose materials; soft; very coarse grain; no plasticity, no cohesion; moisture increases with depth - damp, clay begins to agglomerate (bond). Large sandstone blocks below 25', sub-angular to sub-round, no gravels like in B12-U.
30'	first groundwater (driller)
43.0 - 64.0'	Coal [Upper Knobloch (2)] Black, orange mottling stain on frac face; no stain below 46'
64.0 - 65.0'	Shale Bluish-gray - bluish white; fissile; dense - medium dense

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Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B1-C

Date Hole Started: 12/28/10 Date Hole Finished: 12/28/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T3S R45E Sec 27 NENW;
N 492160.74, E 2822873.31
Location Description: 15' North of B1U, just
West of Stevens corrals
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 37.5

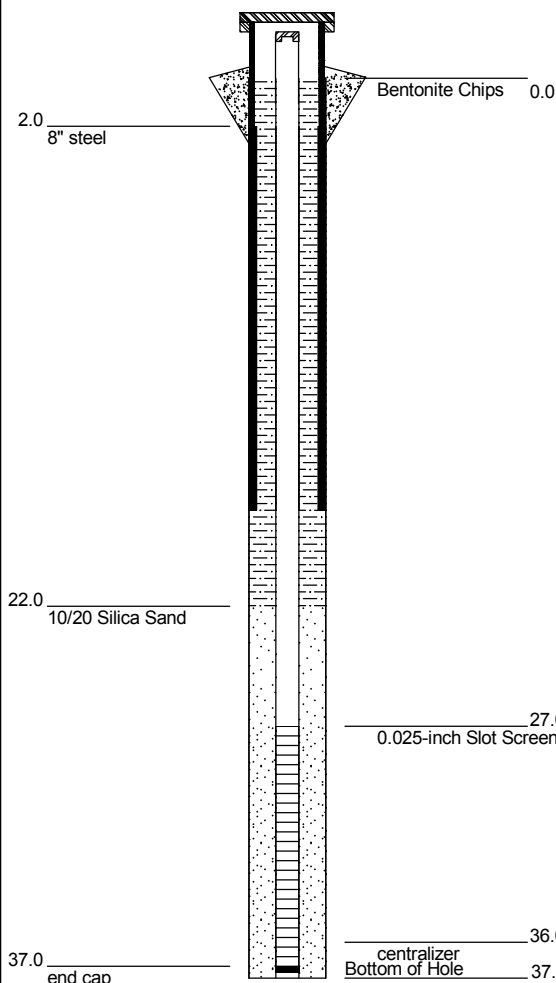
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-37.5
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	27-37
Sand Pack?	Y	10/20 Silica Sand	22-37.5
Annular Seal?	Y	Bentonite Chips	0-22
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Lift for 20 Minutes
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 492160.74	Easting: 2822873.31	
Static Water Level Below MP: Dry	Surface Casing Height (ft): 2.28	
Date:	Riser Height (ft): 1.83	
MP Description:	Ground Surface Elevation (ft): 3077.39	
MP Height Above or Below Ground (ft): 1.83	MP Elevation (ft): 3079.23	

Remarks: Well completed 15:45 pm; bailed for water - dry at 1600 hours 12/28/2010. Dry on 12/29/10

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 6.0' Clayey silt Slightly moist, fine gravels; moderate brown (5YR 4/4), roots, becomes sandy with depth, soft, slightly calcareous
6.0 - 7.0' Sand Slightly moist, medium grained, light olive gray (5Y 5/2)
7.0 - 9.0' Sand and gravel [Alluvium/Colluvium] Clinker gravels, moderate reddish brown (10R 4/6), dry
9.0 - 19.0' Shale-baked [Bedrock:Clinker] Dry, moderate orange pink (10R 7/4) and grayish pink (10R 8/2), hard/brittle
19.0 - 29.0' Shale-baked [Clinker] Dry, light olive gray (5Y 6/1) with black streaks, angular, brittle, moist at 25'
29.0 - 34.0' Clay (Ash) Wet, pale gray pink, clays and some fine sandstone
34.0 - 37.5' Claystone Light olive gray (5Y 6/1), firm, greasy

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B1-U

Date Hole Started: 12/28/10 Date Hole Finished: 12/28/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T3S, R45E, Sec. 27
NENW; N 492152.65, E 2822876.07
Location Description: West of Stevens' corrals

Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Underburden
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 90

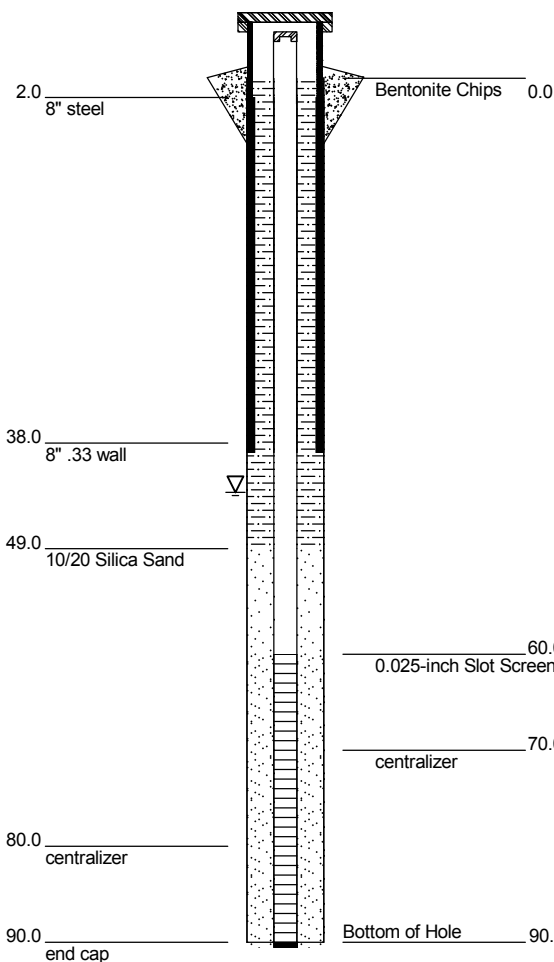
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-90
Surface Casing Used?	Y	8" steel	+2-38
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	60-90
Sand Pack?	Y	10/20 Silica Sand	49-90
Annular Seal?	Y	Bentonite Chips	0-49
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Lift
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 492152.65	Easting: 2822876.07	
Static Water Level Below MP: 45	Surface Casing Height (ft): 2.16	
Date: 12/29/2010	Riser Height (ft): 1.86	
MP Description: Top PVC	Ground Surface Elevation (ft): 3077.45	
MP Height Above or Below Ground (ft): 1.86	MP Elevation (ft): 3079.31	

Remarks: SC=1,050 μ mhos/cm at 89'; SC=1500 μ mhos/cm after development; 8" .33 wall at 38-39'; 8" drag bit.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 6.0' Clayey silt Slightly moist, fine gravels; moderate brown (5YR 4/4), roots, becomes sandy with depth, soft, slightly calcareous
6.0 - 7.0' Sand Medium grain, slightly moist, light olive gray (5Y 5/2)
7.0 - 9.0' Sand and gravel [Alluvium/Colluvium] Clinker gravels, moderate reddish brown (10R 4/6), dry
9.0 - 19.0' Shale-baked [Bedrock:Clinker] Dry, moderate orange pink (10R 7/4) and grayish orange pink (10R 8/2), hard/brittle
19.0 - 29.0' Shale-baked [Clinker] Light olive gray (5Y 6/1) with black streaks, angular, brittle and dry, moist at 25'
29.0 - 34.0' Clay (Ash) Moist, pale pink, soft, pale yellowish orange (10YR 8/6)
34.0 - 35.0' Sandstone, altered [Clinker] Dark reddish brown and dusky brown, moderately hard
35.0 - 36.0' Clay/silt (Ash) Moist, soft, pale pink
36.0 - 40.0' Mudstone [Bedrock] Wet, moist, soft, greenish gray (5G 6/1), black carbonaceous streaks
40.0 - 44.0' Siltstone [Bedrock] Slightly moist, soft, carbonaceous (plant remains visible), pale yellowish brown (10YR 6/2), dry at 43'
44.0 - 45.0' Siltstone Slightly moist, soft, carbonaceous (plant remains visible), stained to dark yellowish orange (10YR 6/6)
45.0 - 46.0' Siltstone Slightly moist, soft, carbonaceous (plant remains visible), back to gray
46.0 - 47.0' Fine sand/silt Moist, soft, light gray
47.0 - 70.0' Fine sand Wet, light olive gray (5Y 5/2), poorly cemented, arenite, black/salt-pepper, (adding 18 gpm drilling from 50-60'), making about 7-10 gpm at 60'
70.0 - 80.0' Fine sand Light olive gray (5Y 5/2) to yellowish olive gray, micaceous, slightly better cemented at 75-80', some medium/coarse fragments
80.0 - 89.0' Fine sand Light olive gray (5Y 5/2) to yellowish olive gray, micaceous, flaggy sandstone fragments (making 50 gpm)
89.0 - 90.0' Claystone Firm, olive gray (5Y 4/1), minor black organic inclusions

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Billings, Montana



Monitor Well Log

Hole Name: B2-K

Date Hole Started: 1/26/2011 Date Hole Finished: 1/26/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: State of Montana
Legal Description: T3S, R44E, Sec. 36; N 483992.32, E 2804348.00
Location Description: B2 Battery
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole:
Target Aquifer: Knobloch
Hole Diameter (in): 8"
Total Depth Drilled (ft): 304

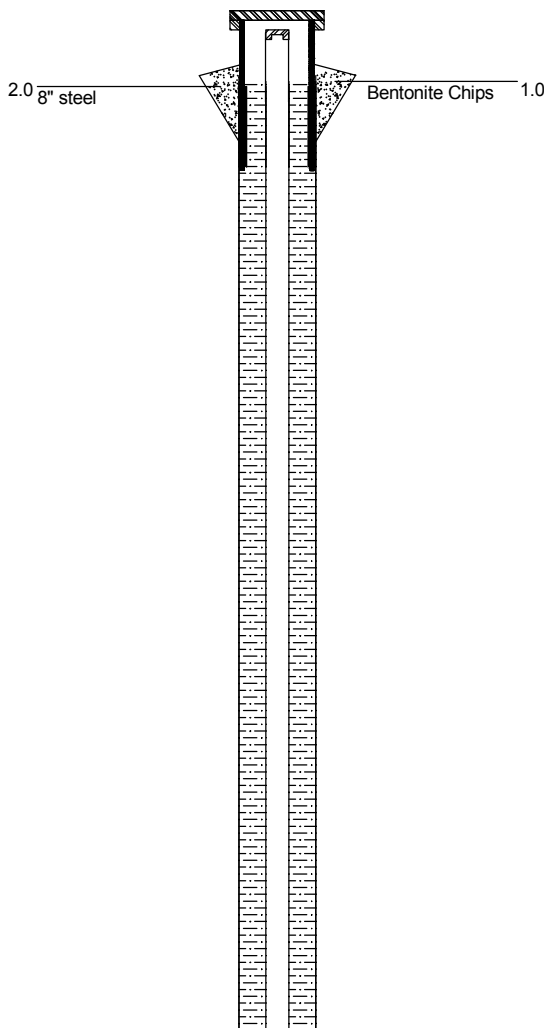
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-304
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	244-304
Sand Pack?	Y	10/20 Silica Sand	228-304
Annular Seal?	Y	Bentonite Chips	+1-228
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air lift
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 483992.32	Easting: 2804348	
Static Water Level Below MP: 234.51	Surface Casing Height (ft): 1.90	
Date: 6/29/2011	Riser Height (ft): 1.56	
MP Description:	Ground Surface Elevation (ft): 3269.35	
MP Height Above or Below Ground (ft): 1.56	MP Elevation (ft): 3270.91	

Remarks: Drill with 7 7/8" bit to 20', ream with 11 3/4". Stopped at 220' to check sandstone, blew with rig air, SC= injection water. Start development with bailer at 3:00p.m. bailed at 7 gal/35s. Removed ~240 gallons

WELL CONSTRUCTION



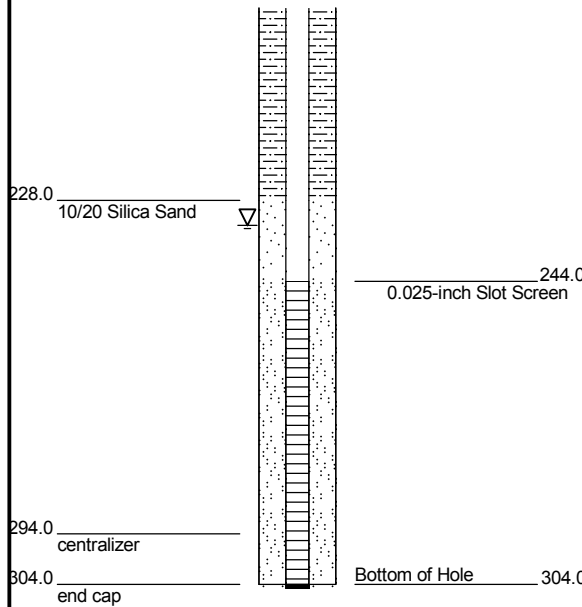
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0'	Silt with shale bedrock fragments [Topsoil] Dry, dark yellowish orange, soft, loose, roots, debris
1.0 - 5.0'	Shale [Fort Union Formation/Bedrock] Dry, light brown (5YR 5/6) to moderate yellowish brown (10YR 5/4), soft to firm
5.0 - 6.5'	Coal shale Dry, brownish gray to dark yellowish brown, soft to firm
6.5 - 10.0'	Coal Dry, dusky yellowish brown (10YR 2/2) to black, stiff, brittle, well fractured/cleated
10.0 - 25.0'	Siltstone, some very fine sandstone Dry, very soft, many colors: pale yellowish brown to light olive gray at 10-12'; light brown (5YR 5/6) at 12-13'; light gray at 13-14'; moderate yellowish brown at 14-14.5'; light gray at 15-25'; carbonaceous shale at 14.5-15'
25.0 - 34.0'	Shale Dry, medium gray to brownish gray, firm to stiff, carbonaceous from 25-30' (dark brown)
34.0 - 41.0'	Siltstone, some very fine sandstone Dry to slightly moist, medium light gray, soft to firm, some very thin dark beds
41.0 - 43.0'	Coal Dry, dusky yellowish brown and moderate brown, impurities, pyrite
43.0 - 54.5'	Shale Dry, medium gray color to moderate olive brown, firm, carbonaceous at 43-44' and at 54', some calcareous at 51-51.5' gray cemented zone, very hard
54.5 - 57.0'	Sandstone Moist, medium gray, soft; not making water
57.0 - 65.0'	Shale Dry, medium gray, firm, carbonaceous stringer at 59'. Medium light gray, very hard cemented zone, calcareous at 63-64'
65.0 - 75.0'	Siltstone, interbedded sandstone Dry to slightly moist, medium light gray, soft
75.0 - 126.5'	Silty fine sandstone Medium light gray, soft, very moist at 81', cemented zone at 85', intercalated shale at 85-93', less shale, sandstone hardness to some firm at 93' Very hard grayish orange shale stringer at 108-109' Silty clayey at 109-117' Very sandy, less
126.5 - 128.5'	Coal Black, cleated, blocky, stiff
128.5 - 160.0'	Shale Medium dark gray, stiff, carbonaceous at 128.5-130', becomes silty at 145', mild color change to medium gray
160.0 - 165.0'	Fine to very fine sandstone Dry, medium light gray to light olive gray (5Y 6/1)
165.0 - 190.0'	Siltstone, some very fine sandstone in top 5' Dry, medium gray, firm, cemented zone at 184'



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

190.0 - 195.0' **Sandstone**

Dry, medium gray, firm

195.0 - 217.0' **Siltstone, some very fine sandstone in top 5'**

Dry, medium gray, firm, very thinly bedded coal stringer at 195.5' (trace), thin cemented light brown shale at 202'

217.0 - 222.0' **Sandstone, fine grain, silty**

Medium gray, soft to firm, blew with rig air, not making water

222.0 - 242.0' **Shale, inter calcated sandstone**

Dry, medium gray, traces very hard light brown shale (non-calcareous), carbonaceous at 222', very thin coal stringer, black, hard. Less to no sand at 236-242'

242.0 - 303.5' **Coal** [Knobloch]

Black, no visible impurities, possibly cleated on multiple planes

303.5 - 304.0' **Sandstone, silty, fine grain** [Bedrock]

Medium light gray, firm to stiff

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B2-O

Date Hole Started: 1/26/2011 Date Hole Finished: 1/26/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: State of Montana
Legal Description: T3S, R44E, Sec. 36; N 483992.43, E 2804337.58
Location Description: B2 Battery overburden
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole:
Target Aquifer: Overburden
Hole Diameter (in): 8"
Total Depth Drilled (ft): 130

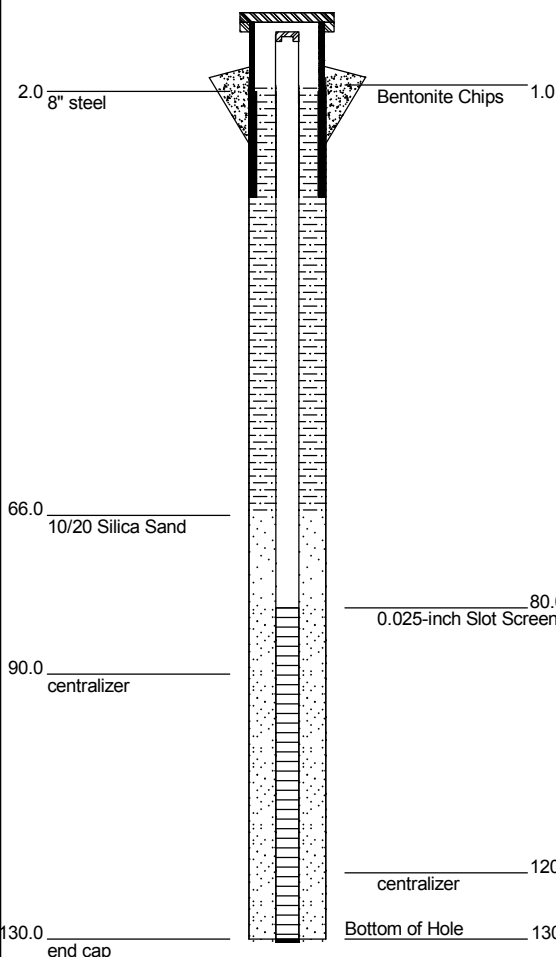
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-130
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	80-130
Sand Pack?	Y	10/20 Silica Sand	66-130
Annular Seal?	Y	Bentonite Chips	+1-66
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air lift
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 483992.43	Easting: 2804337.58	
Static Water Level Below MP: Dry	Surface Casing Height (ft): 2.01	
Date: 7/15/2011	Riser Height (ft): 1.64	
MP Description:	Ground Surface Elevation (ft): 3269.76	
MP Height Above or Below Ground (ft): 1.64	MP Elevation (ft): 3271.4	

Remarks: 7 7/8' bit to 20', ream with 11 3/4" bit.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0'	Silt with shale bedrock fragments [Topsoil] Dry, dark yellowish orange, soft, loose, roots, debris
1.0 - 5.0'	Shale [Fort Union Formation/Bedrock] Dry, light brown (5YR 5/6) to moderate yellowish brown (10YR 5/4), soft to firm
5.0 - 6.5'	Coal shale Dry, brownish gray to dark yellowish brown, soft to firm
6.5 - 10.0'	Coal Dry, dusky yellowish brown (10YR 2/2) to black, stiff, brittle, well fractured/cleated
10.0 - 25.0'	Siltstone, some very fine sandstone Dry, very soft, many colors: pale yellowish brown to light olive gray at 10-12'; light brown (5YR 5/6) at 12-13'; light gray at 13-14'; moderate yellowish brown at 14-14.5'; light gray at 15-25'; carbonaceous shale at 14.5-15'
25.0 - 34.0'	Shale Dry, medium gray to brownish gray, firm to stiff, carbonaceous from 25-30' (dark brown)
34.0 - 41.0'	Siltstone, some very fine sandstone Dry to slightly moist, medium light gray, soft to firm, some very thin dark beds
41.0 - 43.0'	Coal Dry, dusky yellowish brown and moderate brown, impurities, pyrite
43.0 - 54.5'	Shale Dry, medium gray color to moderate olive brown, firm, carbonaceous at 43-44', some calcareous at 54'; light gray cemented zone at 51-51.5', very hard, calcareous, reacts with acid
54.5 - 57.0'	Sandstone Moist, medium gray, soft
57.0 - 65.0'	Shale Dry, medium gray, firm, carbonaceous stringer at 59'. Medium light gray, very hard cemented zone, calcareous at 63-64'
65.0 - 75.0'	Siltstone, interbedded fine sandstone Dry to slightly moist, medium light gray, soft
75.0 - 126.5'	Sandstone at 75' (less silt than above) Medium light gray, thin cemented shale stringer, calcareous at 80', very moist at 81', injecting water, cemented zone at 85', intercalated shale at 85-93', less shale but sandstone hardness to some firm. Very hard grayish orange shale at 108-109' Inte
126.5 - 128.5'	Coal Black, cleated, blocky, stiff
128.5 - 130.0'	Shale Medium dark gray, stiff, carbonaceous at 128.5-130', becomes silty at 145', mild color change to medium gray

Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: B2-U

Date Hole Started: 1/25/11

Date Hole Finished: 1/26/11

Client: Arch Coal

Project: Otter Creek Mine Permit (10068)

County: Powder River State: Montana

Property Owner: State of Montana

Legal Description: T3S, R44E, Sec. 36; N

483993.19, E 2804357.02

Location Description: Near existing PVC well in Section 36

Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Ron Askin

Drilling Method: Air Rotary

Drilling Fluids Used:

Purpose of Hole:

Target Aquifer: Underburden

Hole Diameter (in): 8"

Total Depth Drilled (ft): 420

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-420
Surface Casing Used?	Y	8" steel	+2-19
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	360-420
Sand Pack?	Y	10/20 Silica Sand	355-420
Annular Seal?	Y	Bentonite Chips	0-355
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed? Y Air lift

Water Samples Taken? N

Boring Samples Taken? N

Northing: 483993.19

Easting: 2804357.02

Static Water Level Below MP: 281.66

Surface Casing Height (ft): 2.20

Date: 1/26/2011

Riser Height (ft): 1.51

MP Description: Top PVC

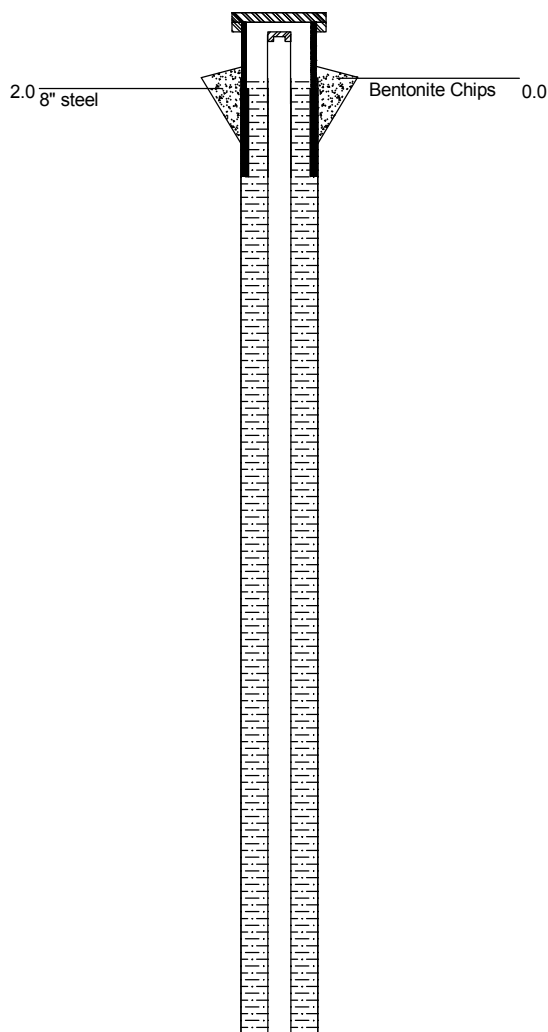
Ground Surface Elevation (ft): 3269.55

MP Height Above or Below Ground (ft): 1.51

MP Elevation (ft): 3271.06

Remarks: PVC well SWL=235.91 BPVC (existing State well); At start of development SC=4700-4990 μ mhos/cm, pH=7.77, temp=14.2°C. Final SC=3110 μ mhos/cm, pH=8.18, temp=14.6°C. Developed with bailer, start 10:00a.m. 7 gal/50s, end 10:53a.m. 5 gpm.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

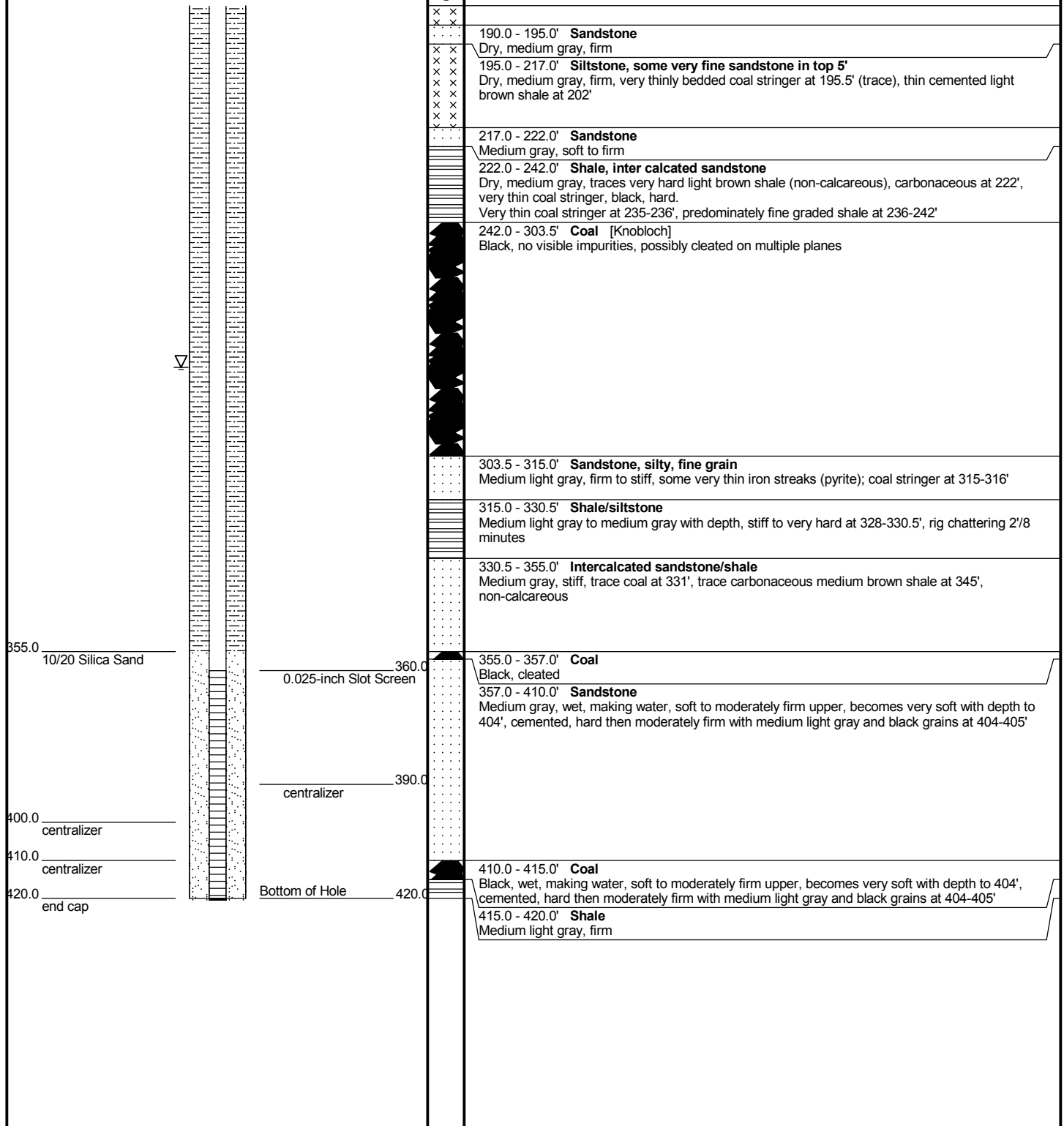
0.0 - 1.0'	Silt with shale bedrock fragments [Topsoil] Dry, dark yellowish orange, soft, loose, roots, debris
1.0 - 5.0'	Shale [Fort Union Formation/Bedrock] Dry, light brown (5YR 5/6) to moderate yellowish brown (10YR 5/4), soft to firm
5.0 - 6.5'	Coal shale Dry, brownish gray to dark yellowish brown, soft to firm
6.5 - 10.0'	Coal Dry, dusky yellowish brown (10YR 2/2) to black, stiff, brittle, well fractured/cleated
10.0 - 25.0'	Siltstone, some very fine sandstone Dry, very soft, many colors: pale yellowish brown to light olive gray at 10-12'; light brown (5YR 5/6) at 12-13'; light gray at 13-14'; moderate yellowish brown at 14-14.5'; light gray at 15-25'; carbonaceous shale at 14.5-15'
25.0 - 34.0'	Shale Dry, medium gray to brownish gray, firm to stiff, carbonaceous from 25-30' (dark brown)
34.0 - 41.0'	Siltstone, some very fine sandstone Dry to slightly moist, medium light gray, soft to firm, some very thin dark beds
41.0 - 43.0'	Coal Dry, dusky yellowish brown and moderate brown, impurities, pyrite
43.0 - 54.5'	Shale Dry, medium gray color to moderate olive brown, firm, carbonaceous at 43-44', some calcareous at 54'; light gray cemented zone at 51-51.5', very hard, calcareous, reacts with acid
54.5 - 57.0'	Sandstone Moist, medium gray, soft
57.0 - 65.0'	Shale Dry, medium gray, firm, carbonaceous stringer at 59'. Medium light gray, very hard cemented zone, calcareous at 63-64'
65.0 - 75.0'	Siltstone, interbedded fine sandstone Dry to slightly moist, medium light gray, soft
75.0 - 126.5'	Sandstone at 75' (less silt than above) Medium light gray, thin cemented shale stringer, calcareous at 80', very moist at 81', injecting water, cemented zone at 85', intercalated shale at 85-93', less shale but sandstone hardness to some firm. Very hard grayish orange shale at 108-109'
126.5 - 128.5'	Coal Black, cleated, blocky, stiff
128.5 - 160.0'	Shale Medium dark gray, stiff, carbonaceous at 128.5-130', becomes silty at 145', mild color change to medium gray
160.0 - 165.0'	Fine to very fine sandstone Dry, medium light gray to light olive gray (5Y 6/1)
165.0 - 190.0'	Siltstone, some very fine sandstone in top 5' Dry, medium gray, firm, cemented zone at 184'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B3-K

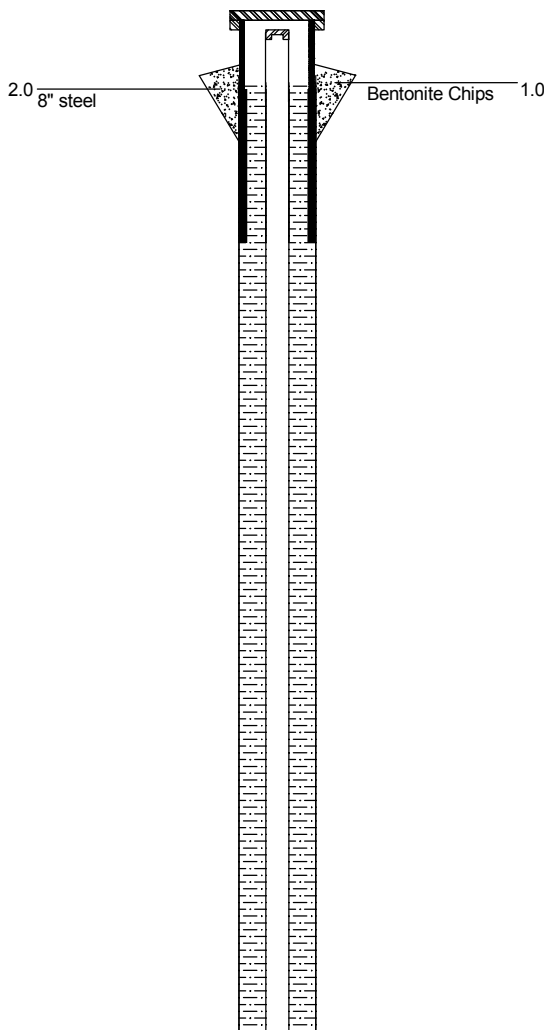
Date Hole Started: 6/30/11 Date Hole Finished: 6/30/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T3S, R45E, Sec. 34; N 484882.23, E 2821620.67
Location Description: B3 battery on Ark Land property
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 10" (0-27"), 8" (27-40")
Total Depth Drilled (ft): 210

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-210
Surface Casing Used?	Y	8" steel	+2-26
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	166-210
Sand Pack?	Y	10/20 silica sand	163-210
Annular Seal?	Y	Bentonite Chips	4-163
Surface Seal?	N		
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Rig Air	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 484882.23		Easting: 2821620.67	
Static Water Level Below MP: 194.36		Surface Casing Height (ft): 1.71	
Date: 6/30/2011		Riser Height (ft): 1.54	
MP Description: Top PVC		Ground Surface Elevation (ft): 3221.52	
MP Height Above or Below Ground (ft): 1.54		MP Elevation (ft): 3223.06	

Remarks: Set 28' of 8" steel; yield <1 gpm; SC=6320 µmhos/cm, pH=7.37, temp=17.5° C

WELL CONSTRUCTION



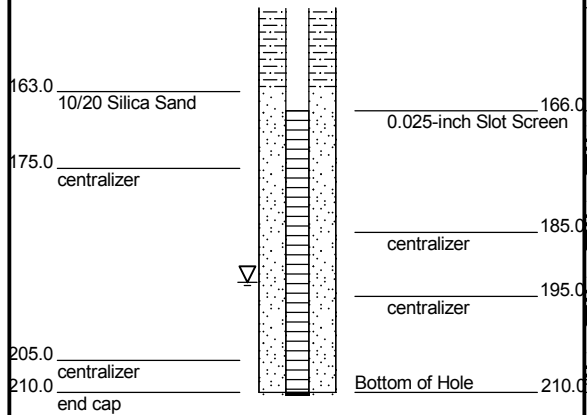
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0'	Silty clay [Topsoil/Colluvium] Dry crust then slightly moist to moist, moderate yellowish brown to light brown, moderately loose, some plasticity, roots
1.0 - 6.0'	Claystone [Weathered Bedrock] Slightly moist, moderate yellowish brown and light brown, moderately dense to soft, trace of gypsum crystals
6.0 - 12.0'	Carbonaceous shale [Bedrock] Slightly moist to dry, brownish gray and some olive gray, moderately firm; brownish black at 8'-9' and 10'-11'
12.0 - 22.0'	Shale with thinly interbedded siltstone [Bedrock] Slightly moist, multicolored: pale yellowish brown, dark yellowish orange; moderately firm, trace of iron streaks; calcareous and non-calcareous
22.0 - 30.0'	Shale Slightly moist, medium gray to brownish gray, possibly mildly carbonaceous, moderately firm, non-plastic
30.0 - 61.0'	Siltstone Slightly moist to dry, pale yellowish brown and moderate yellowish brown; soft - loose to moderately firm, calcareous; very hard cemented zone at 32'-34', interbedded fine sand at 40'-43'; interbedded fine sand 45'-51', cemented zone light brown siltstone at 51'-52' and 58'-59'; interbedded fine sand at 55'-60'
61.0 - 67.0'	Sandstone Dry, pale yellowish brown, soft, very fine to fine grain
67.0 - 70.0'	Siltstone Dry, grayish orange to dark yellowish orange, soft to moderately firm, calcareous
70.0 - 78.0'	Carbonaceous shale Dry, brownish gray (5YR 4/1) and grayish brown (5YR 3/2), moderately firm, most only mildly carbonaceous, very carbonaceous/coal at 76'-77'
78.0 - 89.0'	Shale/siltstone Dry, light olive gray to yellowish brown with depth, moderately dense to very soft with depth; color change to yellowish gray at 87'
89.0 - 120.0'	Sandstone, very fine [Clinker] Dry, yellowish gray (5Y 8/1), cuttings ground, soft; thin light brown siltstone stringer at 98'; color change to grayish orange pink (5YR 7/2) and light brown (5YR 6/4) at 117' [Thermally Altered Bedrock]
120.0 - 166.0'	Siltstone, some very fine sandstone [Clinker] Dry, very pale orange and pale yellowish brown, soft, to very soft in some intervals, calcareous, poor circulation; color change to dark yellowish orange at 130.5', pale yellowish orange at 141'; very hard cemented zone at 142'-146', cemented zone calcareous, yellowish gray and very pale orange; moderately firm from 146'-166'; color change to brownish gray (5YR 6/1) at 160'; color change to light olive gray at 163' [Thermally Altered Bedrock]



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

166.0 - 208.0' **Coal** [Knobloch]
Dry, black to greenish/grayish black, soft and weak, becomes more blocky, cleated, harder at 198'; moist at 195', injecting water

208.0 - 210.0' **Siltstone/ claystone** [Bedrock]
Light olive gray to light gray, moderately firm to soft

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B3-PH1

Date Hole Started: 3/24/2011 Date Hole Finished: 3/24/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: N 45.53069 E 106.17119
(handheld GPS coordinates)
Location Description: B3 battery on Ark Land
property
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: NA
Hole Diameter (in): 8"
Total Depth Drilled (ft): 100

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	N		NA
Surface Casing Used?	N		NA
Screen/Perforations?	N		NA
Sand Pack?	N		NA
Annular Seal?	N		NA
Surface Seal?	Y	Bentonite Chips	0-100

DEVELOPMENT/SAMPLING

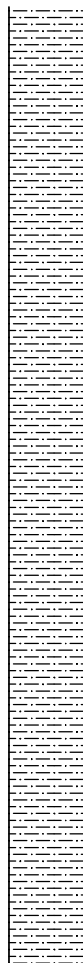
Well Developed? N
Water Samples Taken? N
Boring Samples Taken? N

Northing: 45.53069 Easting: -106.17119
Static Water Level Below MP: Surface Casing Height (ft): NA
Date: Riser Height (ft): NA
MP Description: Ground Surface Elevation (ft):
MP Height Above or Below Ground (ft): MP Elevation (ft):

Remarks: Drill to 100', hole collapsing due to burned sediments, plugged hole 3/8" bentonite chips (68 bags); move locations.

WELL CONSTRUCTION

0.0 Bentonite Chips



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 2.0' **Clay** [Topsoil]
Dry at surface to very moist, moderate yellowish brown, clay cracked at surface, trace coarse sand/gravel clinkers, roots, moderately plastic, rolls to 1/8"

2.0 - 5.0' **Shale** [Bedrock]
Dry, grayish brown and dusky brown from 2'-3', moderately cohesive 3'-5', firm, brownish gray to medium light gray at 3'-5', non-carbonaceous, trace white salt precipitates, non-calcareous

5.0 - 10.0' **Siltstone**
Slightly moist, light brown

10.0 - 17.0' **Silty shale**
Dry, light brown and pale reddish brown at 10'-11', colors change from light olive gray to dusky red at 11'-15', soft to firm, mildly burned or oxidized from nearby burn; stringer very carbonaceous (peat/coal) at 15'; color change to light olive gray at 16'

17.0 - 43.0' **Siltstone**
Dry, grayish orange red, soft to moderately firm

Color change to moderate red at 22', then grades back to grayish orange red
Color change to moderate red at 27', then grades back to grayish orange red
Same color change sequence from 32'-35'
Fine sand interbedded at 35'-38'

43.0 - 45.0' **Sandstone**
Slightly moist, grayish orange pink, soft to very soft

45.0 - 51.0' **Siltstone, some interbedded fine sand**
Dry, soft to firm, colors very pale orange to dusky red (5R 3/4), soft to stiff

51.0 - 54.0' **Sandstone, fine**
Slightly moist, grayish orange pink to light brown (5YR 5/6)

54.0 - 63.0' **Siltstone**
Dry, colors from very pale orange to moderate red, soft to firm

63.0 - 65.0' **Sandstone**
Dry, light brownish gray, soft

65.0 - 78.0' **Siltstone/shale**
Dry, grayish orange pink to moderate reddish brown, oxidized but not bisque

78.0 - 100.0' **Sandstone**
Dry, grayish orange pink/pinkish gray to light brownish gray, some cuttings ground by bit; oxidized, soft to very hard, hole collapsing

Bottom of Hole 100.0

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B3-U

Date Hole Started: 6/30/11 Date Hole Finished: 7/1/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T3S, R45E, Sec. 34; N 484871.99, E 2821619.97
Location Description: B3 battery on Ark Land property
Recorded By: RJL & HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 8"
Total Depth Drilled (ft): 325

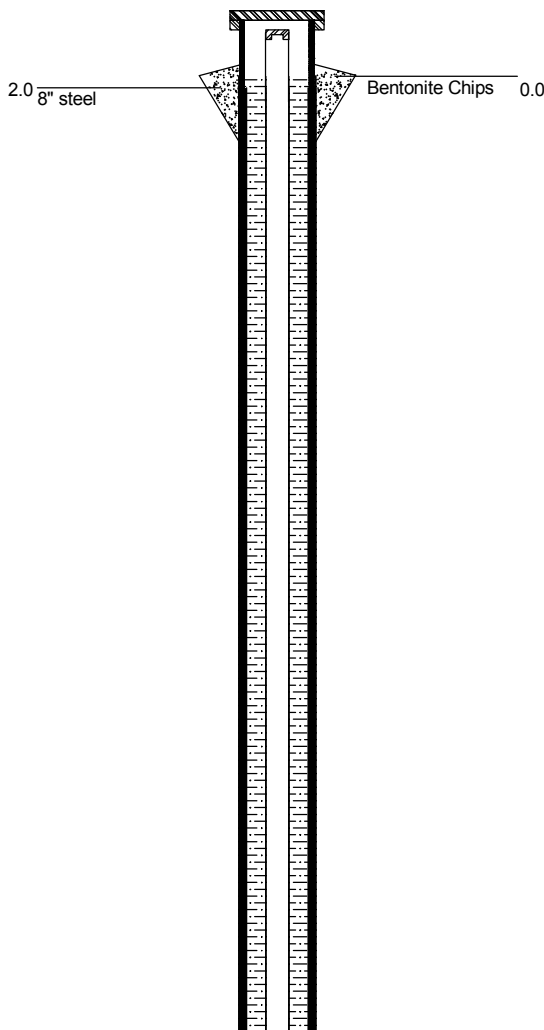
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-325
Surface Casing Used?	Y	8" steel	+2-192
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	304-324
Sand Pack?	Y	10/20 silica sand	297-325
Annular Seal?	Y	Bentonite Chips	0-297
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air Lift
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 484871.99	Easting: 2821619.97	
Static Water Level Below MP: 196.25	Surface Casing Height (ft): 1.42	
Date: 7/6/2011	Riser Height (ft): 1.01	
MP Description:	Ground Surface Elevation (ft): 3221.32	
MP Height Above or Below Ground (ft): 1.01	MP Elevation (ft): 3222.33	

Remarks: Drill to 160' with 7 7/8" drag bit, ream out with 10" bit. Poor circulation, set 160' of 8" steel. Drilling with water at 200' and below. Developed with air lifting - estimate 5 gpm. Initial SC=2100 µmhos/cm, final SC=1830 µmhos/cm.

WELL CONSTRUCTION



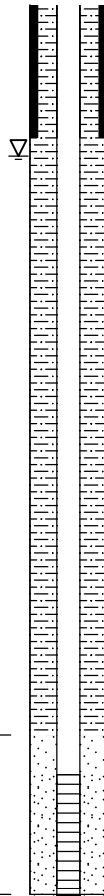
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0'	Silty clay [Topsoil/Colluvium] Dry crust then slightly moist to moist, moderate yellowish brown to light brown, moderately loose, some plasticity, roots
1.0 - 6.0'	Claystone [Weathered Bedrock] Slightly moist, moderate yellowish brown and light brown, moderately dense to soft, trace of gypsum crystals
6.0 - 12.0'	Carbonaceous shale [Bedrock] Slightly moist to dry, brownish gray and some olive gray, moderately firm; brownish black at 8'-9' and 10'-11'
12.0 - 22.0'	Shale with thinly interbedded siltstone [Bedrock] Slightly moist, multicolored: pale yellowish brown, dark yellowish orange; moderately firm, trace of iron streaks; calcareous and non-calcareous
22.0 - 30.0'	Shale Slightly moist, medium gray to brownish gray, possibly mildly carbonaceous, moderately firm, non-plastic
30.0 - 61.0'	Siltstone Slightly moist to dry, pale yellowish brown and moderate yellowish brown; soft - loose to moderately firm, calcareous; very hard cemented zone at 32'-34', interbedded fine sand at 40'-43'; interbedded fine sand 45'-51', cemented zone light brown siltstone at 51'-52' and 58'-59'; interbedded fine sand at 55'-60'
61.0 - 67.0'	Sandstone Dry, pale yellowish brown, soft, very fine to fine grain
67.0 - 70.0'	Siltstone Dry, grayish orange to dark yellowish orange, soft to moderately firm, calcareous
70.0 - 78.0'	Carbonaceous shale Dry, brownish gray (5YR 4/1) and grayish brown (5YR 3/2), moderately firm, most only mildly carbonaceous, very carbonaceous/coal at 76'-77'
78.0 - 89.0'	Shale/siltstone Dry, light olive gray to yellowish brown with depth, moderately dense to very soft with depth; color change to yellowish gray at 87'
89.0 - 120.0'	Sandstone, very fine [Clinker] Dry, yellowish gray (5Y 8/1), cuttings ground, soft; thin light brown siltstone stringer at 98'; color change to grayish orange pink (5YR 7/2) and light brown (5YR 6/4) at 117' [Thermally Altered Bedrock]
120.0 - 160.0'	Siltstone, some very fine sandstone [Clinker] Dry, very pale orange and pale yellowish brown, soft, to very soft in some intervals, calcareous, poor circulation; color change to dark yellowish orange at 130.5', pale yellowish orange at 141'; very hard cemented zone at 142'-146', cemented zone calcareous, yellowish gray and very pale orange; moderately firm from 146'-160'; color change to brownish gray (5YR 6/1) at 160' [Thermally Altered Bedrock]
160.0 - 169.0'	Siltstone/claystone [Clinker] Dry, gray and pale orange (varying shades), weak



WELL CONSTRUCTION

297.0
10/20 Silica Sand304.0
0.025-inch Slot Screen315.0
centralizer325.0
end cap
Bottom of Hole

GRAPHICS

GEOLOGICAL DESCRIPTION

169.0 - 170.0'	Baked claystone [Clinker] Dry, very weak, light brown/orange
170.0 - 185.0'	Coal Dry, brownish black, very weak
185.0 - 192.0'	Coal Dry, becoming slightly cleated
192.0 - 195.0'	Coal Slightly moist, moderately hard to weak
195.0 - 200.0'	Coal Moist, cleated, few glossy surfaces, moderately hard to weak
200.0 - 208.0'	Coal Moist, cleated, black, wet at 203', start adding water to hole
208.0 - 220.0'	Siltstone Gray, weak, laminated
220.0 - 238.0'	Silty sandstone Gray, weak, with fine sand
238.0 - 239.0'	Claystone Gray, weak
239.0 - 242.0'	Coal, finely interbedded with claystone Gray and black, laminated
242.0 - 246.0'	Claystone Gray, moderately hard
246.0 - 249.0'	Shale Gray, hard
249.0 - 261.0'	Claystone Gray, moderately hard, thinly laminated with black organics
261.0 - 261.5'	Coal stringer Black, cleated
261.5 - 264.0'	Claystone Gray
264.0 - 267.0'	Sandstone Tan, hard, very fine grained
267.0 - 270.0'	Sandstone Gray/tan, moderately hard, fine grained
270.0 - 276.0'	Claystone Gray, firm, slightly sandy (very fine)
276.0 - 278.0'	Shale Medium gray, very hard, difficult drilling
278.0 - 283.0'	Siltstone Medium gray, very firm
283.0 - 293.0'	Claystone Medium gray, greasy, thinly laminated
293.0 - 296.0'	Sandstone, very fine Light gray, hard
296.0 - 297.0'	Coal Black, cleated
297.0 - 315.0'	Sandstone Gray/brown, firm, fine to medium grained; black carbonaceous shale stringer at 314', reddish brown, weak
315.0 - 324.0'	Coal Black, cleated, making water, estimated at 5 gpm
324.0 - 325.0'	Claystone Blue/gray, firm, finely laminated

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B4-K

Date Hole Started: 7/26/11 Date Hole Finished: 7/27/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T3S, R45E, Sec. 26,
SW 1/4, SE 1/4; N 488338.13, E 2828613.28
Location Description: 15 feet East of B4-U
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron and Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 8"
Total Depth Drilled (ft): 246

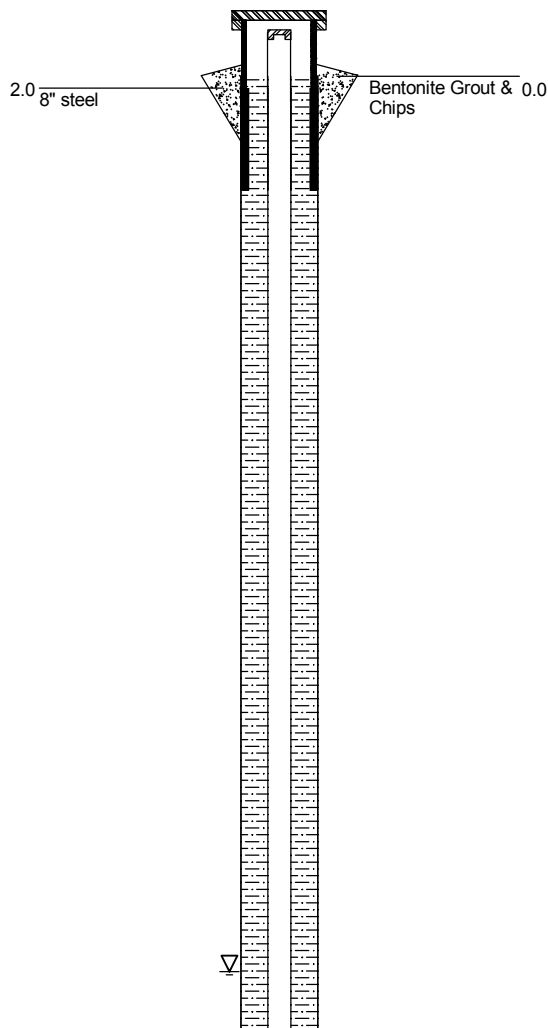
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-246
Surface Casing Used?	Y	8" steel	+2-19
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	181-246
Sand Pack?	Y	10/20 silica sand	175-246
Annular Seal?	Y	Bentonite Grout and Bentonite Chips	0-175
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Lift
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 488338.13	Easting: 2828613.28	
Static Water Level Below MP: 150.51	Surface Casing Height (ft): 1.67	
Date: 8/24/2011	Riser Height (ft): 1.30	
MP Description: Top of PVC	Ground Surface Elevation (ft): 3241.41	
MP Height Above or Below Ground (ft): 1.30	MP Elevation (ft): 3242.71	

Remarks: Lithology based on well B4-U. Start air lift at 11:30 a.m.; 11:50 a.m. SC=3430 μ mhos/cm. Recalibrated SC meter; 12:15 p.m. SC= 4860 μ mhos/cm. While drilling B4-K Askin stopped at 140' on July 26, 2011 at 5:00 p.m.; water came up to 120' by 9:00 a.m. July 27, 2011.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

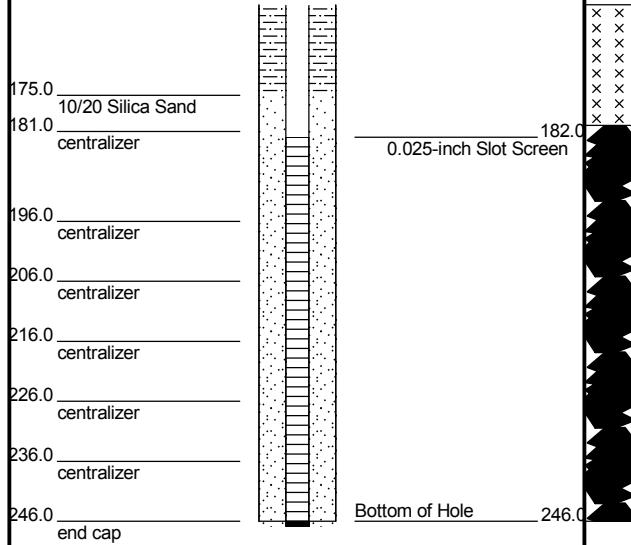
0.0 - 2.0'	Silt [Weathered Bedrock/Colluvium] Some clay, dry, pale yellowish brown, loose
2.0 - 8.0'	Sandstone [Bedrock] Very fine, slightly moist, pale yellow brown to light olive gray; soft
8.0 - 11.0'	Siltstone Dry, dark yellowish orange
11.0 - 12.0'	Shale Slightly moist, dark yellowish brown, moderately firm, low plasticity, mildly carbonaceous
12.0 - 14.0'	Shale Dry, light olive gray to moderately gray, moderately carbonaceous, moderately firm
14.0 - 27.0'	Siltstone Dry, light olive gray, gypsum crystals from 16'-19'; color to dark yellowish orange at 17'. Mild carbonaceous shale stringer at 19'-20'; medium dark gray. Color change to medium dark gray at 22', and dark yellowish orange at 27'
27.0 - 28.0'	Carbonaceous shale Dry, medium gray and dark greenish gray
28.0 - 36.0'	Siltstone Dry, light gray, center very hard, then dark greenish gray and medium gray at 29'. Hardness is dense to medium firm
36.0 - 39.0'	Carbonaceous shale Junk coal, dry, brownish gray and medium dark gray; moderately stiff
39.0 - 105.0'	Siltstone Light gray, dry, firm to stiff, medium/very hard cemented at 45'-47' and 51'-52'. Minor trace very fine sandstone at 50'-53'. Color change to grayish brown at 63'-67'. Color change back to light gray at 67'. Trace interbedded very fine sand and hardness to soft; cemented stringer 0.5' thick at 73'. Color change to light olive gray at 75'
105.0 - 132.0'	Sandstone Slightly moist to moist; medium light gray to medium gray, stiff, cuttings ground, grain size from very fine to fine with depth. Siltstone, dry, medium gray and grayish blue; interbedded from 116'-120'. Siltstone interbedded at 125'. Moist to very moist at 130', injected water, possibly making water. Very thin coal stringer at 132'
132.0 - 145.0'	Shale/siltstone Medium gray, firm to very hard cemented zone at 133'-137'; very hard shale. Color change to medium light gray at 140'
145.0 - 151.0'	Sandstone Medium light gray, medium firm to soft; blew with rig air; open hole possibly making little water
151.0 - 180.0'	Siltstone and shale Medium gray to medium light gray; moderately firm to stiff; thin cemented zone at 165'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



180.0 - 246.0' **Coal** [Knobloch]
Black, hard, dense, cleated 3x

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B4-U

Date Hole Started: 7/25/11 Date Hole Finished: 7/26/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T3S, R45E, Sec. 26
1/4SW, 1/4SE; N 488335.49, E 2828597.54
Location Description: At fence near border with
Section 35
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron and Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Underburden
Hole Diameter (in): 8"
Total Depth Drilled (ft): 341

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" SDR-17 Certa-lok-ID well casing	+2-341
Surface Casing Used?	Y	8" steel	+2-20
Screen/Perforations?	Y	4.5" SDR-17 0.025-inch slot	301-341
Sand Pack?	Y	10/20 silica sand	295-341
Annular Seal?	Y	Bentonite Chips	285-295
Surface Seal?	Y	Bentonite Grout (20% solids)	+1-285

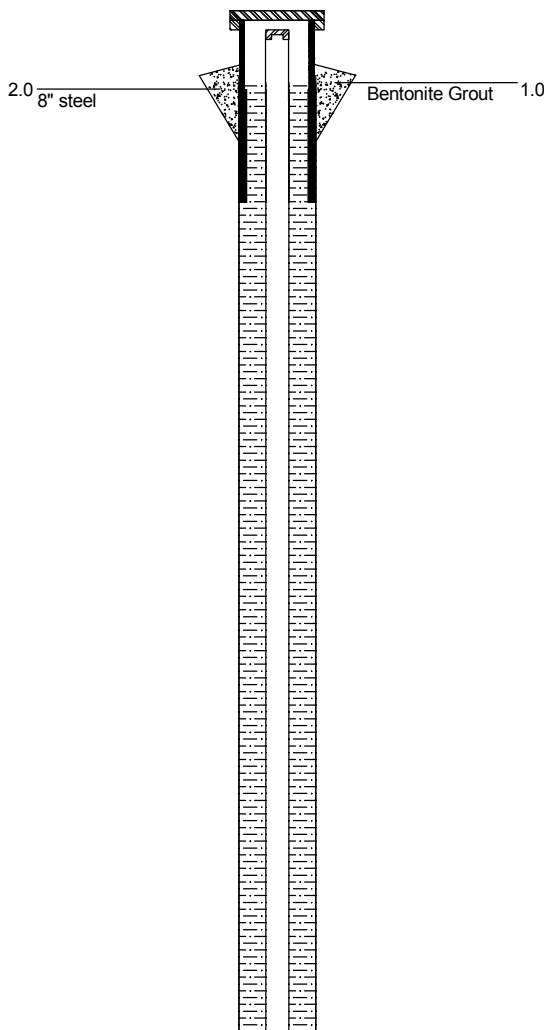
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Bailer
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 488335.49	Easting: 2828597.54
Static Water Level Below MP: 187	Surface Casing Height (ft): 2.09
Date: 7/26/2011	Riser Height (ft): 1.55
MP Description: Top PVC	Ground Surface Elevation (ft): 3241.51
MP Height Above or Below Ground (ft): 1.55	MP Elevation (ft): 3243.06

Remarks: Sealed annular space with 15 bags of 3/8" bentonite chips from 285'-295' bgs prior to developing with rig bailer. Bailed with rig bailer, seal leaking, finished grouting with Hi-solids bentonite grout to seal. Bailed with rig bailer after sealed; yields approx. 1-1.5 gpm. After development water quality: SC=4000 µmhos/cm, pH=8.16, temp= 16.3° C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

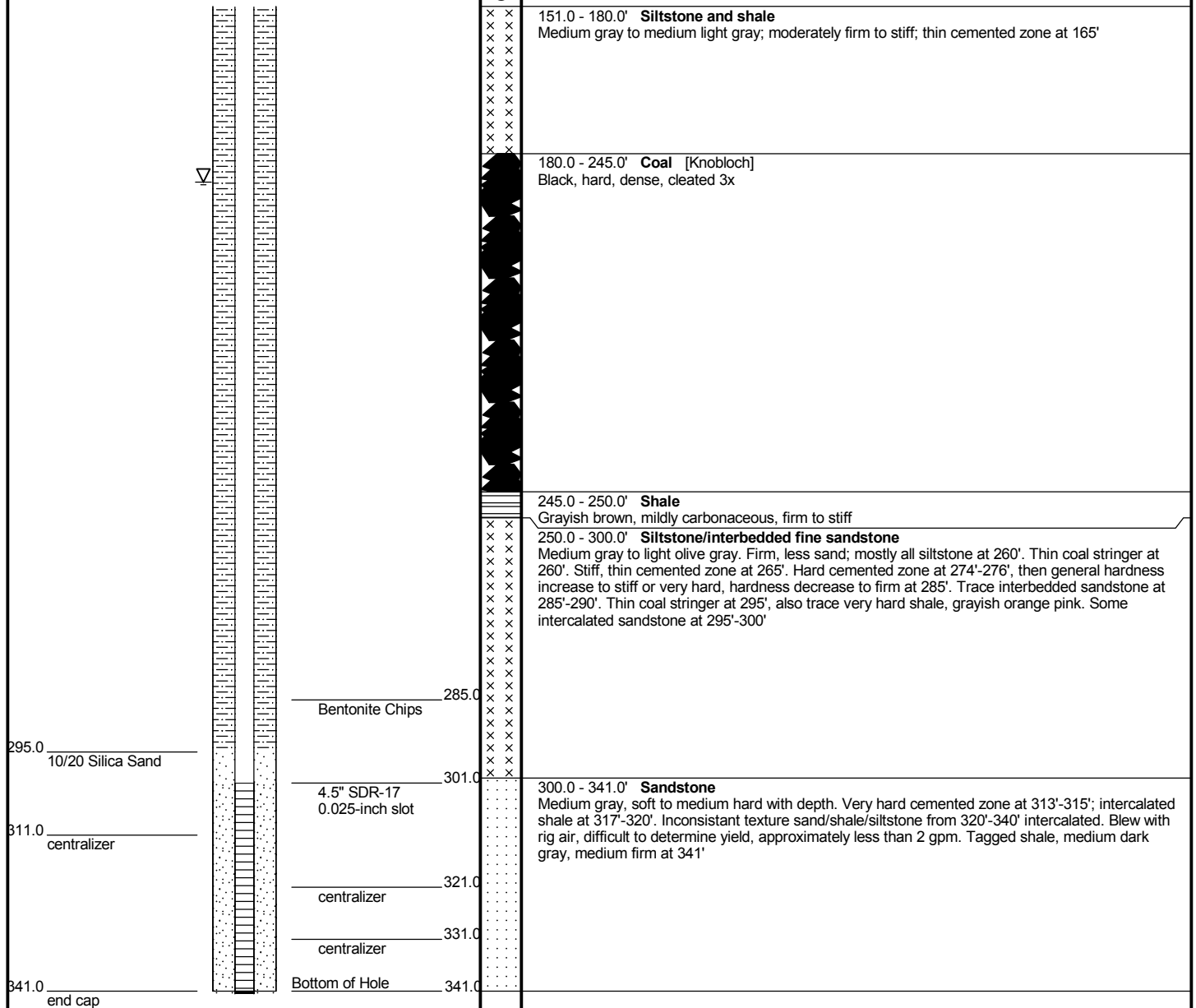
0.0 - 2.0'	Silt [Weathered Bedrock/Colluvium] Some clay, dry, pale yellowish brown, loose
2.0 - 8.0'	Sandstone [Bedrock] Very fine, slightly moist, pale yellow brown to light olive gray; soft
8.0 - 11.0'	Siltstone Dry, dark yellowish orange
11.0 - 12.0'	Shale Slightly moist, dark yellowish brown, moderately firm, low plasticity, mildly carbonaceous
12.0 - 14.0'	Shale Dry, light olive gray to moderately gray, moderately carbonaceous, moderately firm
14.0 - 27.0'	Siltstone Dry, light olive gray, gypsum crystals from 16'-19'; color to dark yellowish orange at 17'. Mild carbonaceous shale stringer at 19'-20'; medium dark gray. Color change to medium dark gray at 22', and dark yellowish orange at 27'
27.0 - 28.0'	Carbonaceous shale Dry, medium gray and dark greenish gray
28.0 - 36.0'	Siltstone Dry, light gray, center very hard, then dark greenish gray and medium gray at 29'. Hardness is dense to medium firm
36.0 - 39.0'	Carbonaceous shale Junk coal, dry, brownish gray and medium dark gray; moderately stiff
39.0 - 105.0'	Siltstone Light gray, dry, firm to stiff, medium/very hard cemented at 45'-47' and 51'-52'. Minor trace very fine sandstone at 50'-53'. Color change to grayish brown at 63'-67'. Color change back to light gray at 67'. Trace interbedded very fine sand and hardness to soft; cemented stringer 0.5' thick at 73'. Color change to light olive gray at 75'
105.0 - 132.0'	Sandstone Slightly moist to moist; medium light gray to medium gray, stiff, cuttings ground, grain size from very fine to fine with depth. Siltstone, dry, medium gray and grayish blue; interbedded from 116'-120'. Siltstone interbedded at 125'. Moist to very moist at 130', injected water, possibly making water. Very thin coal stringer at 132'
132.0 - 145.0'	Shale/siltstone Medium gray, firm to very hard cemented zone at 133'-137'; very hard shale. Color change to medium light gray at 140'
145.0 - 151.0'	Sandstone Medium light gray, medium firm to soft; blew with rig air; open hole possibly making little water



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B5-K

Date Hole Started: 3/25/2011 Date Hole Finished: 3/25/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 11; N 474964.49, E 2826831.71
Location Description: B5 battery near weather station
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 11" (0-20'), 8" (20-260')
Total Depth Drilled (ft): 260

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-260
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	185-260
Sand Pack?	Y	10/20 silica sand	173.5-260
Annular Seal?	Y	Bentonite Chips	+1-173.5
Surface Seal?	N		

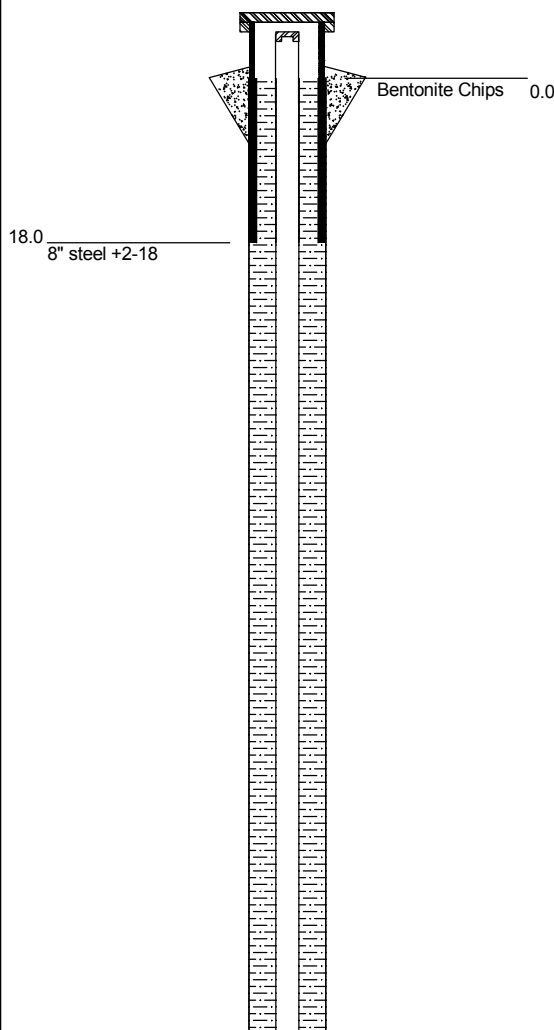
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air & bailer
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 474964.49	Easting: 2826831.71
Static Water Level Below MP: 181.77	Surface Casing Height (ft): 1.99
Date: 3/25/2011	Riser Height (ft): 1.66
MP Description: Top PVC	Ground Surface Elevation (ft): 3223.85
MP Height Above or Below Ground (ft): 1.66	MP Elevation (ft): 3225.51

Remarks: Developed with rig air and bailer; bailed at 13 gpm for 20 minutes, rig air for 25 minutes during completion. SC=1670 μ mhos/cm, pH=8.46, temp=12.1° C; water color = medium dark brown, turbid after development.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

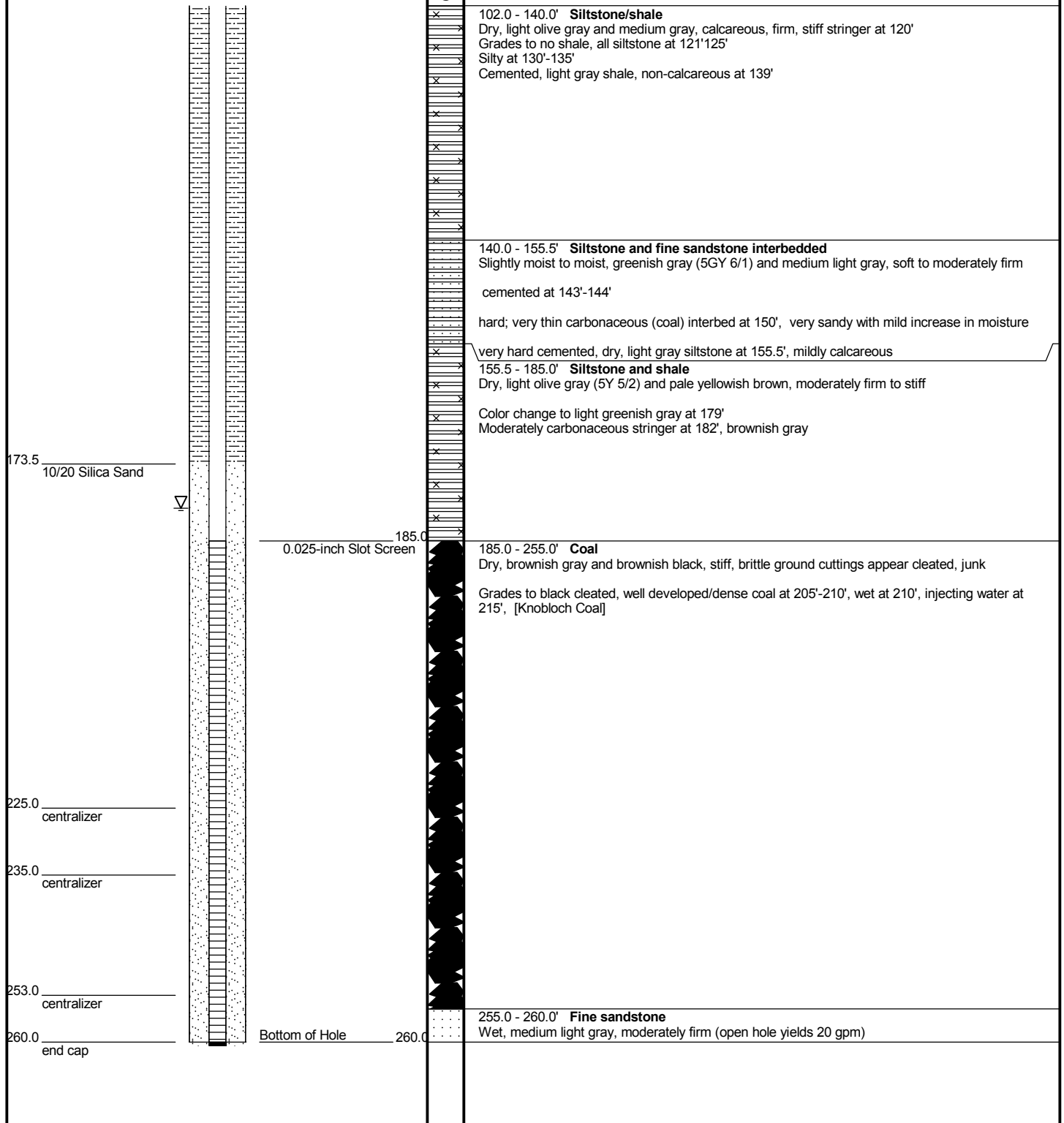
0.0 - 3.0' Silty clay/grades to siltstone [Colluvium/Weathered Bedrock] Moist, soft, weathered, roots to 3', calcareous, trace grayish white precipitates; trace clinker gravel from 0'-1'
3.0 - 6.0' Sandstone, fine [Bedrock] Slightly moist, light olive gray to medium light gray, soft
6.0 - 7.0' Siltstone Dry, pale yellowish brown to light olive gray, moderately firm to stiff, calcareous
7.0 - 9.0' Coal Dry, brownish gray and black with medium gray shale, firm to stiff, junk
9.0 - 10.0' Carbonaceous shale Dry, moderate brown and grayish red, moderately firm, moderately carbonaceous, trace micaceous material
10.0 - 13.0' Coal Dry, brownish gray black, firm to stiff, junk
13.0 - 34.0' Siltstone Dry to slight moist, light olive gray and very pale orange (10YR 8/2), soft to very soft, most cuttings gravel to rock flow Color change to medium gray at 20', calcareous Moist at 22', interbedded very fine sandstone starting at 22' Color change to olive grown at 24'
34.0 - 35.0' Coal Dry, brownish black, stiff to hard
35.0 - 42.0' Carbonaceous shale to non carbonaceous shale at 36' Dry, olive gray (5Y 4/1) moderately firm; medium dark gray to medium light gray and greenish gray with change from carbonaceous shale to non-carbonaceous shale
42.0 - 44.0' Siltstone Dry, medium light gray, soft
44.0 - 45.0' Coal Dry, brownish black (5YR 2/1), stiff, ground cuttings, multiple cleats?, junk
45.0 - 76.0' Shale Dry, colors medium light gray, olive gray, moderately firm to stiff with hard cemented zones as follows: Cemented zone, light gray shale at 48'; Moderately carbonaceous at 51'-52'; Cemented zone, light gray shale at 53'; Cemented zone, light gray shale at 67'; Cemented zone, light gray shale at 69'; Moderately carbonaceous at 72'-74'
76.0 - 80.0' Siltstone and interbedded fine sandstone Dry, medium to medium light gray, soft to moderately firm, non-calcareous
80.0 - 99.0' Shale Dry, medium light gray and light olive gray, firm, non-carbonaceous, non-calcareous; Interbedded siltstone at 81'-82' and at 84'-86' Carbonaceous stringer at 95.5', dark yellowish gray and brownish black
99.0 - 102.0' Siltstone and interbedded fine sandstone Slightly moist, light gray, soft to firm



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B5-O

Date Hole Started: 4/6/2011 Date Hole Finished: 4/6/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 11; N 474962.21, E 2826808.49
Location Description: B5 battery near weather station
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Overburden
Hole Diameter (in): 8"
Total Depth Drilled (ft): 156

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-156
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	141-156
Sand Pack?	Y	10/20 silica sand	136-156
Annular Seal?	Y	Bentonite Chips	+1-136
Surface Seal?	N		

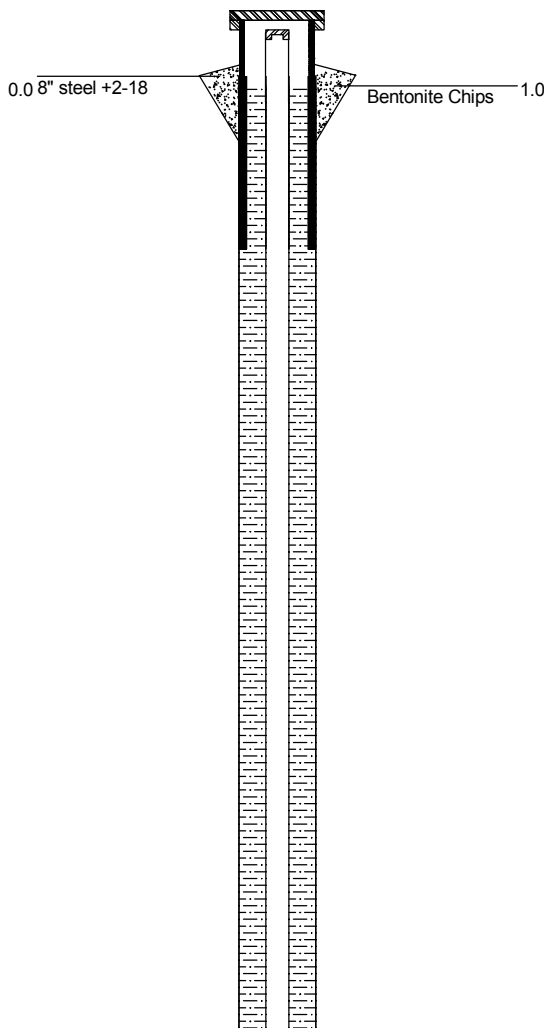
DEVELOPMENT/SAMPLING

Well Developed?	N
Water Samples Taken?	N
Boring Samples Taken?	N

Northing: 474962.21	Easting: 2826808.49
Static Water Level Below MP: dry	Surface Casing Height (ft): 1.93
Date: 4/7/2011	Riser Height (ft): 1.56
MP Description: Top PVC	Ground Surface Elevation (ft): 3224.64
MP Height Above or Below Ground (ft): 1.56	MP Elevation (ft): 3226.2

Remarks: Lithology based on well B5-K, cuttings verified in field during drilling. Dry hole

WELL CONSTRUCTION



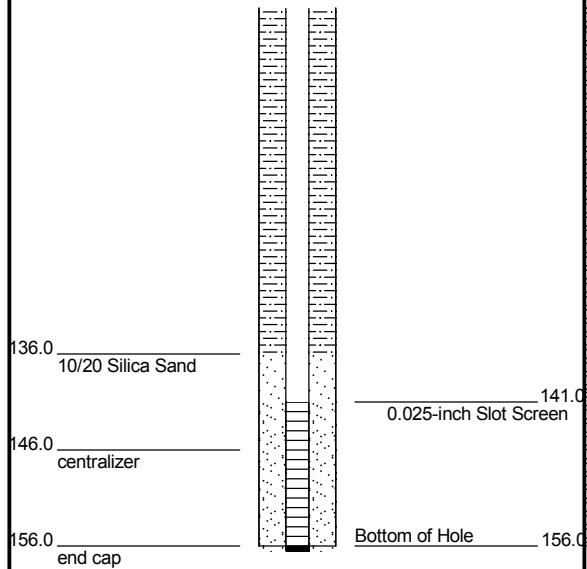
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silty clay/grades to siltstone [Colluvium/Weathered Bedrock] Moist, soft, weathered, roots to 3', calcareous, trace grayish white precipitates; trace clinker gravel from 0'-1'
3.0 - 6.0'	Sandstone, fine [Bedrock] Slightly moist, light olive gray to medium light gray, soft
6.0 - 7.0'	Siltstone Dry, pale yellowish brown to light olive gray, moderately firm to stiff, calcareous
7.0 - 9.0'	Coal Dry, brownish gray and black with medium gray shale, firm to stiff, junk
9.0 - 10.0'	Carbonaceous shale Dry, moderate brown and grayish red, moderately firm, moderately carbonaceous, trace micaceous material
10.0 - 13.0'	Coal Dry, brownish gray black, firm to stiff, junk
13.0 - 34.0'	Siltstone Dry to slight moist, light olive gray and very pale orange (10YR 8/2), soft to very soft, most cuttings gravel to rock flow Color change to medium gray at 20', calcareous Moist at 22', interbedded very fine sandstone starting at 22' Color change to olive green at 24'
34.0 - 35.0'	Coal Dry, brownish black, stiff to hard
35.0 - 42.0'	Carbonaceous shale to non carbonaceous shale at 36' Dry, olive gray (5Y 4/1) moderately firm; medium dark gray to medium light gray and greenish gray with change from carbonaceous shale to non-carbonaceous shale
42.0 - 44.0'	Siltstone Dry, medium light gray, soft
44.0 - 45.0'	Coal Dry, brownish black (5YR 2/1), stiff, ground cuttings, multiple cleats?, junk
45.0 - 76.0'	Shale Dry, colors medium light gray, olive gray, moderately firm to stiff with hard cemented zones as follows: Cemented zone, light gray shale at 48'; Moderately carbonaceous at 51'-52'; Cemented zone, light gray shale at 53'; Cemented zone, light gray shale at 67'; Cemented zone, light gray shale at 69'; Moderately carbonaceous at 72'-74'
76.0 - 80.0'	Siltstone and interbedded fine sandstone Dry, medium to medium light gray, soft to moderately firm, non-calcareous
80.0 - 99.0'	Shale Dry, medium light gray and light olive gray, firm, non-carbonaceous, non-calcareous; Interbedded siltstone at 81'-82' and at 84'-86' Carbonaceous stringer at 95.5', dark yellowish gray and brownish black



WELL CONSTRUCTION



GEOLOGICAL DESCRIPTION

99.0 - 102.0' **Siltstone and interbedded fine sandstone**

Slightly moist, light gray, soft to firm

102.0 - 140.0' **Siltstone/shale**

Dry, light olive gray and medium gray, calcareous, firm, stiff stringer at 120'

Grades to no shale, all siltstone at 121'-125'

Silty at 130'-135'

Cemented, light gray shale, non-calcareous at 139'

140.0 - 156.0' **Siltstone and fine sandstone interbedded**

Slightly moist to moist, greenish gray (5GY 6/1) and medium light gray, soft to moderately firm; cemented at 143'-144'; hard, very thin carbonaceous (coal) interbed at 150', very sandy, mild increase in moisture; very hard cemented, dry, light gray siltstone at 155.5', mildly calcareous

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B5-PH1

Date Hole Started: 3/25/2011 Date Hole Finished: 3/25/2011

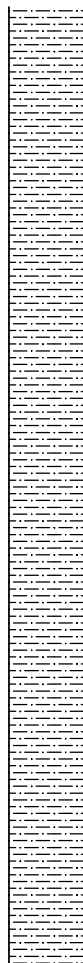
Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 10;
N45.50291, E-106.1569 (NAD83)
Location Description: near weather station
Recorded By: RJJ
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: NA
Hole Diameter (in): 8"
Total Depth Drilled (ft): 105

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	N		NA
Surface Casing Used?	N		NA
Screen/Perforations?	N		NA
Sand Pack?	N		NA
Annular Seal?	N		NA
Surface Seal?	Y	Bentonite Chips	0-100
DEVELOPMENT/SAMPLING			
Well Developed?	N		
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 475137.55		Easting: 2825224.07	
Static Water Level Below MP:		Surface Casing Height (ft): NA	
Date:		Riser Height (ft): NA	
MP Description:		Ground Surface Elevation (ft): 3196.32	
MP Height Above or Below Ground (ft):		MP Elevation (ft):	

Remarks: Lost circulation in burn, plugged hole with 3/8" bentonite chips (68 bags).

WELL CONSTRUCTION

0.0 Bentonite Chips



Bottom of Hole



GEOLOGICAL DESCRIPTION

0.0 - 1.0'	Silty clay [Colluvium/Topsoil] Moist, moderate brown, soft, moderately dense
1.0 - 8.0'	Siltstone [Bedrock] Dry to slightly moist, very pale orange to pale yellowish orange, very soft, highly weathered to 6', then hardens to moderately firm and less weathered at 6'-8', colors change to pale yellowish brown and olive gray
8.0 - 10.0'	Shale, very silty Dry, dark yellowish brown to pale yellowish brown with depth, moderately carbonaceous to non-carbonaceous with depth, soft to moderately firm
10.0 - 15.0'	Siltstone/shale, interbedded Dry, pale yellowish brown and olive gray to medium light gray, moderately firm to firm, all non-calcareous
15.0 - 18.0'	Siltstone [Bedrock] Dry, multi-colored from pale yellowish brown, pale yellowish orange to dark yellowish brown, soft, non-calcareous
18.0 - 48.0'	Shale/siltstone, interbedded Dry, medium light gray to medium gray, moderately firm to firm, all non-calcareous; slight carbonaceous at 18'-20', some thin laminations and oxidized beds: brownish gray at 21'-22'; light brown (5YR 5/6) at 25'-26', pale reddish brown at 33'-34'; then color changes from grays to orange/reds; highly oxidized colors variable from grayish orange, light brown (5YR 5/6), and moderate red (5R 5/4)
	Hardness to stiff from 43'-44' Hard from 47'-48'
48.0 - 66.0'	Siltstone/some very fine sandstone Dry, dark yellowish orange, (10YR 6/6) and light brown to grayish orange pink, soft; very hard cemented zone at 65.5'-66', burned sandstone
66.0 - 75.5'	Fine sandstone Dry, very pale orange and grayish orange pink, soft to very soft; burned cemented zone at 72'-73', hard
75.5 - 79.0'	Oxidized shale (burned) Dry, light brown (5YR 6/4) and grayish orange, very hard, rig chattering
79.0 - 84.0'	Sandstone, very fine Dry, grayish orange to grayish orange pink with depth, soft with some intercalated very hard shale; stringer of very hard burned shale at 83'
84.0 - 100.0'	Siltstone Dry, light brown (5YR 6/4 and 5YR 5/6), hard to very hard, cuttings ground, some interbedded fine sandstone at 87'-88'; oxidized, sandy at 92'-94'
100.0 - 105.0'	Oxidized shale [Clinker] Dry, moderate orange pink to light brown, very hard/cemented

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B5-U

Date Hole Started: 4/5/2011 Date Hole Finished: 4/6/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 11;
N474963.53, E 2826819.95
Location Description: B5 battery near weather
station
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Underburden
Hole Diameter (in): 11"(0-18'), 8"(18-500')
Total Depth Drilled (ft): 500

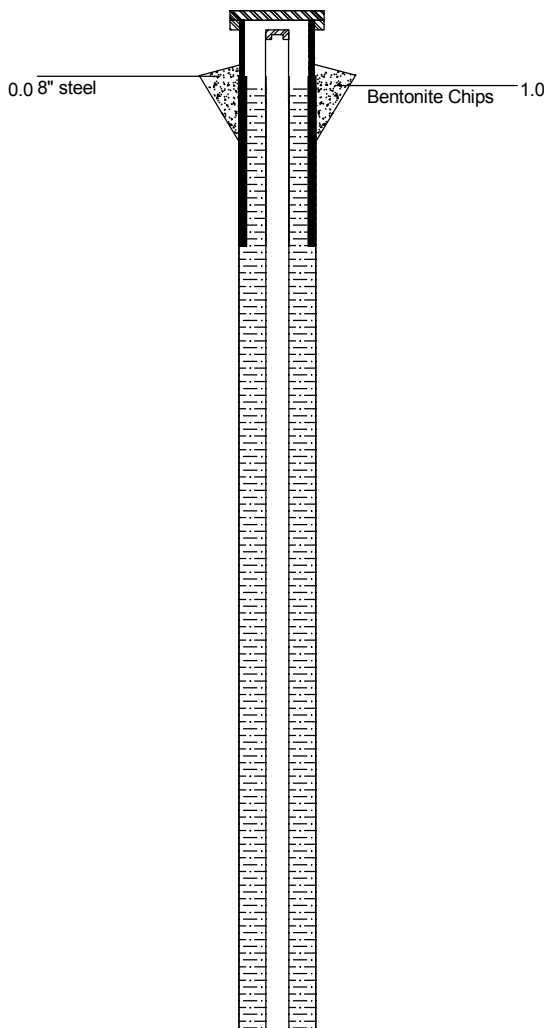
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" SDR-17 Certa-lok-ID well casing	+2-500
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	4.5" 0.025-inch slot SDR-17	450-500
Sand Pack?	Y	10/20 silica sand	446-500
Annular Seal?	Y	Bentonite Chips	+1-446
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 474963.53	Easting: 2826819.95	
Static Water Level Below MP:	162.93	Surface Casing Height (ft): 1.87
Date: 4/6/2011		Riser Height (ft): 1.47
MP Description: Top PVC		Ground Surface Elevation (ft): 3224.17
MP Height Above or Below Ground (ft):	1.47	MP Elevation (ft): 3225.64

Remarks: Sand pack interval estimated based on 2' per bag, measuring string broke off in well. Cuttings verified in field. Injecting water at 225', developed with rig air at 280' bgs 5 minutes, at 320' bgs 20 minutes ~500 gallons removed; SC=1096 µmhos/cm after development.

WELL CONSTRUCTION

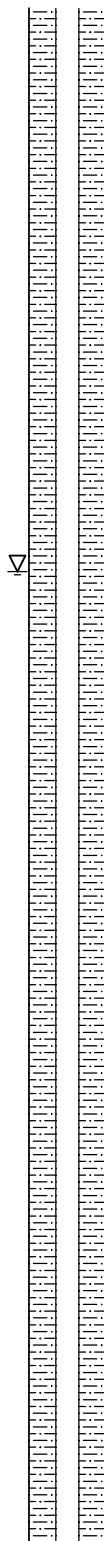


GEOLOGICAL DESCRIPTION

0.0 - 3.0'	Silty clay/grades to siltstone [Colluvium/Weathered Bedrock] Moist, soft, weathered, roots to 3', calcareous, trace grayish white precipitates; trace clinker gravel from 0'-1'
3.0 - 6.0'	Sandstone, fine [Bedrock] Slightly moist, light olive gray to medium light gray, soft
6.0 - 7.0'	Siltstone Dry, pale yellowish brown to light olive gray, moderately firm to stiff, calcareous
7.0 - 9.0'	Coal Dry, brownish gray and black with medium gray shale, firm to stiff, junk
9.0 - 10.0'	Carbonaceous shale Dry, moderate brown and grayish red, moderately firm, moderately carbonaceous, trace micaceous material
10.0 - 13.0'	Coal Dry, brownish gray black, firm to stiff, junk
13.0 - 34.0'	Siltstone Dry to slight moist, light olive gray and very pale orange (10YR 8/2), soft to very soft, most cuttings gravel to rock flow
	Color change to medium gray at 20', calcareous Moist at 22', interbedded very fine sandstone starting at 22' Color change to olive green at 24'
34.0 - 35.0'	Coal Dry, brownish black, stiff to hard
35.0 - 42.0'	Carbonaceous shale to non carbonaceous shale at 36' Dry, olive gray (5Y 4/1) moderately firm; medium dark gray to medium light gray and greenish gray with change from carbonaceous shale to non-carbonaceous shale
42.0 - 44.0'	Siltstone Dry, medium light gray, soft
44.0 - 45.0'	Coal Dry, brownish black (5YR 2/1), stiff, cuttings ground, multiple cleats?, junk
45.0 - 76.0'	Shale Dry, colors medium light gray, olive gray, moderately firm to stiff with hard cemented zones as follows: Cemented zone, light gray shale at 48'; Moderately carbonaceous at 51'-52'; Cemented zone, light gray shale at 53'; Cemented zone, light gray shale at 67'; Cemented zone, light gray shale at 69'; Moderately carbonaceous at 72'-74'
76.0 - 80.0'	Siltstone and interbedded fine sandstone Dry, medium to medium light gray, soft to moderately firm, non-calcareous
80.0 - 99.0'	Shale Dry, medium light gray and light olive gray, firm, non-carbonaceous, non-calcareous; Interbedded siltstone at 81'-82' and at 84'-86' Carbonaceous stringer at 95.5', dark yellowish gray and brownish black
99.0 - 102.0'	Siltstone and interbedded fine sandstone



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

Slightly moist, light gray, soft to firm

102.0 - 140.0' **Siltstone/shale**

Dry, light olive gray and medium gray, calcareous, firm, stiff stringer at 120'

Grades to no shale, all siltstone at 121'-125'

Silty at 130'-135'

Cemented, light gray shale, non-calcareous at 139'

140.0 - 155.5' **Siltstone and fine sandstone interbedded**

Slightly moist to moist, greenish gray (5GY 6/1) and medium light gray, soft to moderately firm; cemented at 143'-144', hard; very thin carbonaceous (coal) interbed at 150', interbed very sandy, slight moisture increase; very hard cemented, dry, light gray siltstone at 155.5', mildly calcareous

155.5 - 185.0' **Siltstone and shale**

Dry, light olive gray (5Y 5/2) and pale yellowish brown, moderately firm to stiff

Color change to light greenish gray at 179'

Moderately carbonaceous stringer at 182', brownish gray

185.0 - 255.0' **Coal**

Dry, brownish gray and brownish black, stiff, brittle ground cuttings appear cleated, junk

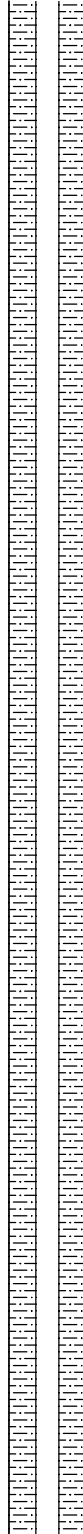
Grades to black cleated, well developed coal at 205'-210', wet at 210', injecting water at 215', dense [Knobloch Coal]

255.0 - 266.0' **Sandstone**

Wet, medium light gray, moderately firm to very hard at 261', rig chattering/slow to advance; hardness returning to moderately firm at 265'



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

x x x x x

266.0 - 275.0' **Siltstone**

Medium light gray, moderately firm to firm, thin coal stringer at 270'

x x x x x

275.0 - 290.0' **Sandstone**

Medium light gray, soft to moderately firm, very hard cemented zone at 283'-284.5', very pale orange; then sandstone/intercalated shale 284.5'-292'

x x x x x

290.0 - 292.0' **Siltstone/claystone**

Medium light gray to light olive gray, firm, calcareous

x x x x x

292.0 - 295.0' **Coal/interbedded carbonaceous shale**

Medium gray to light brownish gray shale, black coal, moderately firm to firm

x x x x x

295.0 - 299.0' **Sandstone with coal stringers throughout**

Light brownish gray sandstone, black coal, firm

x x x x x

299.0 - 308.0' **Fine sandstone, some silt**

Light gray to medium light gray, firm, siltstone calcareous, very hard sandstone stringer cemented 305'-306'

x x x x x

308.0 - 317.0' **Siltstone/shale**

Medium light gray, moderately firm to very stiff, calcareous/reacts strongly with HCl

x x x x x

317.0 - 321.0' **Coal**

Black, cleated multiple places, moderately dense but very dirty, has intercalated light brownish gray sandstone and shale throughout

x x x x x

321.0 - 335.0' **Siltstone and interbedded sandstone**

Medium light gray, moderately firm, calcareous

x x x x x

335.0 - 380.0' **Sandstone**

Medium light gray and light olive gray; coal stringer at 344'-345'; intercalated coal, very dirty at 353'-362'. Stop at 360', blow on hole and make multiple checks of TDS. No change in TDS from water in coal interval.

x x x x x

Very hard fine sandstone interval at 362', rig slow, chattering

Hardness to stiff at 370'

Interbedded coal/carbonaceous shale interval at 375'-380'; shale also calcareous; light brownish gray. Stop at 380', blow on hole and make multiple TDS checks, not making water

x x x x x

380.0 - 399.0' **Shale/siltstone**

Light olive gray and medium light gray, non-calcareous

Very hard shale at 383'-384.5'

Coal stringer at 385'-286'

Becomes sandy at 389'; some interbedded sandstone from 389-399'

x x x x x

399.0 - 404.0' **Sandstone**

Medium light gray to light brownish gray, firm to very hard, not making water

x x x x x

404.0 - 440.0' **Siltstone and interbedded shale**

Medium light gray to brownish gray, moderately firm to hard; carbonaceous to non-carbonaceous

Predominately siltstone at 412', moderate firm

Coal stringer at 420'

Color changes to brownish gray and light brownish gray at 429'

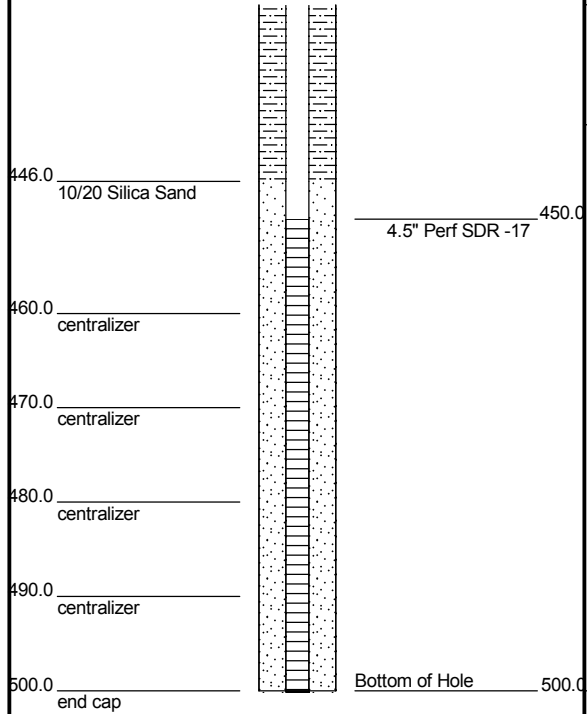
Coal stringer at 430'

x x x x x

WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



440.0 - 500.0' **Fine sandstone**
 interbedded siltstone/claystone, wet, brownish gray to light olive gray to medium light gray with depth; texture to all sandstone at 450', moderately firm to very soft with depth, fine to moderately fine grain with depth

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Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B6-K

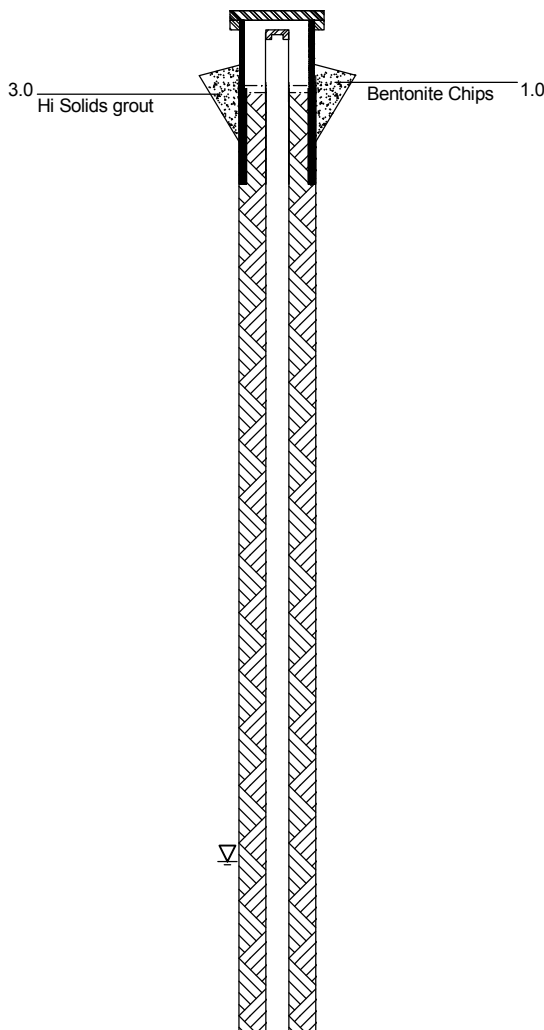
Date Hole Started: 8/16/11 Date Hole Finished: 8/16/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 12; N 474230.48, E 2834696.30
Location Description: B6 battery on Tarter property, Shorty Creek Drainage
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 11"(0-18') 8"(18'-247')
Total Depth Drilled (ft): 247

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-247
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	180-247
Sand Pack?	Y	10/20 Silica Sand	174-247
Annular Seal?	Y	Bentonite Chips	164-174, +1-3
Surface Seal?	Y	Hi Solids grout	3-164
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Submersible Pump	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 474230.48		Easting: 2834696.3	
Static Water Level Below MP: 132.92		Surface Casing Height (ft): 2.11	
Date: 8/17/2011		Riser Height (ft): 2.06	
MP Description: Top PVC		Ground Surface Elevation (ft): 3232.90	
MP Height Above or Below Ground (ft): 2.06		MP Elevation (ft): 3234.96	

Remarks: Drilled to 20' with 11" bit, set 8" steel casing. Developed with submersible pump at 20 gpm. Pump hung at 206' BMP. Recovered 11' when pumped turned off temporarily for 7 minutes. WL=152.23' BMP after 50 minutes at 20 gpm. SC= 2200 µmhos/cm, pH= 8.27, temp= 18.2°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

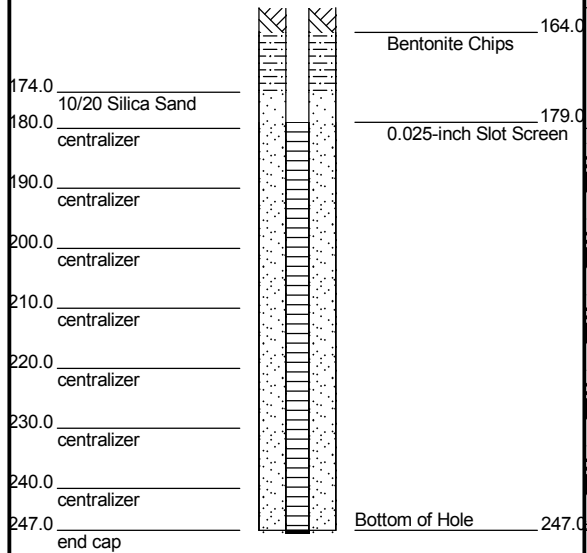
0.0 - 7.0'	Silt [Colluvium]	Dry to slightly moist, pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), roots and debris in top 1'
7.0 - 39.0'	Siltstone [Bedrock]	Dry to slightly moist, dark yellowish orange (10YR 6/6) to light olive gray at 10', moderately firm, calcareous. Very hard cemented shale stringer 13'-14', light olive gray to light brownish gray (5Y 6/1), also calcareous. Very hard cemented shale, calcareous, medium light gray (N6) and greenish gray (5G 6/1) at 21'-22'. Color change to light olive gray at 24'. Color change to dark yellowish orange (10YR 6/6) at 26'. Color change to light olive gray at 31'; becomes soft at 35' and color changes to moderate yellowish brown (10YR 5/4) and grayish orange (10YR 7/4)
39.0 - 41.0'	Coal/carbonaceous shale	Dry, dark brownish black (5YR 2/1), stiff
41.0 - 80.0'	Siltstone/shale	Dry, medium gray (N5) and medium light gray (N6), firm to stiff. Very hard cemented zone at 56'; metal shavings from drill bit in cuttings. Non-calcareous at 41'-57', calcareous from 57'-80'
80.0 - 100.0'	Sandstone [Bedrock]	Dry, medium light gray (N6) and greenish gray (5GY 6/1), soft to moderately firm, some siltstone from 80'-87'. Very hard, cemented, very fine grained sandstone from 87'-90.5'. Color change to medium dark gray (N4), moisture to moist at 91', hardness to soft; sandstone becomes clayey at 99'
100.0 - 145.0'	Siltstone, sandy/clayey	Slightly moist, moderately firm, medium dark gray (N4), non-calcareous, soft to firm, texturally complex. Calcareous cemented zone at 111', medium light gray (N6); becomes very sandy at 137', moisture to moist; very clayey, mildly plastic at 142', then grades to very sandy at 145', injecting water at 145'
145.0 - 155.0'	Sandstone	Wet, light olive gray to medium gray (N5). Thin interbedded siltstone stringer at 150', silty again at 154'-155'. Sandstone is fine to very fine and silty at 155'. Blew on open hole at 155', makes some water



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



155.0 - 180.0' **Siltstone**
Dark gray (N3), some sand/some clay, moderately firm. Hard cemented, intercalated shale, light brownish gray [5YR 6/1] at 158'. Very thin coal stringer at 163', texture grades to no sand below coal stringer, becomes shaley, non-plastic

180.0 - 246.0' **Coal** [Knobloch]
Hard, loose, black (N1), cleated

246.0 - 247.0' **Shale** [Underburden]
Dry, light olive gray (5Y 5/2), stiff

Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: B6-O

Date Hole Started: 8/18/11 Date Hole Finished: 8/18/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 12; N 474204.77, E 2834702.77
Location Description: B6 battery on Tarter property, Shorty Creek Drainage
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Overburden
Hole Diameter (in): 8"
Total Depth Drilled (ft): 155

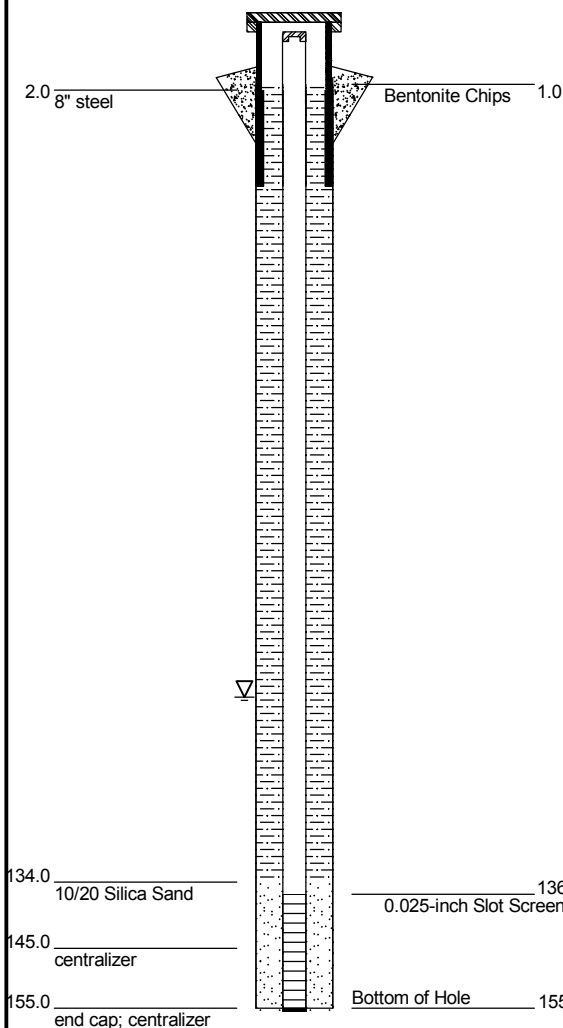
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-155
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	136-155
Sand Pack?	Y	10/20 Silica Sand	134-155
Annular Seal?	Y	Bentonite Chips	+1-134
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailer
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 474204.77	Easting: 2834702.77	
Static Water Level Below MP:	104.67	Surface Casing Height (ft): 2.04
Date: 8/19/2011		Riser Height (ft): 1.52
MP Description:		Ground Surface Elevation (ft): 3233.75
MP Height Above or Below Ground (ft):	1.52	MP Elevation (ft): 3235.26

Remarks: Lithology based on B6-K. No water injected, developed with bailer, yield very low <1 gpm, SC= 6700 μ mhos/cm, pH= 8.1, temp= 13.6°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 7.0' Silt [Colluvium] Dry to slightly moist, pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), roots and debris in top 1'
7.0 - 39.0' Siltstone [Bedrock] Dry to slightly moist, dark yellowish orange (10YR 6/6) to light olive gray at 10', moderately firm, calcareous. Very hard cemented shale stringer 13'-14', light olive gray to light brownish gray (5Y 6/1), also calcareous. Very hard cemented shale, calcareous, medium light gray (N6) and greenish gray (5G 6/1) at 21'-22'. Color change to light olive gray at 24'. Color change to dark yellowish orange (10YR 6/6) at 26'. Color change to light olive gray at 31'; becomes soft at 35' and color changes to moderate yellowish brown (10YR 5/4) and grayish orange (10YR 7/4)
39.0 - 41.0' Coal/carbonaceous shale Dry, dark brownish black (5YR 2/1), stiff
41.0 - 82.0' Siltstone/shale Dry, medium gray (N5) and medium light gray (N6), firm to stiff. Metal shavings from drill bit in cuttings. Non-calcareous at 41'-57', calcareous from 57'-80'; very hard cemented zone at 64'-66' and at 75'-76'
82.0 - 100.0' Sandstone [Bedrock] Dry, medium light gray (N6) and greenish gray (5GY 6/1), soft to moderately firm, <u>some siltstone</u> from 80'-82'. <u>Sandy texture at 82'-83.5', very hard, cemented, thin sandstone</u> very fine grained sandstone from 83.5'-90.5'. Color change to medium dark gray (N4), moisture to moist at 91', hardness to soft; sandstone becomes clayey at 99'
100.0 - 137.0' Siltstone, sandy/clayey Slightly moist, moderately firm, medium dark gray (N4), non-calcareous, soft to firm, texturally complex. Calcareous cemented zone at 111', medium light gray (N6); becomes very sandy at 137', moisture to moist; very clayey, mildly plastic at 142', then grades to very sandy at 145', injecting water at 145'
137.0 - 155.0' Sandstone Wet, light olive gray to medium gray (N5), clayey at 142' and 155', fine-grained sand, TD=155', tagged siltstone at 155'

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B6-U

Date Hole Started: 8/17/11 Date Hole Finished: 8/17/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 12; N 474218.93, E 2834699.12
Location Description: B6 battery on Tarter property, Shorty Creek Drainage
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal Underburden
Hole Diameter (in): 11"(0-18') 8"(18'-364')
Total Depth Drilled (ft): 364

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" SDR-17 Certa-lok-ID well casing	+2-364
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, SDR-17	352-364
Sand Pack?	Y	10/20 Silica Sand	347-364
Annular Seal?	Y	Bentonite Chips	337-347, 0-12
Surface Seal?	Y	Hi Solids grout	12-337

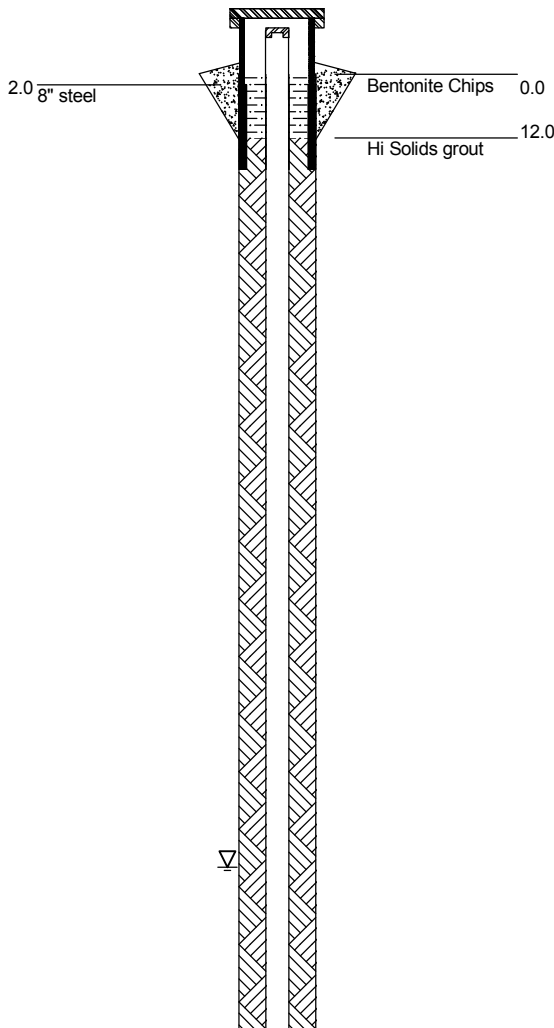
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Bailer
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 474218.93	Easting: 2834699.12
Static Water Level Below MP: 151.51	Surface Casing Height (ft): 2.48
Date: 8/18/2011	Riser Height (ft): 2.03
MP Description: Top PVC	Ground Surface Elevation (ft): 3233.21
MP Height Above or Below Ground (ft): 2.03	MP Elevation (ft): 3235.24

Remarks: Bailed with rig bailer to develop. Bailed until water column <20', yield ~4 gpm. (pumped at 2 gpm). SC=1334 µmhos/cm, pH= 8.83, temp.= 16.1°C after development

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

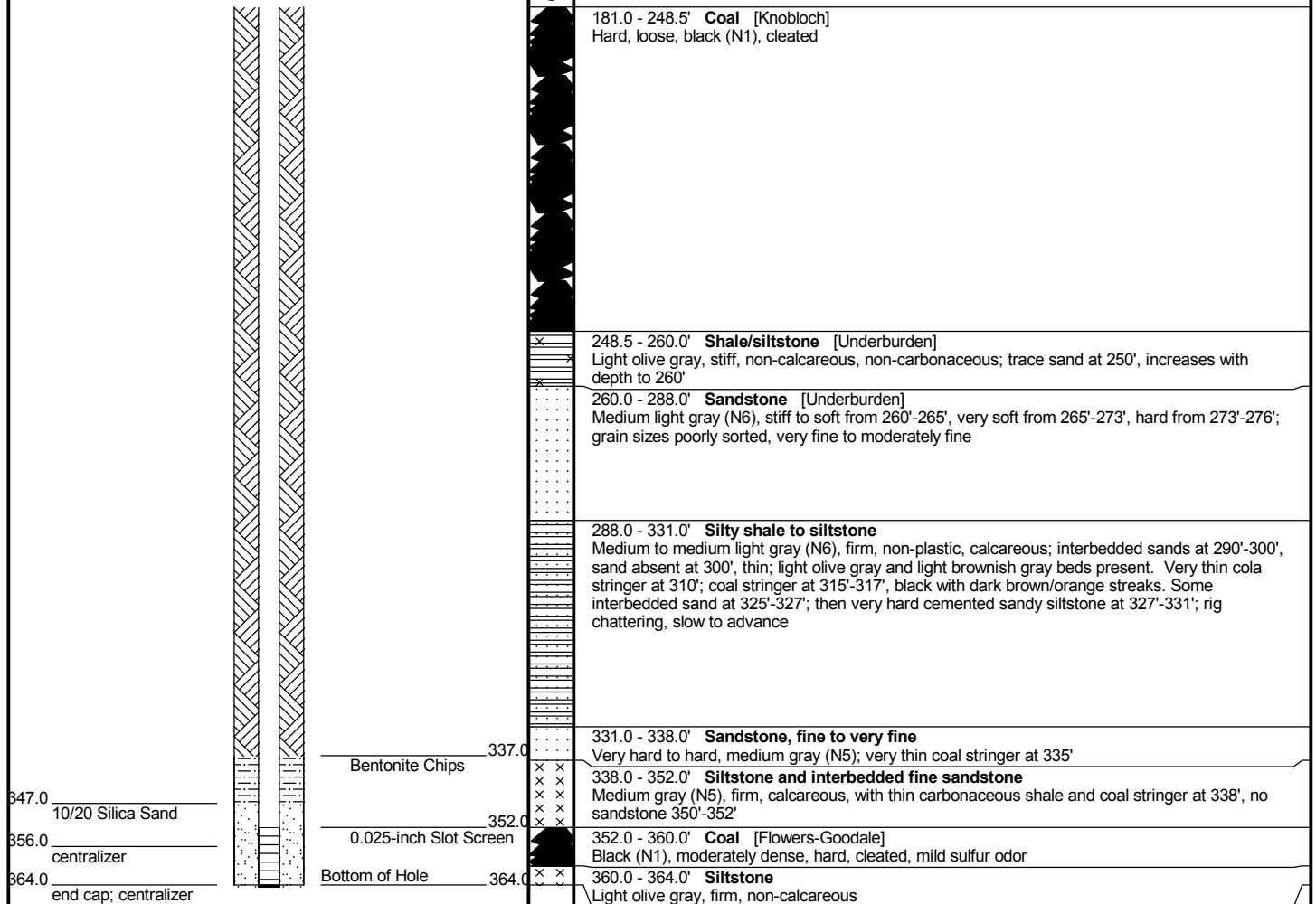
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7.0 - 39.0' Siltstone [Bedrock] Dry to slightly moist, dark yellowish orange (10YR 6/6) to light olive gray at 10', moderately firm, calcareous. Very hard cemented shale stringer 13'-14', light olive gray to light brownish gray (5Y 6/1), also calcareous. Very hard cemented shale, calcareous, medium light gray (N6) and greenish gray (5G 6/1) at 21'-22'. Color change to light olive gray at 24'. Color change to dark yellowish orange (10YR 6/6) at 26'. Color change to light olive gray at 31'; becomes soft at 35' and color changes to moderate yellowish brown (10YR 5/4) and grayish orange (10YR 7/4)
39.0 - 41.0' Coal/carbonaceous shale Dry, dark brownish black (5YR 2/1), stiff
41.0 - 80.0' Siltstone/shale Dry, medium gray (N5) and medium light gray (N6), firm to stiff. Very hard cemented zone at 56'; metal shavings from drill bit in cuttings. Non-calcareous at 41'-57', calcareous from 57'-80'
80.0 - 100.0' Sandstone [Bedrock] Dry, medium light gray (N6) and greenish gray (5GY 6/1), soft to moderately firm, some siltstone from 80'-87'. Very hard, cemented, very fine grained sandstone from 87'-90.5'. Color change to medium dark gray (N4), moisture to moist at 91', hardness to soft; sandstone becomes clayey at 99'
100.0 - 145.0' Siltstone, sandy/clayey Slightly moist, moderately firm, medium dark gray (N4), non-calcareous, soft to firm, texturally complex. Calcareous cemented zone at 111', medium light gray (N6); becomes very sandy at 137', moisture to moist; very clayey, mildly plastic at 142', then grades to very sandy at 145', injecting water at 140'
145.0 - 155.0' Sandstone Wet, light olive gray to medium gray (N5). Thin interbedded siltstone stringer at 150', silty again at 154'-155'. Sandstone is fine to very fine and silty at 155'. Blew on open hole at 155', makes some water
155.0 - 181.0' Siltstone Dark gray (N3), some sand/some clay, moderately firm. Hard cemented, intercalated shale, light brownish gray [5YR 6/1] at 158'. Very thin coal stringer at 163', texture grades to no sand below coal stringer, becomes shaley, non-plastic



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



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Billings, Montana



Monitor Well Log

Hole Name: B7-KL

Date Hole Started: 3/17/2011 Date Hole Finished: 3/17/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: State of Montana
Legal Description: T4S, R45, Sec. 36;
N456282.92, E 2835495.36
Location Description: B7 battery on State land

Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Lower Knobloch
Hole Diameter (in): 8"
Total Depth Drilled (ft): 340

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-340
Surface Casing Used?	Y	8" steel	+2-21
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	320-340
Sand Pack?	Y	10/20 silica sand	318-340
Annular Seal?	Y	Bentonite Chips	+1-318
Surface Seal?	N		

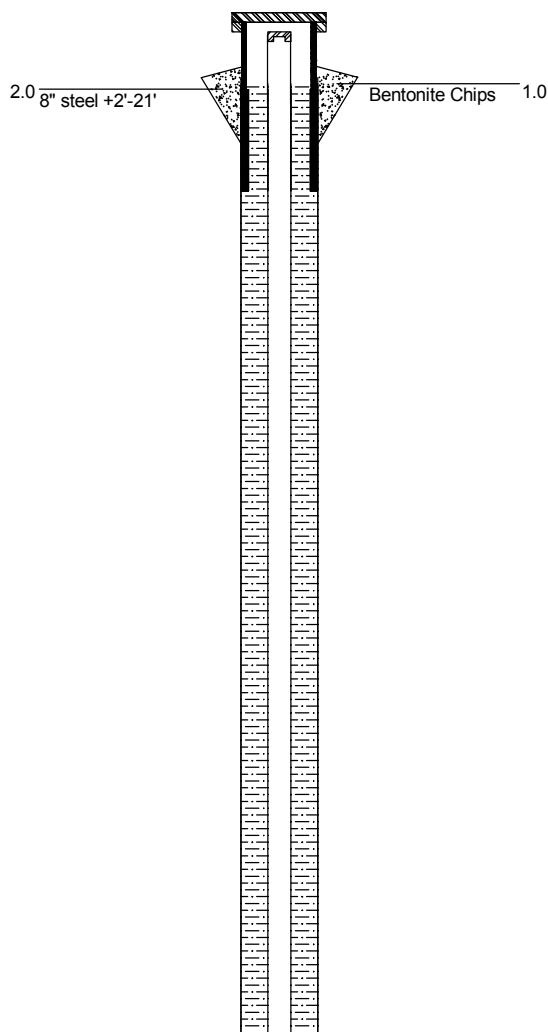
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Bailer
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 456282.92	Easting: 2835495.36
Static Water Level Below MP: 212.90	Surface Casing Height (ft): 1.86
Date: 3/22/2011	Riser Height (ft): 1.51
MP Description: Top PVC	Ground Surface Elevation (ft): 3336.06
MP Height Above or Below Ground (ft): 1.51	MP Elevation (ft): 3337.57

Remarks: Develop well with bailer, yield ~ 6 gpm initially then yield dropped to 4 gpm (steady). Final SC=1950 µmhos/cm, pH=8.84, temp=14.1°C, developed on 3/18/2011.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

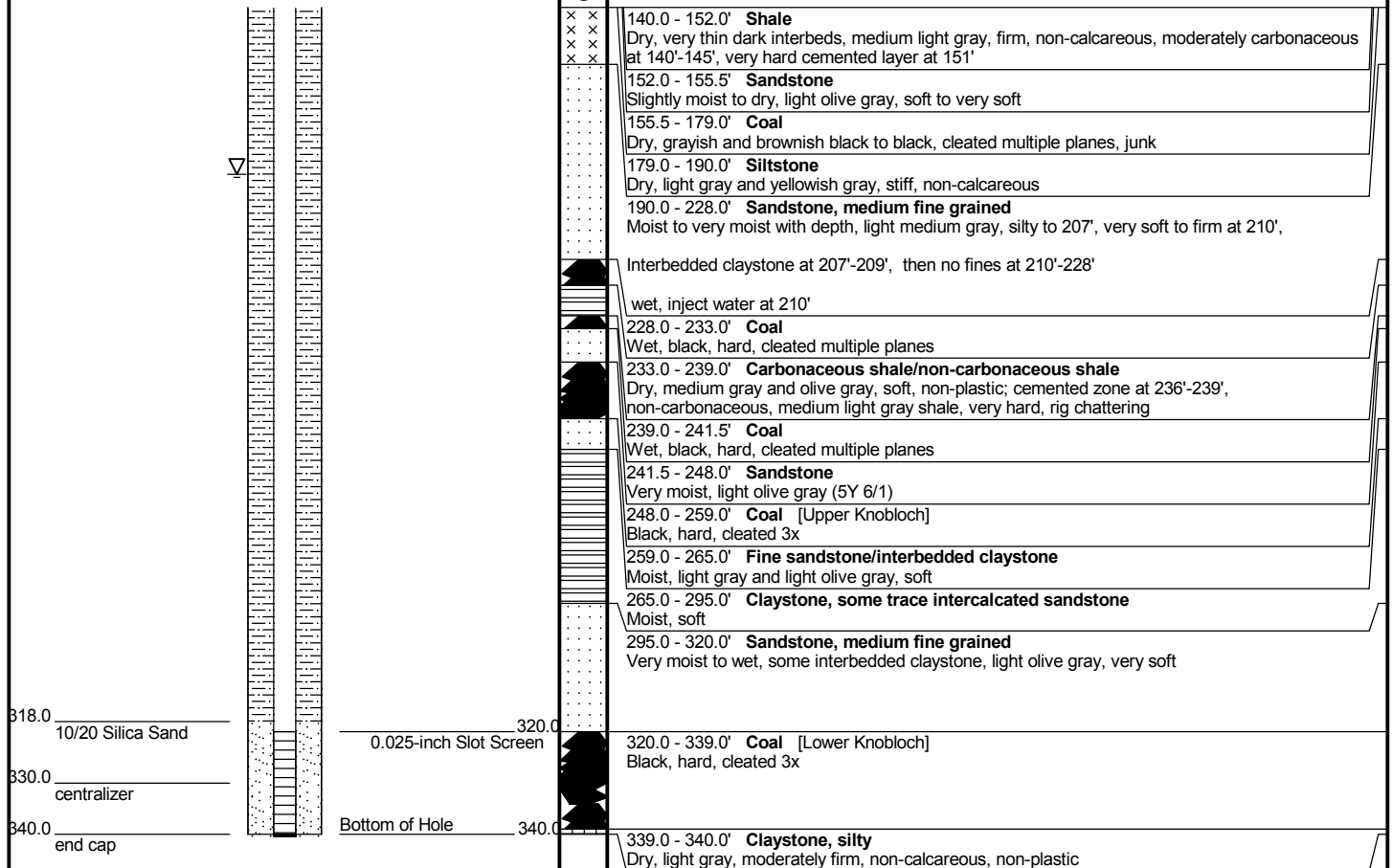
0.0 - 5.0' Siltstone [Bedrock] Slightly moist to dry, pale yellowish brown and grayish orange, soft to moderately firm, weathered topsoil top 3'
5.0 - 18.0' Siltstone/shale Dry, colors from dark yellowish orange at 5' to medium gray at 18', hard to moderately firm, all moderately carbonaceous (reacts with HCl)
18.0 - 19.0' Carbonaceous shale stringer Dry, medium dark gray, moderately firm
19.0 - 20.0' Carbonaceous shale/coal Dry, brownish black, hard, not cleated
20.0 - 37.0' Siltstone Dry, medium light gray to olive gray, firm, non-carbonaceous
37.0 - 47.0' Sandstone Dry to slightly moist, medium gray, moderately firm to soft with depth; cemented layer at 40'-41', very light gray sandstone; cemented very hard layer at 44'-47'; bluish white to medium light gray, rig chattering, slow to advance, moderately calcareous
47.0 - 52.0' Silty sandstone Moist, medium light gray, soft
52.0 - 60.0' Siltstone Dry, medium light gray, color change at 56' to brownish gray (5YR 4/1)
60.0 - 62.0' Siltstone, some very fine sand Moist, light olive gray to medium gray, soft, non-calcareous
62.0 - 65.0' Carbonaceous shale Dry, olive gray (5Y 3/2), moderately firm, stringer cemented siltstone at 63', very light gray, non-calcareous
65.0 - 67.0' Sandstone Slightly moist, medium light gray, very soft, non-calcareous, medium fine grained
67.0 - 70.0' Shale Dry, grayish brown, mildly carbonaceous, moderately firm
70.0 - 71.0' Sandstone Moist, medium light gray, fine grained
71.0 - 77.0' Siltstone Dry to slightly moist, medium gray, soft; carbonaceous shale stringer at 71', dry, brownish gray
77.0 - 104.0' Shale, interbedded siltstone Dry, medium light gray and greenish gray, firm, mildly calcareous, reacts to HCl
104.0 - 108.0' Interbedded sandstone/siltstone Very fine, soft, medium dark gray
108.0 - 119.0' Shale Dry, medium light gray, moderately firm, non-calcareous
119.0 - 122.5' Coal Dry, brownish black, cleated
122.5 - 140.0' Siltstone Dry, very light gray to light gray, calcareous, soft to moderately firm, interbedded sandstone at 125'-130', hard/cemented stringer at 130'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: B7-KU

Date Hole Started: 3/18/2011 Date Hole Finished: 3/18/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: State of Montana
Legal Description: T4S, R45, Sec. 36; N
456295.87, E 2835498.12
Location Description: B7 battery on State land

Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Ron Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water

Purpose of Hole: Install Monitor Well

Target Aquifer: Upper Knobloch

Hole Diameter (in): 8"

Total Depth Drilled (ft): 260

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-260
Surface Casing Used?	Y	8" steel	+2-21
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	250-260
Sand Pack?	Y	10/20 silica sand	247-260
Annular Seal?	Y	Bentonite Chips	+1-247
Surface Seal?	N		

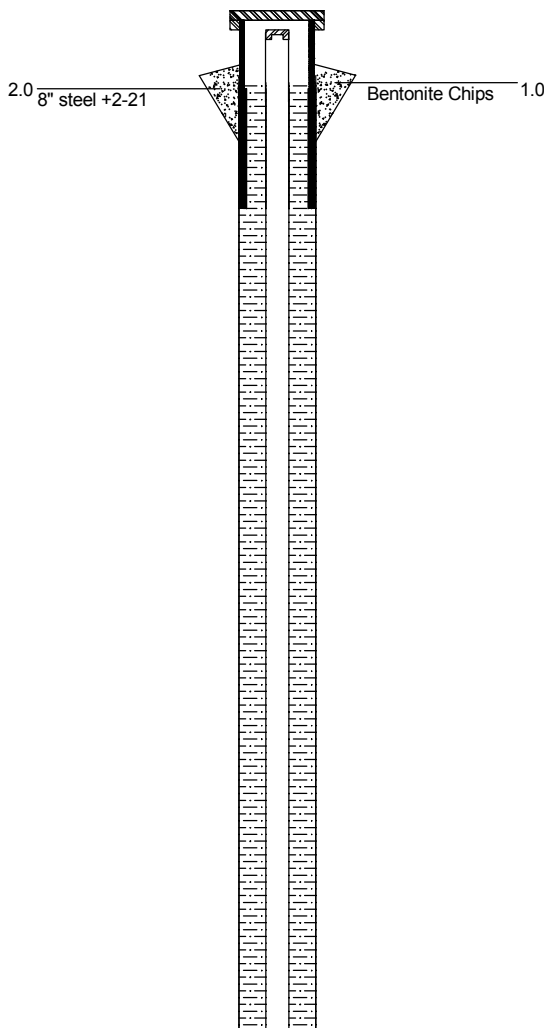
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Bailer
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 456295.87	Easting: 2835498.12
Static Water Level Below MP: 194.11	Surface Casing Height (ft): 1.72
Date: 3/22/2011	Riser Height (ft): 1.46
MP Description: Top PVC	Ground Surface Elevation (ft): 3336.44
MP Height Above or Below Ground (ft): 1.46	MP Elevation (ft): 3337.9

Remarks: Lithology based on well B7-KL, checked cuttings for verification. Developed well with bailer, ~7 gpm initially then yield dropped to 4 gpm. Final SC=4780 µmhos/cm, pH=8.38.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

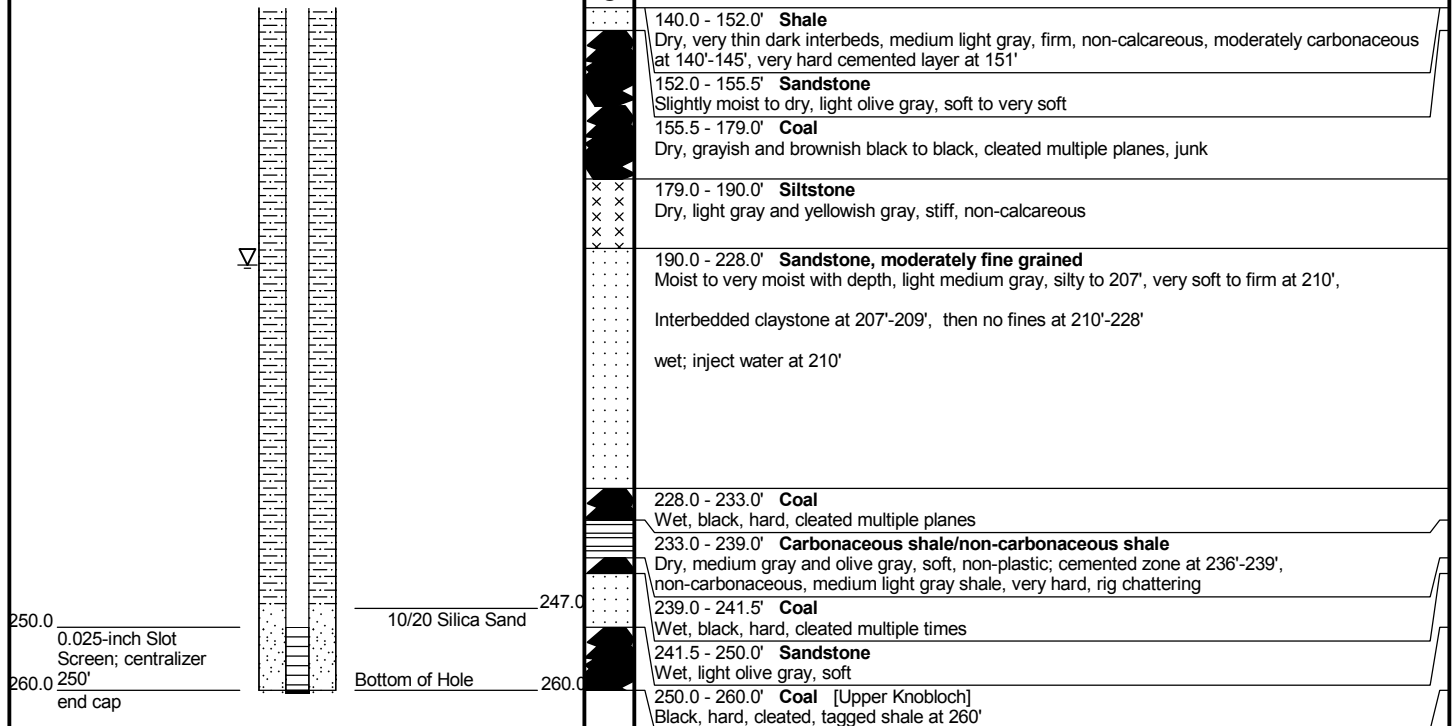
0.0 - 5.0'	Siltstone [Bedrock] Slightly moist to dry, pale yellowish brown and grayish orange, soft to moderately firm, weathered topsoil top 3'
5.0 - 18.0'	Siltstone/shale Dry, colors from dark yellowish orange at 5' to medium gray at 18', hard to moderately firm, all moderately carbonaceous (reacts with HCl)
18.0 - 19.0'	Carbonaceous shale stringer Dry, medium dark gray, moderately firm
19.0 - 20.0'	Carbonaceous shale/coal Dry, brownish black, hard, not cleated
20.0 - 37.0'	Siltstone Dry, medium light gray to olive gray, firm, non-carbonaceous
37.0 - 47.0'	Sandstone Dry to slightly moist, medium gray, moderately firm to soft with depth; cemented layer at 40'-41', very light gray sandstone; cemented very hard layer at 44'-47'; bluish white to medium light gray, rig chattering, slow to advance, moderately calcareous
47.0 - 52.0'	Silty sandstone Moist, medium light gray, soft
52.0 - 60.0'	Siltstone Dry, medium light gray, color change at 56' to brownish gray (5YR 4/1)
60.0 - 62.0'	Siltstone, some very fine sand Moist, light olive gray to medium gray, soft, non-calcareous
62.0 - 65.0'	Carbonaceous shale Dry, olive gray (5Y 3/2), moderately firm, stringer cemented siltstone at 63', very light gray, non-calcareous
65.0 - 67.0'	Sandstone Slightly moist, medium light gray, very soft, non-calcareous, medium fine grained
67.0 - 70.0'	Shale Dry, grayish brown, mildly carbonaceous, moderately firm
70.0 - 71.0'	Sandstone Moist, medium light gray, fine grained
71.0 - 77.0'	Siltstone Dry to slightly moist, medium gray, soft; carbonaceous shale stringer at 71', dry, brownish gray
77.0 - 104.0'	Shale, interbedded siltstone Dry, medium light gray and greenish gray, firm, mildly calcareous, reacts to HCl
104.0 - 108.0'	Interbedded sandstone/siltstone Very fine, soft, medium dark gray
108.0 - 119.0'	Shale Dry, medium light gray, moderately firm, non-calcareous
119.0 - 122.5'	Coal Dry, brownish black, cleated
122.5 - 140.0'	Siltstone Dry, very light gray to light gray, calcareous, soft to moderately firm, interbedded sandstone at 125'-130', hard/cemented stringer at 130'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: B7-O

Date Hole Started: 3/18/2011 Date Hole Finished: 3/18/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: State of Montana
Legal Description: T4S, R45, Sec. 36; N
456309.23, E 2835498.99
Location Description: B7 battery on State land

Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Ron Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water

Purpose of Hole: Install Monitor Well

Target Aquifer: Overburden

Hole Diameter (in): 8"

Total Depth Drilled (ft): 233

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-233
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	228-233
Sand Pack?	Y	10/20 silica sand	211-233
Annular Seal?	Y	Bentonite Chips	+1-211
Surface Seal?	N		

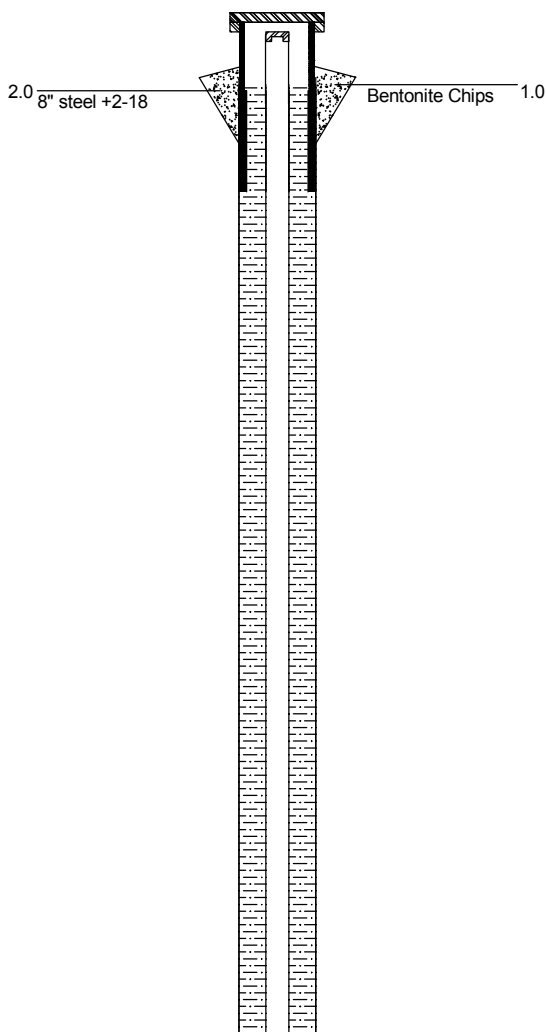
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Bailer
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 456309.23	Easting: 2835498.99
Static Water Level Below MP: 181.37	Surface Casing Height (ft): 1.77
Date: 3/22/2011	Riser Height (ft): 1.45
MP Description: Top PVC	Ground Surface Elevation (ft): 3336.86
MP Height Above or Below Ground (ft): 1.45	MP Elevation (ft): 3338.31

Remarks: Lithology based on well B7-KL, checked cuttings for verification. Yield = 3 gpm, SC=5390 μ mhos/cm, pH=8.16, temp=13.0°C after development.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

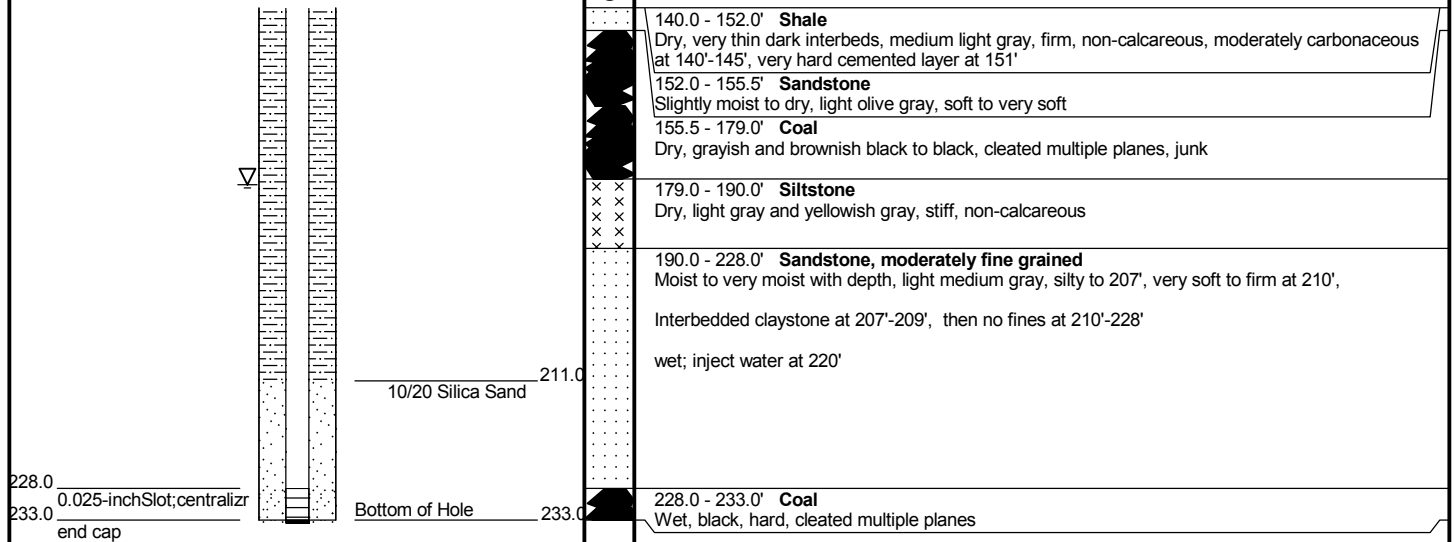
0.0 - 5.0'	Siltstone [Bedrock] Slightly moist to dry, pale yellowish brown and grayish orange, soft to moderately firm, weathered topsoil top 3'
5.0 - 18.0'	Siltstone/shale Dry, colors from dark yellowish orange at 5' to medium gray at 18', hard to moderately firm, all moderately carbonaceous (reacts with HCl)
18.0 - 19.0'	Carbonaceous shale stringer Dry, medium dark gray, moderately firm
19.0 - 20.0'	Carbonaceous shale/coal Dry, brownish black, hard, not cleated
20.0 - 37.0'	Siltstone Dry, medium light gray to olive gray, firm, non-carbonaceous
37.0 - 47.0'	Sandstone Dry to slightly moist, medium gray, moderately firm to soft with depth; cemented layer at 40'-41', very light gray sandstone; cemented very hard layer at 44'-47'; bluish white to medium light gray, rig chattering, slow to advance, moderately carbonaceous
47.0 - 52.0'	Silty sandstone Moist, medium light gray, soft
52.0 - 60.0'	Siltstone Dry, medium light gray, color change at 56' to brownish gray (5YR 4/1)
60.0 - 62.0'	Siltstone, some very fine sand Moist, light olive gray to medium gray, soft, non-calcareous
62.0 - 65.0'	Carbonaceous shale Dry, olive gray (5Y 3/2), moderately firm, stringer cemented siltstone at 63', very light gray, non-calcareous
65.0 - 67.0'	Sandstone Slightly moist, medium light gray, very soft, non-calcareous, medium fine grained
67.0 - 70.0'	Shale Dry, grayish brown, mildly carbonaceous, moderately firm
70.0 - 71.0'	Sandstone Moist, medium light gray, fine grained
71.0 - 77.0'	Siltstone Dry to slightly moist, medium gray, soft; carbonaceous shale stringer at 71', dry, brownish gray
77.0 - 104.0'	Shale, interbedded siltstone Dry, medium light gray and greenish gray, firm, mildly calcareous, reacts to HCl
104.0 - 108.0'	Interbedded sandstone/siltstone Very fine, soft, medium dark gray
108.0 - 119.0'	Shale Dry, medium light gray, moderately firm, non-calcareous
119.0 - 122.5'	Coal Dry, brownish black, cleated
122.5 - 140.0'	Siltstone Dry, very light gray to light gray, calcareous, soft to moderately firm, interbedded sandstone at 125'-130', hard/cemented stringer at 130'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B7-U

Date Hole Started: 3/21/11 Date Hole Finished: 3/22/11

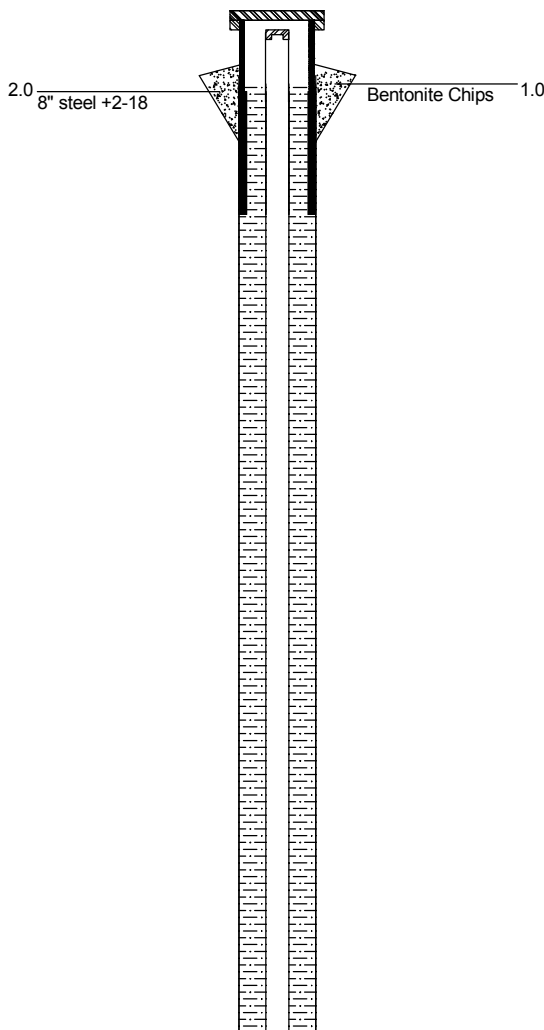
Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: State of Montana
Legal Description: T4S, R45E, Sec. 36; N
456268.71, E 2835491.91
Location Description: B7 battery on State land

Recorded By: RJL & HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Underburden
Hole Diameter (in): 8"
Total Depth Drilled (ft): 450

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" SDR-17 Certa-lok-ID well casing	+2-450
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	0.025-inch SDR-slotted	410-450
Sand Pack?	Y	10/20 silica sand	400-450
Annular Seal?	Y	Bentonite Chips	+1-400
Surface Seal?	N		
DEVELOPMENT/SAMPLING			
Well Developed?	Y	Rig Bailer	
Water Samples Taken?	N		
Boring Samples Taken?	N		
Northing: 456268.71		Easting: 2835491.91	
Static Water Level Below MP: 209.25		Surface Casing Height (ft): 1.76	
Date: 3/23/2011		Riser Height (ft): 1.46	
MP Description: Top PVC		Ground Surface Elevation (ft): 3335.27	
MP Height Above or Below Ground (ft): 1.46		MP Elevation (ft): 3336.73	

Remarks: Lithology from 0'-340' based on well B7-KL, checked cuttings for verification. Injecting water at 200'; stopped at 400' to circulate; not making more than above units combined. At 440' stopped to circulate, check water production, making 2-5 gpm.

WELL CONSTRUCTION



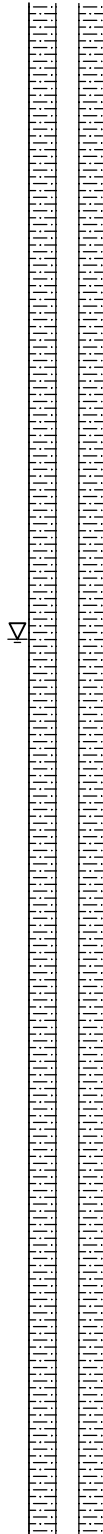
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 5.0'	Siltstone [Bedrock]
Slightly moist to dry, pale yellowish brown and grayish orange, soft to moderately firm, weathered topsoil top 3'	
5.0 - 18.0'	Siltstone/shale
Dry, colors from dark yellowish orange at 5' to medium gray at 18', hard to moderately firm, all moderately carbonaceous (reacts with HCl)	
18.0 - 19.0'	Carbonaceous shale stringer
Dry, medium dark gray, moderately firm	
19.0 - 20.0'	Carbonaceous shale/coal
Dry, brownish black, hard, not cleated	
20.0 - 37.0'	Siltstone
Dry, medium light gray to olive gray, firm, non-carbonaceous	
37.0 - 47.0'	Sandstone
Dry to slightly moist, medium gray, moderately firm to soft with depth; cemented layer at 40'-41', very light gray sandstone; cemented very hard layer at 44'-47'; bluish white to medium light gray, rig chattering, slow to advance, moderately carbonaceous	
47.0 - 52.0'	Silty sandstone
Moist, medium light gray, soft	
52.0 - 60.0'	Siltstone
Dry, medium light gray, color change at 56' to brownish gray (5YR 4/1)	
60.0 - 62.0'	Siltstone, some very fine sand
Moist, light olive gray to medium gray, soft, non-calcareous	
62.0 - 65.0'	Carbonaceous shale
Dry, olive gray (5Y 3/2), moderately firm, stringer cemented siltstone at 63', very light gray, non-calcareous	
65.0 - 67.0'	Sandstone
Slightly moist, medium light gray, very soft, non-calcareous, medium fine grained	
67.0 - 70.0'	Shale
Dry, grayish brown, mildly carbonaceous, moderately firm	
70.0 - 71.0'	Sandstone
Moist, medium light gray, fine grained	
71.0 - 77.0'	Siltstone
Dry to slightly moist, medium gray, soft; carbonaceous shale stringer at 71', dry, brownish gray	
77.0 - 104.0'	Shale, interbedded siltstone
Dry, medium light gray and greenish gray, firm, mildly calcareous, reacts to HCl	
104.0 - 108.0'	Interbedded sandstone/siltstone
Very fine, soft, medium dark gray	
108.0 - 119.0'	Shale
Dry, medium light gray, moderately firm, non-calcareous	
119.0 - 122.5'	Coal
Dry, brownish black, cleated	



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

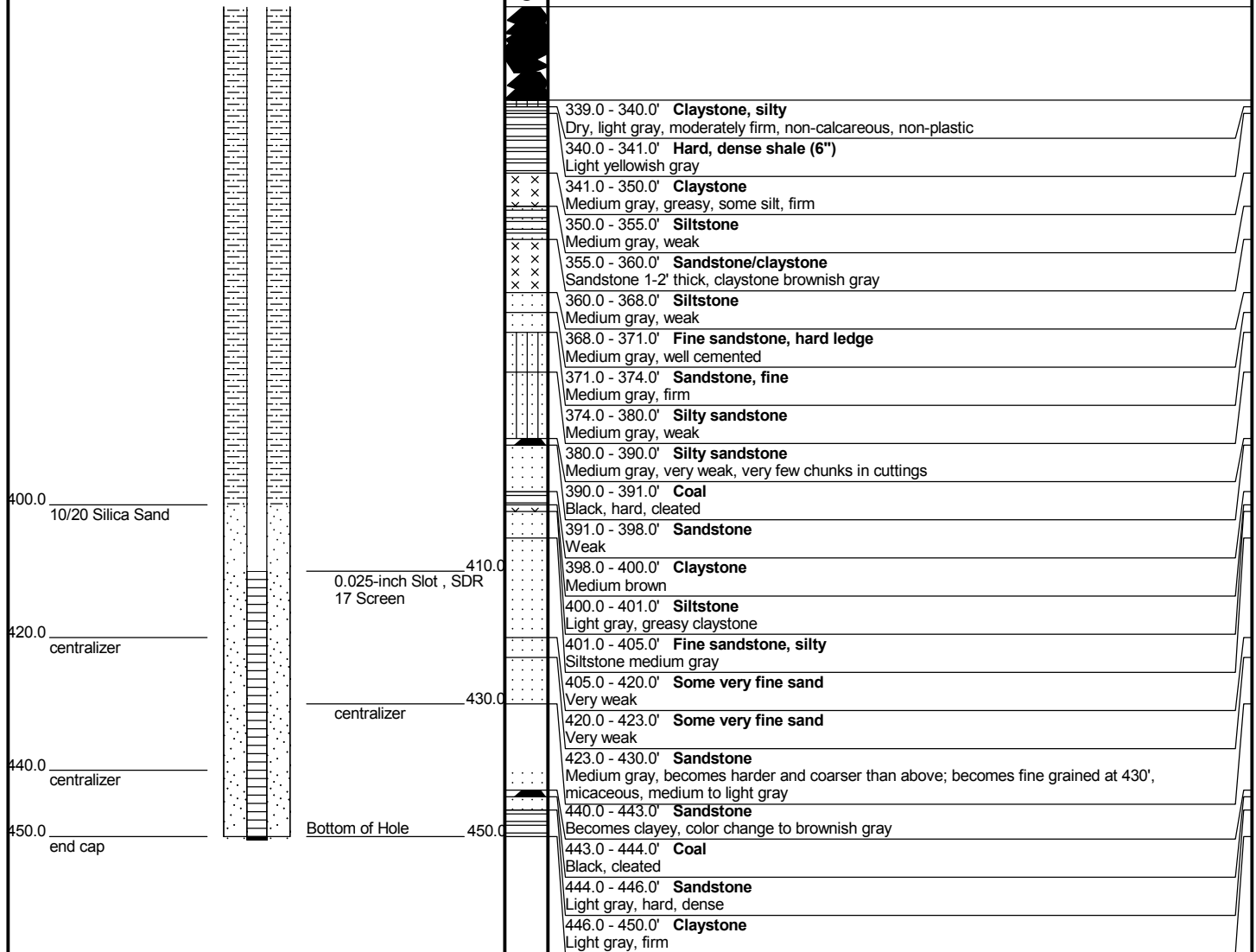
122.5 - 140.0'	Siltstone Dry, very light gray to light gray, calcareous, soft to moderately firm, interbedded sandstone at 125'-130', hard/cemented stringer at 130'
140.0 - 152.0'	Shale Dry, very thin dark interbeds, medium light gray, firm, non-calcareous, moderately carbonaceous at 140'-145', very hard cemented layer at 151'
152.0 - 155.5'	Sandstone Slightly moist to dry, light olive gray, soft to very soft
155.5 - 179.0'	Coal Dry, grayish and brownish black to black, cleated multiple planes, junk
179.0 - 190.0'	Siltstone Dry, light gray and yellowish gray, stiff, non-calcareous
190.0 - 228.0'	Sandstone, moderately fine grained Moist to very moist with depth, light medium gray, silty to 207', very soft to firm at 210', wet; inject water at 200' Interbedded claystone at 207'-209', then no fines at 210'-228'
228.0 - 233.0'	Coal Wet, black, hard, cleated multiple planes
233.0 - 239.0'	Carbonaceous shale/non-carbonaceous shale Dry, medium gray and olive gray, soft, non-plastic; cemented zone at 236'-239', non-carbonaceous, medium light gray shale, very hard, rig chattering
239.0 - 241.5'	Coal Wet, black, hard, cleated multiple times
241.5 - 248.0'	Sandstone Very moist, light olive gray (5Y 6/1)
248.0 - 259.0'	Coal [Upper Knobloch] Black, hard, cleated 3x
259.0 - 265.0'	Fine sandstone/interbedded claystone Moist, light gray and light olive gray, soft
265.0 - 295.0'	Claystone, some trace intercalated sandstone Moist, soft
295.0 - 320.0'	Sandstone, medium fine grained Very moist to wet, some interbedded claystone, light olive gray, very soft
320.0 - 339.0'	Coal [Lower Knobloch] Black, hard, cleated 3x



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B8-KL

Date Hole Started: 7/7/2011 Date Hole Finished: 7/7/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 20; N 463623.24, E 2813713.47
Location Description: B8 Battery

Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Ron and Doug Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water

Purpose of Hole: Install Monitor Well

Target Aquifer: Lower Knobloch Coal

Hole Diameter (in): 8"

Total Depth Drilled (ft): 282

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-282
Surface Casing Used?	Y	8" steel	+2-25
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	266-282
Sand Pack?	Y	10/20 silica sand	263-282
Annular Seal?	Y	Bentonite Grout and Bentonite Chips	0-247 and 247-263
Surface Seal?	N		

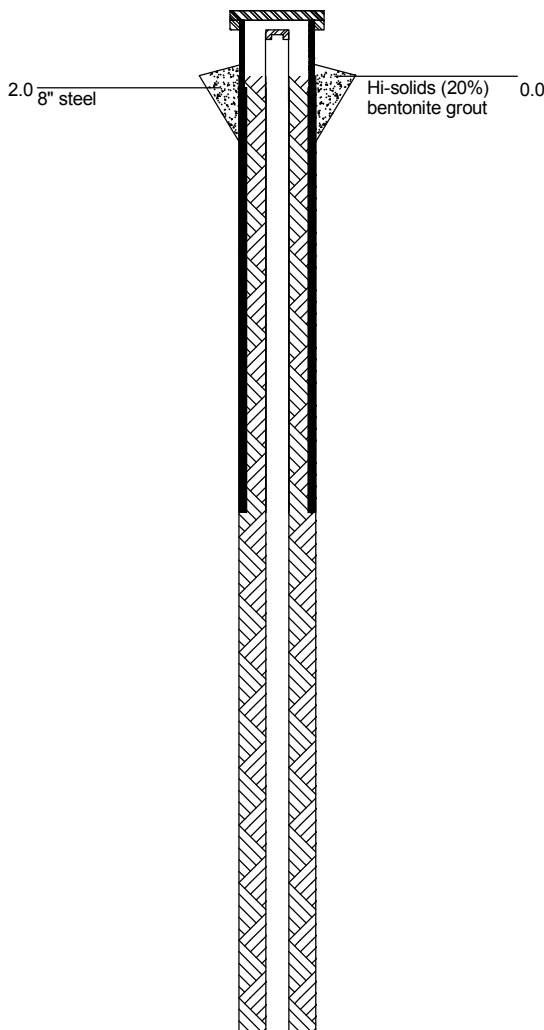
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 463623.24	Easting: 2813713.47
Static Water Level Below MP: 173.48	Surface Casing Height (ft): 1.87
Date: 7/12/2011	Riser Height (ft): 1.60
MP Description: Top PVC	Ground Surface Elevation (ft): 3223.85
MP Height Above or Below Ground (ft): 1.60	MP Elevation (ft): 3225.45

Remarks: Inject water at 60'. Annular seal with Hi-Solids (20% solid) bentonite grout and 3/8" bentonite chips. Pump test at 8 gpm, yield at full draw down +/- 12.5. SC=2090 µmhos/cm after 300 gallon purge, pH=8.18; SWL 7-11-2011 174.17 Top PVC. Developed 65 minutes - 700 to 750 gallons pumped

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

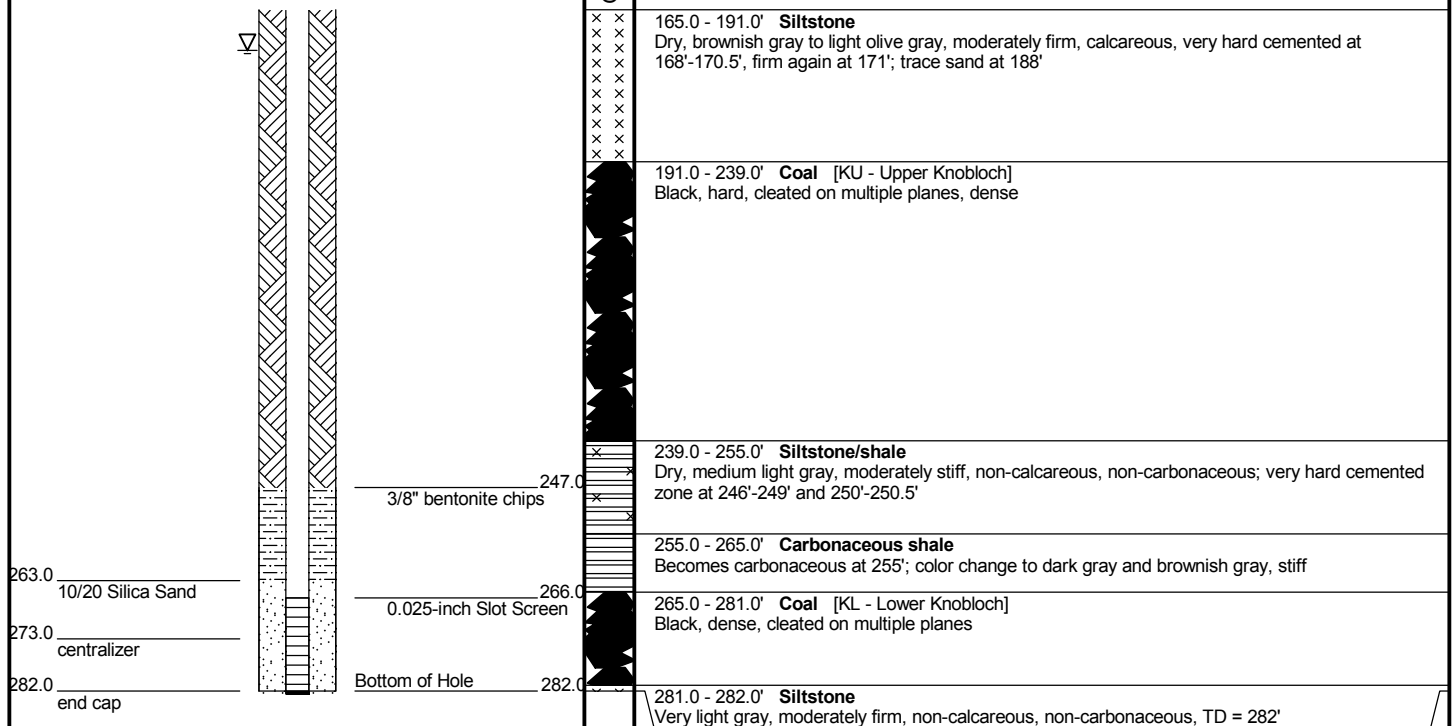
0.0 - 10.0'	Silt and clay [Topsoil/Colluvium] Slightly moist, moderate yellowish brown, loose, roots, non-plastic
10.0 - 10.5'	Shale [Bedrock] Dry, dark yellowish brown, hard, cemented
10.5 - 22.0'	Siltstone [Bedrock] Dry, pale yellowish brown and medium yellowish brown, very soft, calcareous, some interbedded fine sand at 15'-20'
22.0 - 80.0'	Sandstone, fine to very fine Dry, grayish orange, soft, calcareous, streaks of light brown throughout (5YR 5/6); cemented fine sandstone stringer, yellowish gray at 22' and 26'. Grain size increases with depth from 41'-51', to fine and medium fine grained. Color change to very light gray at 41', color change to light brown and moderate yellowish brown at 51'; becomes moist at 55', wet, inject water at 60'. Cemented siltstone stringer at 65', light brown; yield ~2 gpm open hole, TDS = 4,300 ppm
80.0 - 100.0'	Siltstone Moderate yellowish brown, soft to moderately firm, some fine sandstone interbedded
100.0 - 105.5'	Siltstone Dry, light olive gray, moderately firm, calcareous, trace coal, very minimal trace at 102'
105.5 - 165.0'	Sandstone Medium light gray to medium gray, hard, cemented, rig chattering; becomes silty, hardness decreases to firm at 111'; no silt, hard again at 115'-116'; soft to moderately firm from 116'-120', wet, making water at 130', yield ~30 gpm, TDS=1,800 ppm; trace coal at 160'-162'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B8-KU

Date Hole Started: 7/11/11 Date Hole Finished: 7/11/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 20; N 463632.67, E 2813740.46
Location Description: B8 Battery
Recorded By: RJL & AJH
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Fresh water-Ashland supply
Purpose of Hole: Install Monitor Well
Target Aquifer: Upper Knobloch
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 240

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-240
Surface Casing Used?	Y	8" steel	1.48-7.52
Screen/Perforations?	Y	4.5" Sch 40, 0.025-inch slot	193-240
Sand Pack?	Y	10/20 silica sand	183-240
Annular Seal?	Y	Bentonite Grout	0-183
Surface Seal?	Y	Bentonite Grout	0-183

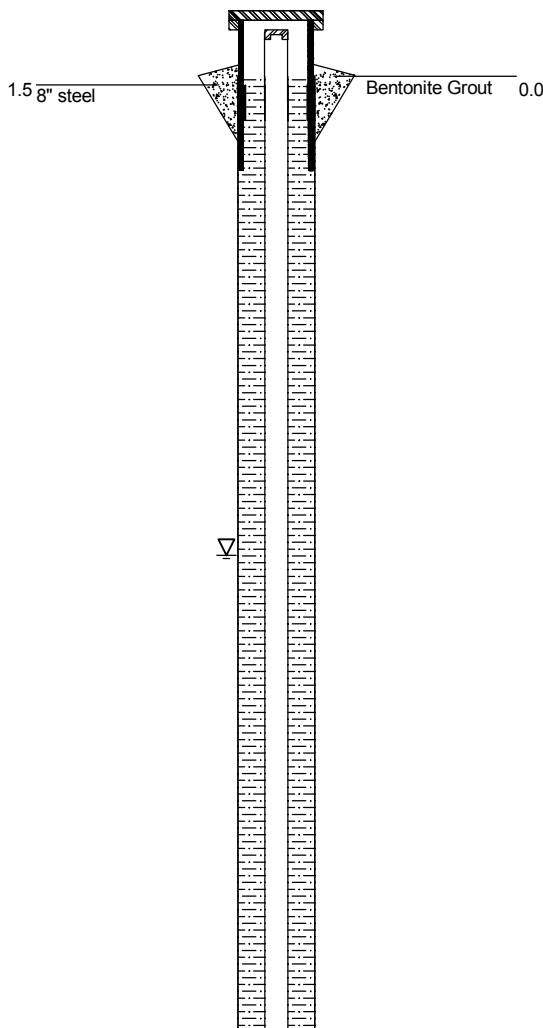
DEVELOPMENT/SAMPLING

Well Developed?	Y	Pumped
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 463632.67	Easting: 2813740.46
Static Water Level Below MP: 83.69	Surface Casing Height (ft): 1.69
Date: 7/12/2011	Riser Height (ft): 1.36
MP Description: Top PVC	Ground Surface Elevation (ft): 3223.79
MP Height Above or Below Ground (ft): 1.36	MP Elevation (ft): 3225.14

Remarks: Lithology based on well B8-KL. Injection at 60'; three hours for development and completion. Developed with 4 inch submersible pump; pumped at 19 gpm.

WELL CONSTRUCTION



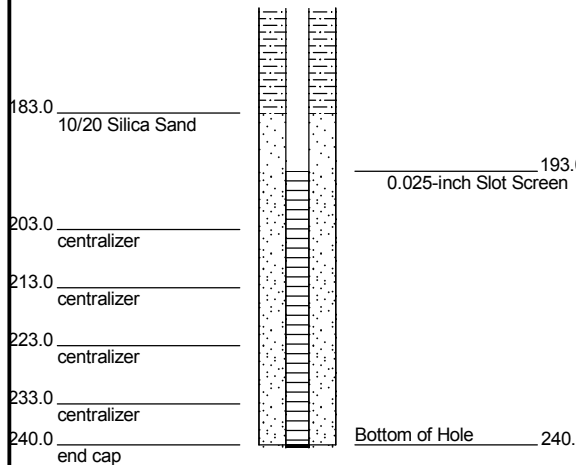
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 10.0'	Silt and clay [Topsoil/Colluvium] Slightly moist, moderate yellowish brown (10YR 5/4), loose, roots, non-plastic
10.0 - 10.5'	Shale [Bedrock] Dry, dark yellowish brown (10YR 4/2), hard, cemented
10.5 - 22.0'	Siltstone [Bedrock] Dry, pale yellowish brown (10YR 6/2) and medium yellowish brown (10YR 5/4), very soft, calcareous, some interbedded fine sand at 15'-20'
22.0 - 80.0'	Sandstone, fine to very fine Dry, grayish orange (10YR 7/4), soft, calcareous, streaks of light brown throughout (5YR 5/6); cemented fine sandstone stringer, yellowish gray (5Y 8/1) at 22' and 26'. Grain size increases with depth from 41'-51', to fine and medium fine grained. Color change to very light gray (N8) at 41', color change to light brown (5YR 6/4) and moderate yellowish brown (10YR 5/4) at 51'; becomes moist at 55', wet, begin injecting water at 60'. Cemented siltstone stringer at 65', light brown (5TR 5/6); yield ~2 gpm open hole, TDS = 4,300 ppm
80.0 - 100.0'	Siltstone Moderate yellowish brown (10YR 5/4), soft to moderately firm, some fine sandstone interbedded
100.0 - 105.5'	Siltstone Dry, light olive gray (5Y 6/1), moderately firm, calcareous, trace coal, very minimal trace at 102'
105.5 - 165.0'	Sandstone Medium light gray (N6) to medium gray (N5), hard, cemented, rig chattering; becomes silty, hardness decreases to firm at 111'; no silt, hard again at 115'-116'; soft to moderately firm from 116'-120', wet, making water at 130', yield estimated at 5-7 gpm; trace coal at 160'-162'



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

165.0 - 191.0' **Siltstone**

Dry, brownish gray (5YR 4/1) to light olive gray (5Y 6/1), moderately firm, calcareous, very hard cemented at 168'-170.5', firm again at 171'; trace sand at 188'

191.0 - 239.0' **Coal** [KU - Upper Knobloch]

Black, hard, cleated on multiple planes, dense, estimated yield 19 gpm

239.0 - 255.0' **Siltstone/shale**

Dry, medium light gray (N6), moderately stiff, non-calcareous, non-carbonaceous; very hard cemented zone at 246'-249' and 250'-250.5'

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: B8-O

Date Hole Started: 7/11/11 Date Hole Finished: 7/11/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 20 N
463636.15, E 2813751.51
Location Description: B8 Battery
Recorded By: RJL & AJH
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Fresh water-Ashland supply
Purpose of Hole: Install Monitor Well
Target Aquifer: Overburden
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 165

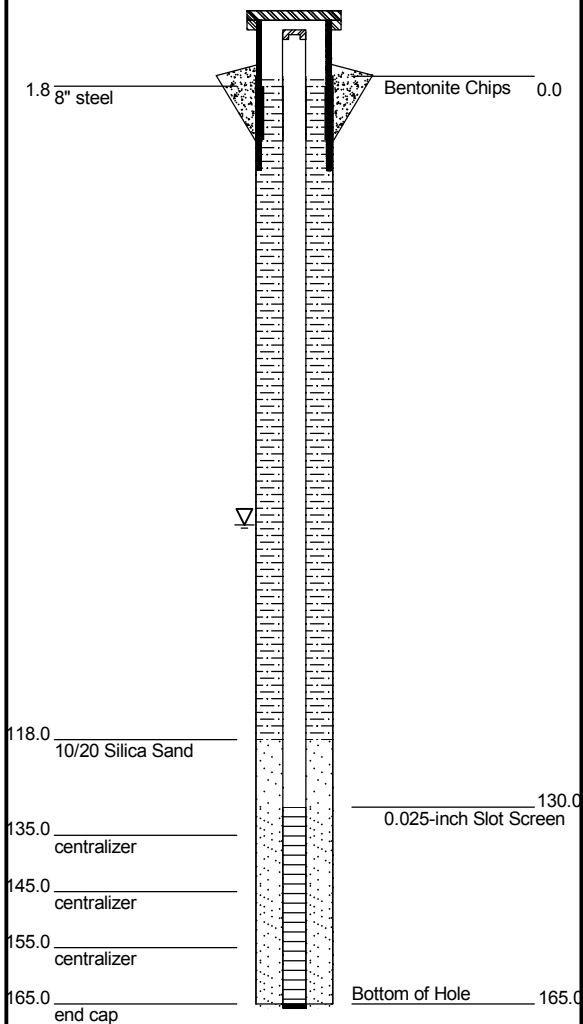
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-165
Surface Casing Used?	Y	8" steel	+1.75-11.25
Screen/Perforations?	Y	4.5" 0.025-inch slot	130-165
Sand Pack?	Y	10/20 silica sand	118-165
Annular Seal?	Y	Bentonite Chips	118-0
Surface Seal?	Y	Bentonite Chips	118-0

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Lift
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 463636.15	Easting: 2813751.51	
Static Water Level Below MP: 81.28	Surface Casing Height (ft): 1.78	
Date: 7/12/2011	Riser Height (ft): 1.48	
MP Description: Top PVC	Ground Surface Elevation (ft): 3223.82	
MP Height Above or Below Ground (ft): 1.48	MP Elevation (ft): 3225.3	

Remarks: Lithology based on well B8-KL. Drilled through sandstone, deepest water at 130'-165' interval, screened this interval; trace water at 70' maybe 1-2 gpm at 80'. Yield estimated at 5-7 gpm during air-lift development.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 10.0'	Silt and clay [Topsoil/Colluvium] Slightly moist, moderate yellowish brown (10YR 5/4), loose, roots, non-plastic
10.0 - 10.5'	Shale [Bedrock] Dry, dark yellowish brown (10YR 4/2), hard, cemented
10.5 - 22.0'	Siltstone [Bedrock] Dry, pale yellowish brown (10YR 6/2) and medium yellowish brown (10YR 5/4), very soft, calcareous, some interbedded fine sand at 15'-20'
22.0 - 80.0'	Sandstone, fine to very fine Dry, grayish orange (10YR 7/4), soft, calcareous, streaks of light brown throughout (5YR 5/6); cemented fine sandstone stringer, yellowish gray (5Y 8/1) at 22' and 26'. Grain size increases with depth from 41'-51', to fine and medium fine grained. Color change to very light gray at 41', color change to light brown (5YR 5/6) and moderate yellowish brown (10YR 5/4) at 51'; becomes moist at 55', wet, begin injecting water at 60'. Cemented siltstone stringer at 65', light brown (5YR 5/6); yield ~2 gpm open hole, TDS = 4,300 ppm
80.0 - 100.0'	Siltstone Moderate yellowish brown (10YR 5/4), soft to moderately firm, some fine sandstone interbedded
100.0 - 104.5'	Siltstone Dry, light olive gray (5Y 6/1), moderately firm, calcareous, trace coal, very minimal trace at 102'
104.5 - 110.0'	Shale Dark gray (N3)
110.0 - 163.0'	Sandstone Medium light gray (N6) to medium gray (N5), hard, cemented, rig chattering; becomes silty, hardness decreases to firm at 111'; no silt, hard again at 115'-116'; soft to moderately firm from 116'-120', wet, making water at 130', yield estimated at 5-7 gpm; trace coal at 160'
163.0 - 165.0'	Clayey siltstone [Fort Union Formation] Olive gray (5Y 4/1), weakly calcareous, weakly laminated (mm)

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Billings, Montana



Monitor Well Log

Hole Name: B8-U

Date Hole Started: 7/8/2011 Date Hole Finished: 7/8/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 20; N 463627.36, E 2813725.73
Location Description: B8 Battery

Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Ron and Doug Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water

Purpose of Hole: Install Monitor Well

Target Aquifer: Knobloch Underburden

Hole Diameter (in): 8"

Total Depth Drilled (ft): 480

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" SDR-17 PVC	2-480
Surface Casing Used?	Y	8" steel	+2-18
Screen/Perforations?	Y	4.5" 0.025-inch slot SDR-17	440-480
Sand Pack?	Y	10/20 silica sand	436-480
Annular Seal?	Y	Bentonite Grout and Bentonite Chips	0-436
Surface Seal?	N		

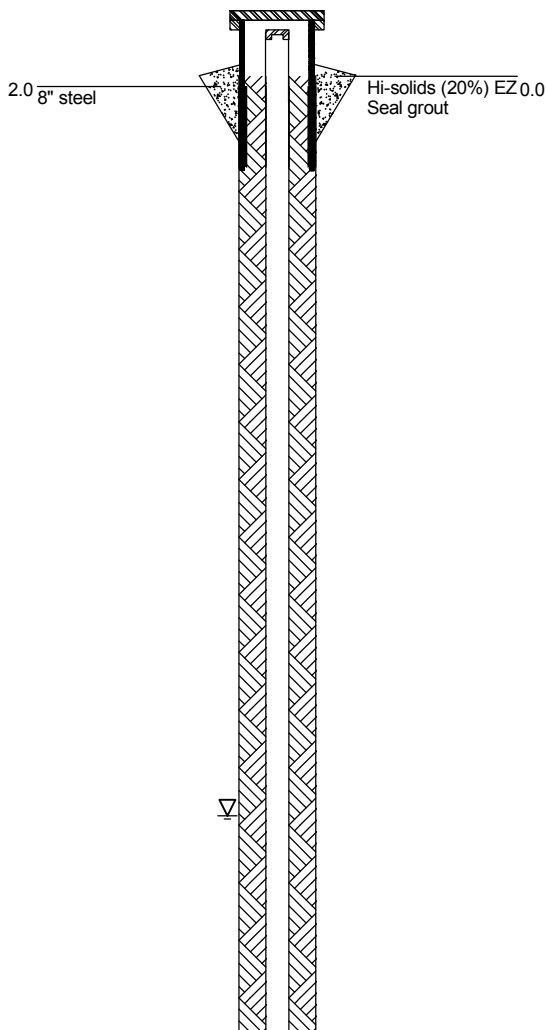
DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 463627.36	Easting: 2813725.73
Static Water Level Below MP: 147.71	Surface Casing Height (ft): 1.60
Date: 7/12/2011	Riser Height (ft): 1.35
MP Description: Top PVC	Ground Surface Elevation (ft): 3223.87
MP Height Above or Below Ground (ft): 1.35	MP Elevation (ft): 3225.22

Remarks: Lithology based on Log B8-KL; cuttings verified in field during drilling. Injecting water at 60'. Developed air lift 1 hour; yield at 5 gpm with pipe at 380'. SC=2290 µmhos/cm development water, pH=7.8

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

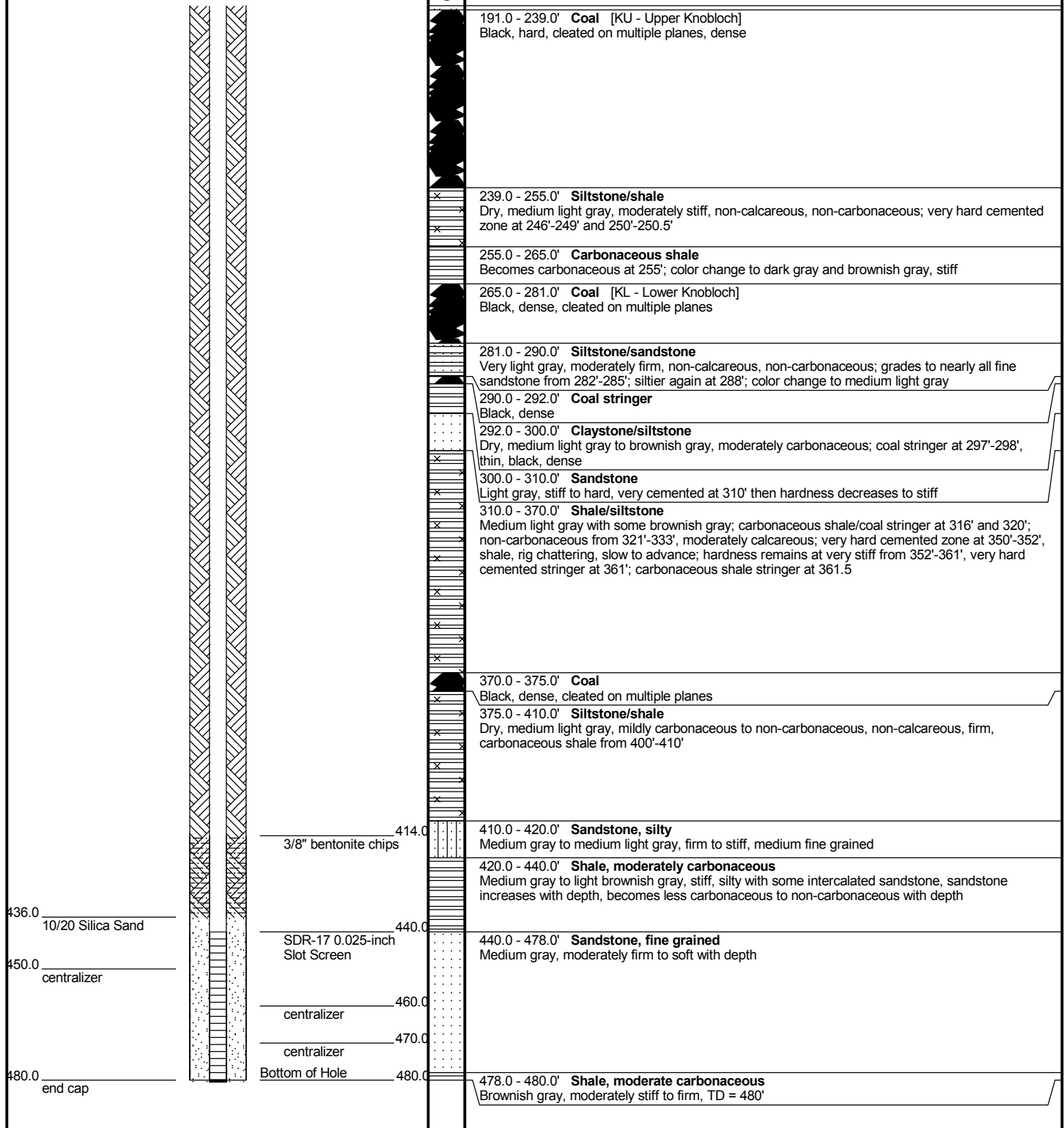
0.0 - 10.0'	Silt and clay [Topsoil/Colluvium] Slightly moist, moderate yellowish brown, loose, roots, non-plastic
10.0 - 10.5'	Shale [Bedrock] Dry, dark yellowish brown, hard, cemented
10.5 - 22.0'	Siltstone [Bedrock] Dry, pale yellowish brown and medium yellowish brown, very soft, calcareous, some interbedded fine sand at 15'-20'
22.0 - 80.0'	Sandstone, fine to very fine Dry, grayish orange, soft, calcareous, streaks of light brown throughout (5YR 5/6); cemented fine sandstone stringer, yellowish gray at 22' and 26'. Grain size increases with depth from 41'-51', to fine and medium fine grained. Color change to very light gray at 41', color change to light brown and moderate yellowish brown at 51'; becomes moist at 55', wet, inject water at 60'. Cemented siltstone stringer at 65', light brown; yield ~2 gpm open hole, TDS = 4,300 ppm
80.0 - 100.0'	Siltstone Moderate yellowish brown, soft to moderately firm, some fine sandstone interbedded
100.0 - 105.5'	Siltstone Dry, light olive gray, moderately firm, calcareous, trace coal, very minimal trace at 102'
105.5 - 165.0'	Sandstone Medium light gray to medium gray, hard, cemented, rig chattering; becomes silty, hardness decreases to firm at 111'; no silt, hard again at 115'-116'; soft to moderately firm from 116'-120', wet, making water at 130', yield ~30 gpm, TDS=1,800 ppm; trace coal at 160'-162'
165.0 - 191.0'	Siltstone Dry, brownish gray to light olive gray, moderately firm, calcareous, very hard cemented at 168'-170.5', firm again at 171'; trace sand at 188'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



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Monitor Well Log

Hole Name: B9-K

Date Hole Started: 7/13/11 Date Hole Finished: 7/13/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: State of Montana
Legal Description: T4S, R45E, Sec. 16, N
471769.36, E 2817516.92
Location Description: North edge State Section
16
Recorded By: AJH
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 185

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+1.27-185
Surface Casing Used?	Y	8" steel	+1.6-18.5
Screen/Perforations?	Y	4.5" 0.025-inch slot	116-185
Sand Pack?	Y	10/20 silica sand	185-109
Annular Seal?	Y	Bentonite Chips	109-0
Surface Seal?	N		

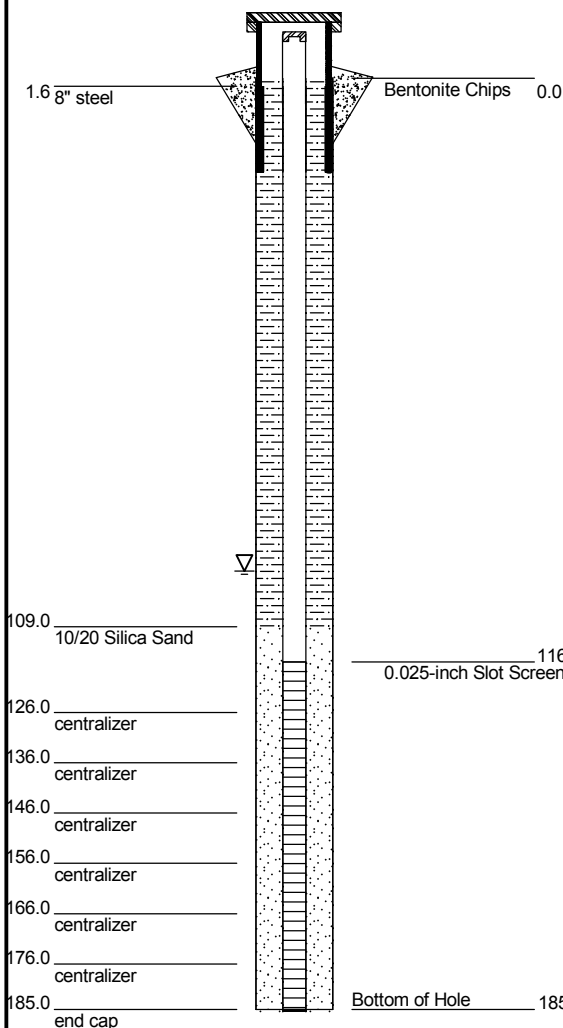
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Lift
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 471769.36	Easting: 2817516.92
Static Water Level Below MP: 99.26	Surface Casing Height (ft): 1.65
Date: 7/15/2011	Riser Height (ft): 1.32
MP Description: Top PVC	Ground Surface Elevation (ft): 3135.00
MP Height Above or Below Ground (ft): 1.32	MP Elevation (ft): 3136.32

Remarks: Lithology based on well B9-U. Tested 40 ft. zone extensively and found to be very moist with no free water. Top of the Knobloch at 115.5' bgs, and bottom of the Knobloch at 185' bgs.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 2.0'	Silty clay [Topsoil] Dry, trace roots, calcareous, pale yellow brown (10YR 6/2)
2.0 - 5.0'	Clay [Colluvium or Weathered Bedrock] Moist to very moist, plastic, calcareous, moderate yellow brown (10YR 5/4)
5.0 - 40.0'	Claystone grading to shale [Fort Union Formation] Dry, weakly calcareous, some burn at 8'-8.5', 12'-13' and 19'-19.5'; dark yellowish orange (10YR 6/6); burn more calcareous, trace carbonaceous layers (laminations in shale), dark gray with depth. less carbon
40.0 - 67.0'	Shale [Fort Union Formation] Slightly moist, medium dark gray (N4). Very moist thin hard layer at 40', tested and found no water. Hard layers also at 50'-50.1' and 66'-67'
67.0 - 70.0'	Silty shale and siltstone Slightly moist, light olive gray (5Y 6/1)
70.0 - 90.5'	Clayey siltstone Slightly moist, light olive gray (5YR 6/1), browner in spots, carbonaceous with trace of coal below 86', calcareous, trace sand
90.5 - 115.5'	Interbedded shale and minor amounts of laminated siltstone Slightly moist, light olive gray (5Y 6/1), hard layers at 94.5' and 108'-108.5', calcareous
115.5 - 183.0'	Coal Dry at top, more moisture with depth, moist at 140', wet at 160'-165', black to brown black, Knobloch starts making water at 175' from open hole; coal is soft at top and harder and cleated in 3 directions at approximately 170' bgs
183.0 - 185.0'	Silty Claystone Dry, light olive gray (5Y 6/1), laminated, soft

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Monitor Well Log

Hole Name: B9-U

Date Hole Started: 7/13/11 Date Hole Finished: 7/13/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: State of Montana
Legal Description: T4S, R45E, Sec. 16, N 471759.32, E 2817523.68
Location Description: North edge State Section 16
Recorded By: AJH
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Underburden for coal
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 295

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" SDR-17 Certa-Lok-ID well casing	+1.41-295
Surface Casing Used?	Y	8" steel	+1.76-18.2
Screen/Perforations?	Y	0.025-inch slot, SDR-17 PVC	282-295
Sand Pack?	Y	10/20 silica sand	295-278
Annular Seal?	Y	Bentonite Chips	278-0
Surface Seal?	N		

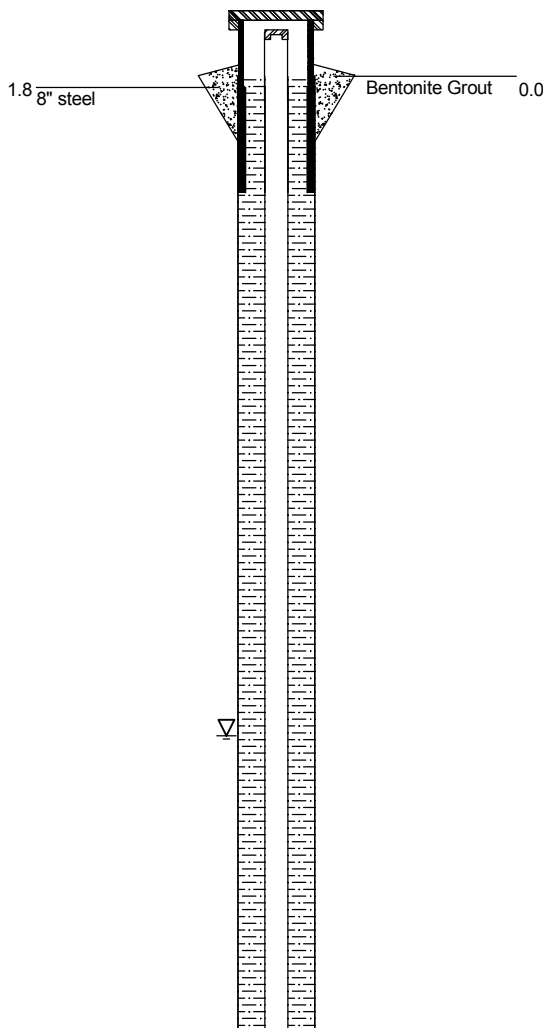
DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailed
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 471759.32	Easting: 2817523.68
Static Water Level Below MP: 104.57	Surface Casing Height (ft): 1.88
Date: 7/15/2011	Riser Height (ft): 1.54
MP Description: Top PVC	Ground Surface Elevation (ft): 3134.60
MP Height Above or Below Ground (ft): 1.54	MP Elevation (ft): 3136.14

Remarks: Tested Knobloch for yield at base of coal, 5-8 gpm. Tested for water at 241'-251' and there was apparently no water, SC=1698 µmhos/cm, pH=8.44, may be trace water due to SC change. Cased coal may be Flowers-Goodale seam. Yield est. at 1.5 gpm.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

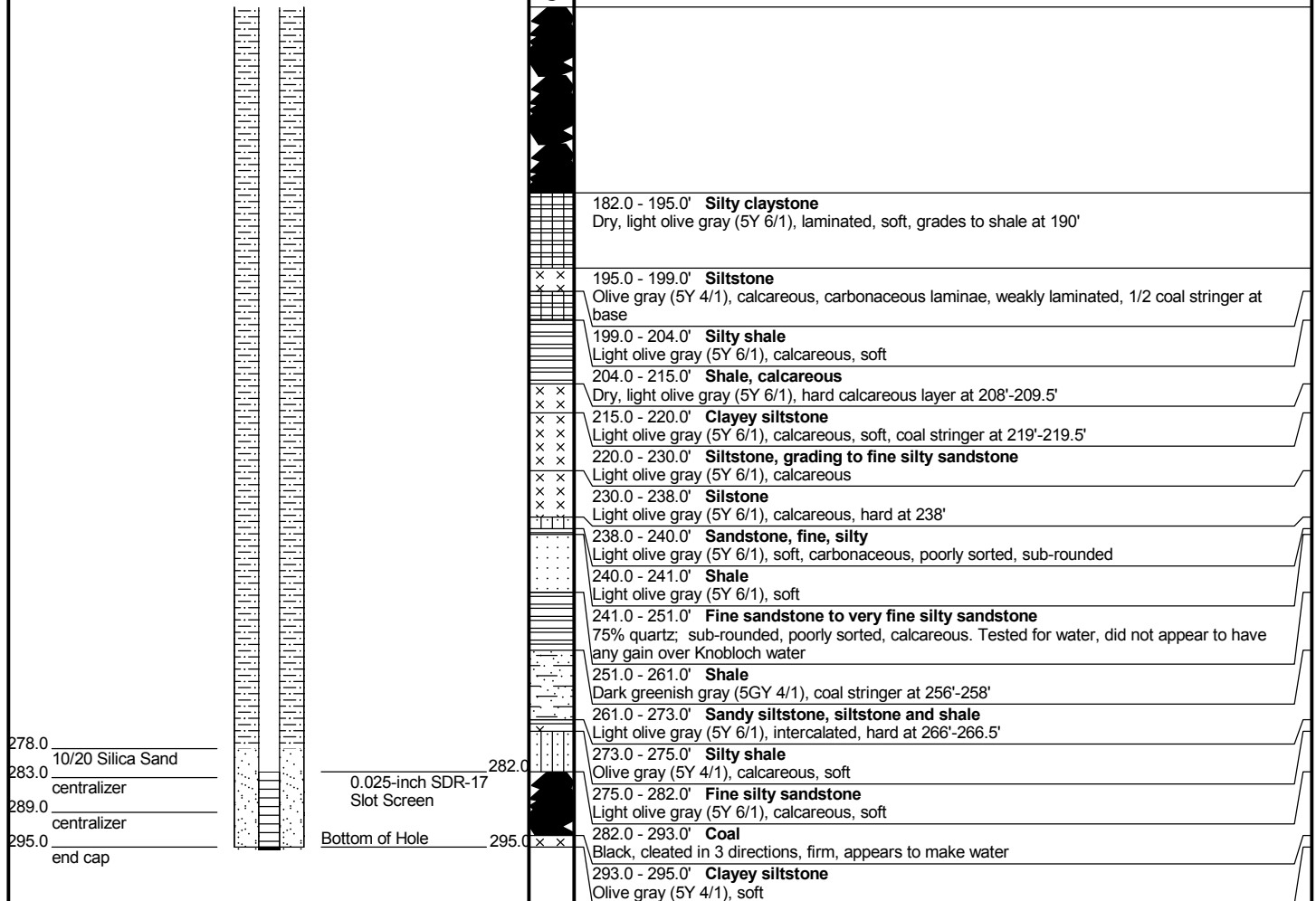
0.0 - 2.0'	Silty clay [Topsoil] Dry, trace roots, calcareous, pale yellow brown (10YR 6/2)
2.0 - 5.0'	Clay [Weathered Bedrock] Moist to very moist, plastic, calcareous, moderate yellow brown (10YR 5/4)
5.0 - 40.0'	Claystone grading to shale [Fort Union Formation] Dry, weakly calcareous, some burn at 8'-8.5', 12'-13' and 19'-19.5'; dark yellowish orange (10YR 6/6); burn more calcareous, trace carbonaceous layers (laminations in shale), dark gray with depth. less carbon
40.0 - 67.0'	Shale [Fort Union Formation] Slightly moist, medium dark gray (N4). Very moist thin hard layer at 40', tested and found no water. Hard layers also at 50'-50.1' and 66'-67'
67.0 - 70.0'	Silty shale and siltstone Slightly moist, light olive gray (5Y 6/1)
70.0 - 90.5'	Clayey siltstone Slightly moist, light olive gray (5YR 6/1), browner in spots, carbonaceous with trace of coal below 86', calcareous, trace sand
90.5 - 115.0'	Interbedded shale and minor amounts of laminated siltstone Slightly moist, light olive gray (5Y 6/1), hard layers at 94.5' and 108'-108.5', calcareous
115.0 - 182.0'	Coal Dry at top, more moisture with depth, moist at 140', wet at 160'-165', black to brown black, Knobloch starts making water at 175' from open hole; coal is soft at top and harder and cleated in 3 directions at approximately 170' bgs



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION





Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description:
Location Description: Just west of Stevens road to house
Recorded By: HJK
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 4.5"
Total Depth Drilled (ft): 19

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	N		NA
Surface Casing Used?	N		NA
Screen/Perforations?	N		NA
Sand Pack?	N		NA
Annular Seal?	N		NA
Surface Seal?	Y	Bentonite Chips	0-19

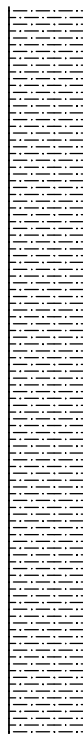
DEVELOPMENT/SAMPLING

Well Developed?	N
Water Samples Taken?	N
Boring Samples Taken?	N

Northing:	Easting:
Static Water Level Below MP:	Surface Casing Height (ft):
Date:	Riser Height (ft):
MP Description:	Ground Surface Elevation (ft):
MP Height Above or Below Ground (ft):	MP Elevation (ft):

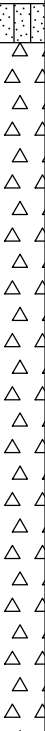
Remarks: Hole abandoned, backfilled with bentonite chips - moved to South to avoid thick clinker.

WELL CONSTRUCTION



Bottom of Hole 19.0

GRAPHICS



GEOLOGICAL DESCRIPTION

0.0 - 1.0' **Silty sand**
Dry, light brown, roots

1.0 - 19.0' **Clinker**
Dry, light reddish brown to moderate red (5R 4/6), dusky red (5R 3/4), altered shales and fine-grained sandstone, hard

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Billings, Montana



Monitor Well Log

Hole Name: C-1

Date Hole Started: 7/5/11

Date Hole Finished: 7/6/11

Client: Arch Coal

Project: Otter Creek Mine Permit (10068)

County: Powder River State: Montana

Property Owner: Ark Land Company

Legal Description: T3S, R45E, Sec. 34, Tract
SW 1/4 NW 1/4; N 485805.50, E 2820986.59

Location Description: Near Stevens/Trusler
property boundary and Sections 33/34 border
Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Ron and Doug Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water

Purpose of Hole: Install Monitor Well

Target Aquifer: Clinker

Hole Diameter (in): 11" (0-40'), 8" (40-150')

Total Depth Drilled (ft): 150

WELL COMPLETION

Y/N

DESCRIPTION

INTERVAL

Well Installed?

Y

8" steel open bottom

+2-147

Surface Casing Used?

Y

8" steel

+2-147

Screen/Perforations?

N

Sand Pack?

N

Annular Seal?

Y

Bentonite Chips

drill & drive

Surface Seal?

N

DEVELOPMENT/SAMPLING

Well Developed?

Y

Rig Air

Water Samples Taken? N

Boring Samples Taken? N

Northing: 485805.5

Easting: 2820986.59

Static Water Level Below MP:

Surface Casing Height (ft):

Date:

Riser Height (ft): 1.70

MP Description:

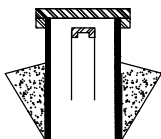
Ground Surface Elevation (ft): 3174.78

MP Height Above or Below Ground (ft): 1.70

MP Elevation (ft): 3176.48

Remarks: Drill and drive 8-inch steel to 100', becomes very hard. Drive end of steel pipe bent down hole. Attempt to drill out with 7 7/8" roller bit; would not drill out but reached 115' with 5" drag bit. Pull steel and start driving again with 8" well master drive shoe welded to drive end (7-6-2011). Drill and drive to 147' bgs, open hole 147'-150'. Yield is very low, not enough water to bail.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0' **Silt with clinker gravel** [Colluvium/Weathered Bedrock Clinker]

Slightly moist, dark reddish brown (10R 3/4) to moderate brown (5YR 3/4)

1.0 - 3.0' **Thermally altered sandstone** [Clinker]

Dry, moderate reddish orange to moderate reddish brown, hard, cuttings ground

3.0 - 35.0' **Thermally altered sandstone/siltstone** [Clinker]

Dry, moderate reddish orange to moderate reddish brown, very hard, cuttings ejected as gravel/cobble size fragments. Very sandy, cuttings were ground at 10', color change to all moderate reddish brown; less sand again at 20'. Color change to moderate orange pink (10R 7/4 and 5YR 8/4) at 22'; color change to grayish red (10R 4/2) at 33'

35.0 - 55.0' **Thermally altered shale** [Clinker]

Dry, pale red and pale brown, some light brown (5YR 6/4), very hard. Color change to grayish orange pink (5YR 7/2) and light brown (5YR 6/4) at 40'

55.0 - 90.0' **Thermally altered siltstone/sandstone**

Dry, sandstone texture fine to very fine, pale red (5R 6/2 and 10R 6/2), hard to very hard. Trace calcareous, very pale orange baked siltstone at 55'. Color change to pale reddish brown at 85'

90.0 - 105.0' **Thermally altered shale**

Dry, pale red to very dusky purple to very dusky red purple, very very hard, rig slow to advance. Medium light gray to light bluish gray color at 99'-101'. Color returns to pale red to very dusky purple to very dusky red purple with traces medium light gray to light bluish gray at 101'. Switch from drag bit to 7 7/8" Tricone roller bit at 102'; drove steel to 120', injected some water at 105'.

105.0 - 110.0' **Burned siltstone/sandstone interbedded**

Dry, pale red, some hard to very hard, ejected as cobbles, other cuttings ground; some medium light gray shale interbeds

110.0 - 134.0' **Burned sandstone** [Clinker]

Dry, pale red to grayish orange and grayish orange pink with depth; softer than above but still hard, cuttings ground mostly to sand size particles, some cohesive gravel size fragments. Color change to very pale orange at 125', poor returns on cuttings/poor circulation

134.0 - 143.0' **Burned shale** [Clinker]

Dry, very light gray and yellowish gray, very hard; colors include pale reddish brown and pale red purple at 137'

143.0 - 145.0' **Burned sandstone/ash** [Clinker/Bedrock]

Slightly moist, trace other vitrified sediments, grayish orange and very pale orange, some hard, some loose, cuttings ground

145.0 - 150.0' **Baked shale/carbonaceous** [Bedrock]

Very moist to wet from 145'-147', medium dark gray, very hard to firm with depth, injecting water at 148'; harder at top due to proximity to burn

147.0

8" steel open bottom

Bottom of Hole

150.0

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Billings, Montana



Monitor Well Log

Hole Name: C-2

Date Hole Started: 6/29/11 Date Hole Finished: 6/29/11

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 9; N 476059.44, E 2818546.45
Location Description: Clinker knob near Highway 484
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: None
Purpose of Hole: Install Monitor Well
Target Aquifer: Base of Clinker
Hole Diameter (in): 8"
Total Depth Drilled (ft): 63

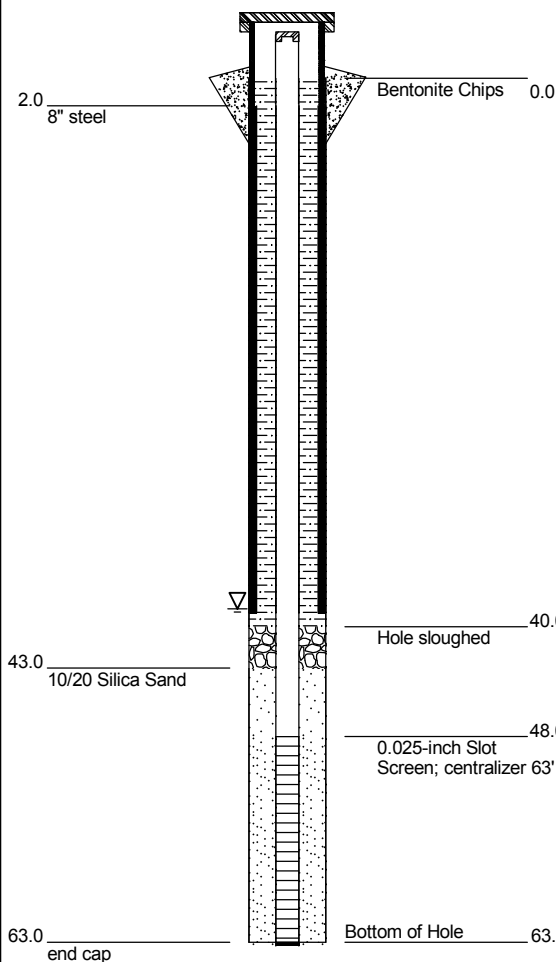
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-63
Surface Casing Used?	Y	8" steel	+2-39
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	48-63
Sand Pack?	Y	10/20 silica sand	43-63
Annular Seal?	Y	Bentonite Chips	0-40
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air, 2 gpm pump
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 476059.44	Easting: 2818546.45	
Static Water Level Below MP: 40.50	Surface Casing Height (ft): 2.20	
Date: 6/29/2011	Riser Height (ft): 1.82	
MP Description: Below PVC	Ground Surface Elevation (ft): 3065.54	
MP Height Above or Below Ground (ft): 1.82	MP Elevation (ft): 3067.36	

Remarks: Drill with 7 7/8" drag bit to 40' ream with 10" drag bit; drive 61' of 8" steel, steel pulled back to expose perforations; developed with rig air and 2 gpm pump, color from dark brown to clear during development. Hole sloughed from 40'-43' bgs when steel pulled back. SC=3450 µmhos/cm, pH=8.03, temp=18.5° C; after development.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 14.0'	Silty clay [Colluvium] Dry to moist, moderate yellowish brown and moderate brown, loose, trace white calcareous precipitates; trace clinker gravel at 9', becomes sandy at 11' and color change to pale reddish brown (10R 5/4)
14.0 - 21.0'	Sandstone, thermally altered [Clinker] Dry, grayish orange pink to pale red, very hard to soft, medium fine grain, color change to pale reddish brown at 21'
21.0 - 33.0'	Baked siltstone/sandstone (50/50) [Clinker] Dry, pale reddish brown, sandstone soft, cuttings ground; siltstone hard ejected as cobble-sized fragments; becomes mostly sandstone from 29'-33'
33.0 - 45.0'	Baked sandstone [Clinker] Dry, pale red (10R 6/2), hard, cuttings ground; moisture to very moist at 43'
45.0 - 55.0'	Baked shale [Clinker] Wet, light brown to moderate reddish brown, very hard, gravel to cobble size cuttings ejected, color change to light olive gray at 53'-55', trace ash - very little to no ash
55.0 - 63.0'	Coal [Knobloch] Wet, black, cleated, very hard, refusal of 8" steel

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: C-3

Date Hole Started: 4/6/2011 Date Hole Finished: 4/13/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Ark Land Company
Legal Description: T4S, R45E, Sec. 10; N 474644.74, E 2823620.11
Location Description: Clinker well west of weather station
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron and Doug Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water/Foam
Purpose of Hole: Install Monitor Well
Target Aquifer: Clinker
Hole Diameter (in): 11"(0-39'), 8"(39-120'), 6"(120-140')
Total Depth Drilled (ft): 140

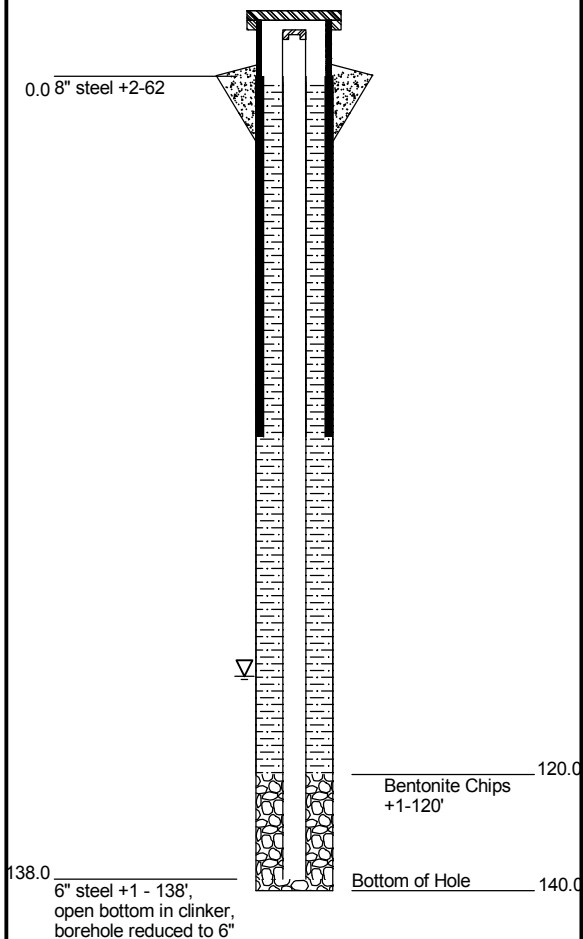
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	6-inch ID steel	+2-138
Surface Casing Used?	Y	8" steel	+2-62
Screen/Perforations?	Y	open hole	
Sand Pack?	N		
Annular Seal?	Y	Bentonite Chips	+1-120
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 474644.74	Easting: 2823620.11	
Static Water Level Below MP: 104.97	Surface Casing Height (ft): 1.96	
Date: 4/13/2011	Riser Height (ft): 1.82	
MP Description: Top 6" Steel	Ground Surface Elevation (ft): 3128.47	
MP Height Above or Below Ground (ft): 1.82	MP Elevation (ft): 3130.29	

Remarks: Drill and drive 8" steel to 62' bgs (refusal), drill to 120', lost circulation/poor returns. Attempted to use Drilling Foam to increase circulation on 4-7-2011. Returned to borehole on 4-13-2011; drive 6" steel to 138', drill to 140' bgs. Hole sloughed to 138' bgs, completed open hole. Well developed with rig air, yield approximately 100 gpm, SC=3700 µmhos/cm after development.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

△ △	0.0 - 10.0' Clinker, burned sandstone Dry, pale reddish brown (0'-1') then moderate reddish orange, hard, cuttings ground by bit, moderately to severely brecciated at ground surface
△ △	10.0 - 19.0' Clinker, baked shale Dry, very hard, moderate reddish orange (10R 6/6) to light brown (5YR 5/6), very thin, soft, pale yellowish orange interbed (precipitated salts) at 15', calcareous
△ △	19.0 - 55.0' Clinker, baked siltstone/some sandstone, thickly interbedded Dry, moderate red (5R 4/6); increasing sand texture to 30', color change to pale red/grayish pink at 30' then decreasing sand texture to 40', color change to moderate reddish orange at 40' Color change to pale reddish brown at 45', sandy Color change to moderate red (5R 4/6) at 50', silty
△ △	55.0 - 124.0' Clinker, baked sandstone, fine to medium fine grain Dry, moderate reddish brown (10R 4/6) and moderate red (5R 4/6), stiff to moderately hard, cuttings ground Becomes very hard at 61'-63', rig slow to advance, color change to grayish orange pink then color back to moderate reddish brown, hardness to stiff Some interbedded baked siltstone at 70', then multiple color changes: Dusky red at 71'-73' Moderate orange pink (10R 7/4) at 73'-74', hardness change to soft, drills fast Moderate orange pink (5YR 8/4) and light red (5R 6/6) at 74'-75' Moderate orange pink (10R 7/4) at 75'-76' Dusky red (5R 3/4) at 76'-77' Moderate reddish orange (10R 6/6) at 77'-80' Moderate reddish brown (10R 4/6) to moderate red (5R 5/4) at 80-87' Colors from moderate reddish orange to pale reddish brown at 87'-100' Moisture increase to slightly moist at 90', increase to moderately moist at 93', very moist at 100', wet at 105' makes water, cuttings returned in clumps, try to inject water at 115' Hardness to very hard at 121'-124'
△ △	to 120' on 4/6/2011, resume drilling at 120' on 4/13/2011 hardness to very hard at 121' - 124'
△ △	124.0 - 129.0' Clinker, baked sandstone, fine to medium fine grain As above, some sandstone with interbedded baked shale, color to pale yellowish orange (10YR 8/6)
△ △	129.0 - 140.0' Clinker, baked shale Wet, very dark red (5R 2/6) and dusky red (5R 3/4), very hard Color change to moderate reddish brown at 131' Color change to dark reddish brown and dusky brown/black at 133'-135' then multi-colored with light to dark grays and grayish reds from 135'-140', laminated black streaks and iron (orange) streaks

Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Monitor Well Log

Hole Name: C-4

Date Hole Started: 11/9/10

Date Hole Finished: 11/9/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15; N 469778.33, E 2824994.5
Location Description: West of K-5 near edge of floodplain
Recorded By: ajh
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Clinker
Hole Diameter (in): 8.6"
Total Depth Drilled (ft): 120

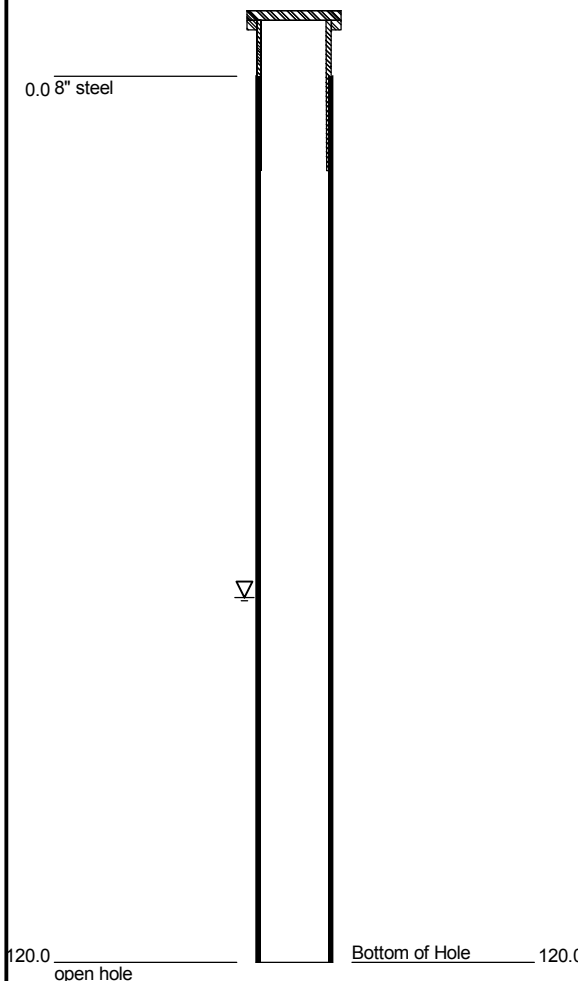
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	8" steel open bottom	0-120
Surface Casing Used?	Y	8" steel, 0.25" wall, 0.33" wall	0-120
Screen/Perforations?	Y	Open End	
Sand Pack?	N		
Annular Seal?	Y	Bentonite added to annulus	0-120
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air Lift
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 469778.33	Easting: 2824994.5	
Static Water Level Below MP: 72.01	Surface Casing Height (ft): 1.50	
Date: 11/9/2012	Riser Height (ft):	
MP Description: Top of Steel	Ground Surface Elevation (ft): 3107.42	
MP Height Above or Below Ground (ft): 1.40	MP Elevation (ft): 3108.81	

Remarks: Developed for 15 minutes, flow estimated at 250gpm, water cleared rapidly, SC=4,140 μ mhos/cm, pH=8.14, temp=11.4°C. Encountered clinker at 43', drilled 8" steel to complete well. Bottom 20' in 0.33 wall steel

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 3.0' Silty Clay	Dry, moderate yellowish brown (10YR 5/4), weakly calcareous, few roots, poor topsoil/colloivium
3.0 - 7.0' Clay [Colluvium]	Moist, moderate brown (5YR 3/4), cohesive, may be plastic, very soft, calcareous, rolls 1/8"
7.0 - 10.0' Clay, silty with siltstone inclusions [Colluvium]	Moist, dark yellowish orange (10YR 6/6), very soft, non calcareous
10.0 - 12.0' Claystone [Bedrock]	Moist, grayish orange (10YR 7/4) to moderate brown (5YR 4/4), weakly calcareous
12.0 - 15.0' Claystone	Moist, grayish orange (10YR 7/4) to moderate brown (5YR 4/4), weakly calcareous but harder
15.0 - 17.0' Shale	Slightly moist, dark yellowish brown (10YR 6/6), weakly calcareous, very soft
17.0 - 18.0' Shale	Slightly moist, dusky yellowish brown (10YR 2/2), weakly calcareous, very soft
18.0 - 20.0' Clayey Siltstone	Slightly moist, dark yellowish orange (10YR 6/6), calcareous, soft
20.0 - 25.0' Claystone, silty	Slightly moist to dry at top, dark yellowish orange (10YR 6/6), calcareous, CaCO ₃ , cemented, hard at 20-20.5'
25.0 - 27.0' Siltstone	Slightly moist, dark yellowish orange (10YR 6/6), calcareous, red streak at 26'
27.0 - 30.0' Siltstone	Dry, light brown (5YR 6/4), calcareous
30.0 - 43.0' Siltstone	Dry, light brown (5YR 6/4), calcareous but stratified (1mm), dark red streak at 36', grades to thermally altered sediments
43.0 - 60.0' Baked siltstone and shale [Clinker]	Dry at top
60.0 - 80.0' Silty sandstone, baked [Clinker]	Moist to wet at 73', moderate reddish brown (10R 4/6) to dusky red (5R 3/4), non calcareous; hard calcareous layer at 73', tan color, poor circulation, high yield of H ₂ O but difficult to determine due to lost circulation. Borehole making 30
80.0 - 100.0' Sandstone and siltstone [Clinker]	Moderate red (5R 4/6) to dark yellowish orange (10YR 6/6), rock fragments to 3", very angular clinker, SC of H ₂ O 4,190 μ mhos/cm at 95', pH 8.21, temp 11.7°C, 100gpm+
100.0 - 110.0' Sandstone and siltstone [Clinker]	Moderate red (5R 4/6) to dark yellowish orange (10YR 6/6), rock fragments to 3", very angular clinker, 150gpm at 100'
110.0 - 120.0' Sandstone and siltstone [Clinker]	Very soft, may have been coal but no coal detected in cuttings, no circulation below pipe

Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Stock Well Log

Hole Name: Chromo-2

Date Hole Started: 4/12/11 Date Hole Finished: 4/13/11

Client: Arch Coal

Project: Otter Creek Mine Permit (10068)

County: Powder River State: Montana

Property Owner: R. Denson

Legal Description: T5S, R45E, Sec 3 NWNE;
N 449883.48, E 2824991.82

Location Description: Denson stock well near
Chromo Creek

Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Ron Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water

Purpose of Hole: Install Stock Well

Target Aquifer: Fort Union Sandstone

Hole Diameter (in): 11" (0-40'), 8" (40-450')

Total Depth Drilled (ft): 450

WELL COMPLETION

	Y/N
Well Installed?	Y
Surface Casing Used?	Y
Screen/Perforations?	Y
Sand Pack?	Y
Annular Seal?	Y
Surface Seal?	N

DESCRIPTION

INTERVAL
+0-450
+2-98
350-450
328-450
63-300, 300-328

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 449883.48

Easting: 2824991.82

Static Water Level Below MP: 28

Surface Casing Height (ft):

Date: 4/13/2011

Riser Height (ft):

MP Description: TOSC

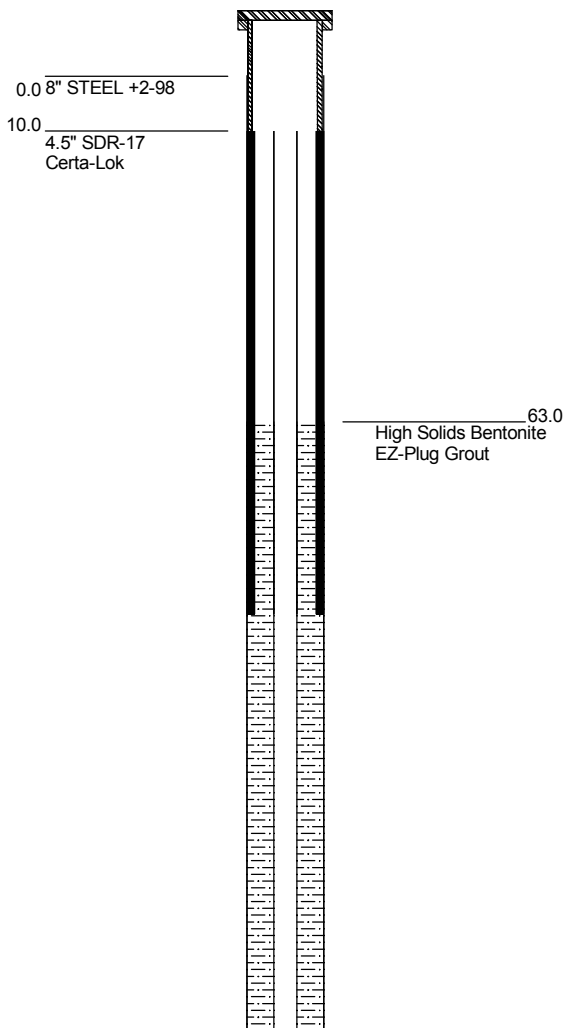
Ground Surface Elevation (ft): 3137.94

MP Height Above or Below Ground (ft):

MP Elevation (ft):

Remarks: Drilled to 30' with 7 7/8" bit, ream out with 12" bit, drive 40' of 8" steel casing. Poured 20 bags bentonite around steel while driving. Added 60' more of 8" steel through gravel (100' total). Inject water at 100'. Developed with rig air at 25 gpm; SC=1095 μ mhos/cm (20 minutes, 500 gallons); ~625 gallons total removed. High Solids Bentonite EZ-Plug Grout - 20% solid.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

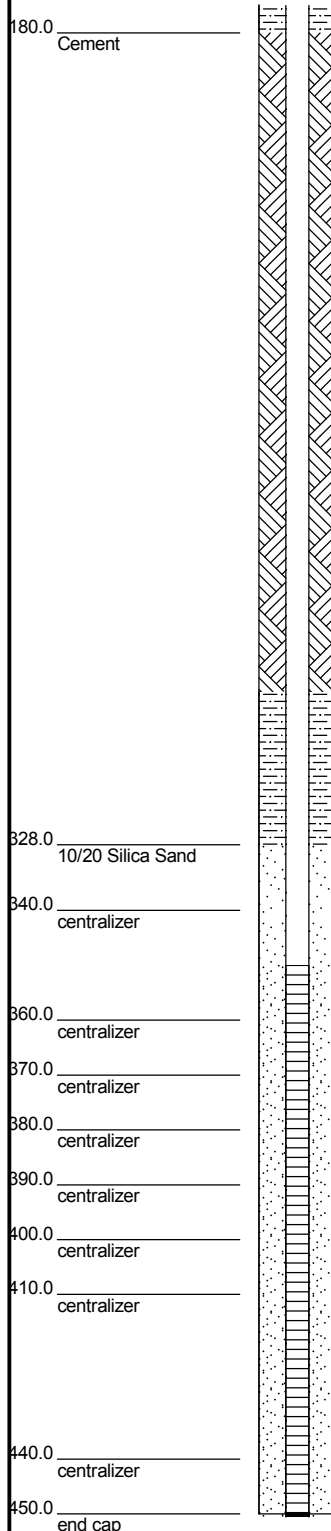
0.0 - 2.0'	Silty clay, some sand [Colluvium] Slightly moist, moderate yellowish brown, loose, non-plastic
2.0 - 5.0'	Silty clay, trace of sand [Colluvium] Dry, pale orange, loose, non-plastic
5.0 - 30.5'	Silty fine sand [Colluvium/Alluvium] Dry to slightly moist with depth, loose to moderately dense with depth, grain size increases to medium fine and medium from 22'-30.5'
30.5 - 78.0'	Sand and gravel, poorly sorted gravel to (10-20%) [Alluvium] Slightly moist, moderate yellowish brown sand with multicolored clinker gravels, some sandstone gravels, clinker: light brown (5YR 5/6), moderate reddish brown, dark yellowish orange Wet at 35', gravel increases to >50%, gravels 3", gravels sub-angular to sub-round, low to medium sphericity, mostly flat, some moderately spherical Becomes increasingly angular at 45', gravels to 5" at 55', sand fraction to 5% at 65'
78.0 - 111.0'	Sandstone, medium fine grain [Bedrock] Wet, light olive gray (5Y 6/1) to olive gray, soft to very soft, lense dense (very soft) from 90'-100', trace coal at 100', moderately siliceous, increasing silica at 105'
111.0 - 115.0'	Siltstone, sandy Dry, medium bluish gray (5B 5/1), moderately firm, non-calcareous, fetid odor
115.0 - 135.0'	Sandstone Wet, makes ~7 gpm, SC=2,140 μ mhos/cm, open hole, medium bluish gray to medium gray, moderately firm to very stiff, rig grinding, fetid odor at top 115'-116'
135.0 - 147.0'	Coal Wet, black, dense, cleated multiple planes, making water, open hole, yield ~10 + gpm
147.0 - 148.5'	Carbonaceous shale Brownish gray (5YR 4/1) and olive gray (5Y 3/2), stiff, moderately plastic
148.5 - 150.0'	Coal Wet, black, dense, cleated multiple planes, open hole, SC=1,800 μ mhos/cm
150.0 - 175.0'	Shale/siltstone Apparently dry, medium light gray and greenish gray, firm to stiff, non-plastic, non-calcareous, thin very hard moderate yellowish brown stringer at 168'



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



175.0 - 205.0'	Sandstone Wet?, medium light gray and greenish gray, firm to soft with depth, thin coal stringer at 203'
205.0 - 308.0'	Siltstone/shale Medium light gray to medium gray, stiff to very hard at 206'-211', rig chattering, non-calcareous at 205'-230', then nearly all at least moderately calcareous to 308' Very thin dark brown laminations at 205'-206' Moderately carbonaceous thin coal stringer at 212'-214', hardens to moderately firm at 214' Coal stringer at 217'-218' Interbedded sandstone at 225'-230' and at 241'-242' Coal stringer/carbonaceous shale stringer at 242' Color change to olive gray (5Y 4/1) at 245' Coal stringer at 250'-252' Color change to greenish gray (5GY 6/1) and medium light gray at 255' Very hard yellowish gray shale stringer at 270' Some interbedded sandstone at 275' Coal/carbonaceous shale stringer, grayish brown, soft at 290'-293'
308.0 - 313.0'	Sandstone, fine grain Medium light gray, very hard, cemented, rig chattering/slow to advance, trace calcareous precipitates at bottom of cemented interval/siltstone contact
313.0 - 335.0'	Siltstone/shale Dry, medium light gray and greenish gray, firm to stiff; carbonaceous shale stringer, grayish brown, soft at 320'; hardness decreases to moderately firm or firm at 321'; becomes very sandy at 330'-335'
335.0 - 445.0'	Sandstone, medium fine grain Wet, moderately firm to soft, medium light gray More cohesive, stiff interval at 350'-355' Moderate yellowish brown interbeds (sandstone) and some intercalated shale at 410'-412' Yield open hole ~100 gpm
445.0 - 450.0'	Siltstone/sandstone [Bedrock] Medium light gray, moderately firm, more cohesive

Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Stock Well Log

Hole Name: GNP PSW1

Date Hole Started: 8/15/11

Date Hole Finished: 8/16/11

Client: Arch Coal

Project: Otter Creek Mine Permit (10068)

County: Powder River State: Montana

Property Owner: Great Northern Properties

Legal Description: N 45.6133, W -106.17452
(NAD 83) (handheld GPS coordinates)

Location Description: GNP, Thane Thomas
stock well

Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Doug Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water

Purpose of Hole: Install Stock Well

Target Aquifer: Sandstone

Hole Diameter (in): 11"(0'-38'), 8"(38'-400')

Total Depth Drilled (ft): 400

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-400
Surface Casing Used?	Y	8" steel	+2-38
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	340-400
Sand Pack?	Y	10/20 Silica Sand	335-400
Annular Seal?	Y	Bentonite Chips	325-335
Surface Seal?	Y	Hi Solids grout (20% solids)	0-325

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 459806.253

Easting: 2821343.951

Static Water Level Below MP: 80

Surface Casing Height (ft): 2.0

Date: 8/16/2011

Riser Height (ft): 2.0

MP Description: Steel Casing

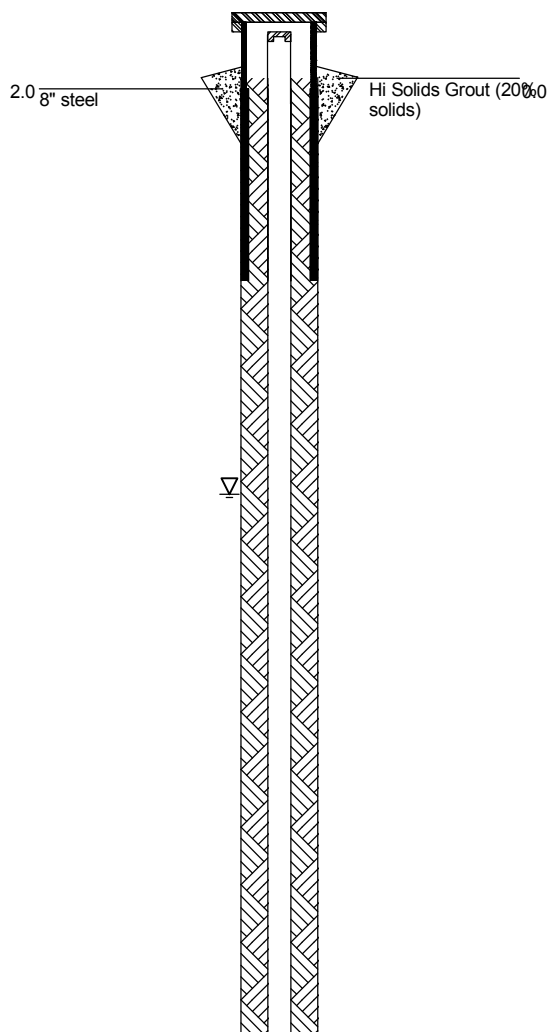
Ground Surface Elevation (ft): 3162.16

MP Height Above or Below Ground (ft): 2.0

MP Elevation (ft):

Remarks: Drilled to 38' with 11" drag bit, set 48' of 8" steel. Drilled with 7 7/8" drag bit. Drillers estimate 15 gpm at 120'. Aug. 16, 2011 blew on open hole with rig air at 140' bgs to develop. Pumping rate at ~10 gpm. Water quality tested at 5 minute intervals; 5 min.=3280 µmhos/cm and clear; 10 min.=2330 µmhos/cm, pH= 8.7, temp= 16.9°C, moderately turbid to clear; 15 min.=1600 µmhos/cm, pH=8.8, temp= 17.0°C, moderately turbid; 20 min.=1510 µmhos/cm, pH= 9.0, temp= 18°C, mild turbidity; 25 min.=1950 µmhos/cm, pH= 9.05, temp= 18.5°C, moderately turbid.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

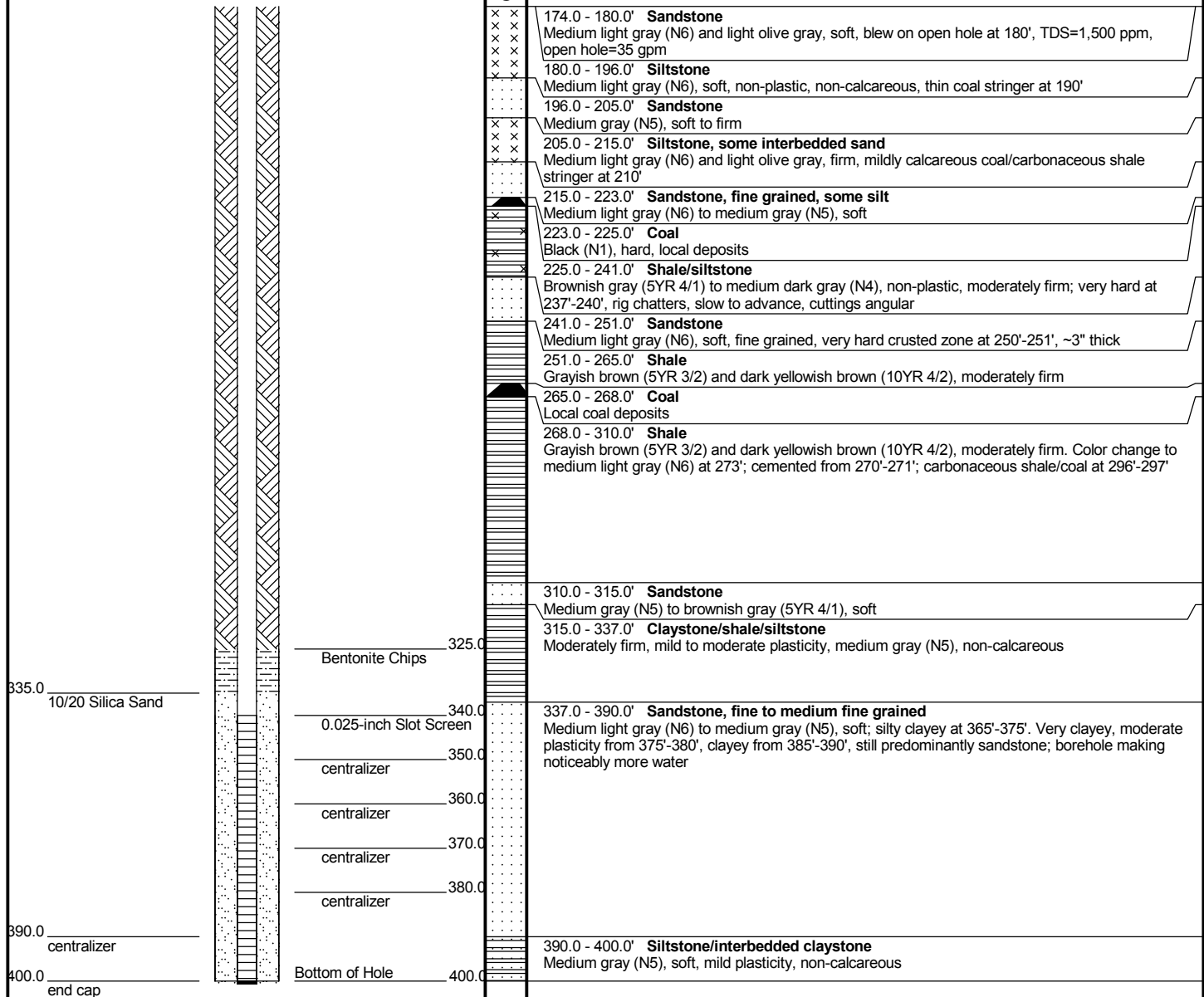
0.0 - 20.0'	Silt with some clay and fine sand [Colluvium] Pale (10YR 6/2) to moderate (10YR 5/4) yellowish brown, loose, soft, trace clinker gravel fragments
20.0 - 35.0'	Sand [Colluvium to Bedrock] Slightly moist, pale (10YR 6/2) to moderate (10YR 5/4) yellowish brown, very fine grain, soft, loose, very clayey at 20'-21', trace clinker gravel fragments
35.0 - 77.0'	Sandstone [Bedrock] Slightly moist, pale yellowish brown (10YR 6/2), soft, with light olive gray interbeds, some moderately cohesive. Dark yellowish orange (10YR 6/6) from 43'-44'. Dark yellowish orange (10YR 6/6) stringer at 47'. Moist at 57', color change to moderate yellowish brown (10YR 5/4), injecting water at 60', TDS=2,700 ppm. Dark gray (N3) particles in sand from 60'-77'; yield 3 gpm open-hole
77.0 - 82.0'	Siltstone/sandstone Brownish gray (5YR 4/1), moderately firm, non-plastic, non-calcareous, grades to all siltstone at 80'
82.0 - 115.0'	Coal [Knobloch] Black (N1), hard, dense, cleated
115.0 - 120.0'	Silty sandstone [Bedrock] Brownish gray (5YR 4/1) to light brownish gray (5YR 6/1), moderately firm. TDS=2,600 ppm, yield= 15 gpm open hole
120.0 - 133.0'	Coal [Knobloch] Black (N1), hard, dense, cleated
133.0 - 137.0'	Shale Medium dark gray (N4) and brownish gray [5YR 4/1], stiff to very hard, moderately carbonaceous, non-calcareous
137.0 - 139.0'	Sandstone Medium light gray (N6), medium fine grained, hard, rig chatters, slow to advance
139.0 - 155.5'	Siltstone/shale Medium dark gray (N4), stiff to firm with depth, non-plastic, non-calcareous, softer at 145', thin dusky brown (5YR 2/2) carbonaceous shale at 155'
155.5 - 174.0'	Coal [Lower Knobloch] Dark brownish gray to black (N1) with depth, firm to dense, some cleats, very strong reduced sulfur odor



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



Hydrometrics, Inc.

Consulting Scientists and Engineers

Billings, Montana



Stock Well Log

Hole Name: GNP PSW2

Date Hole Started: 8/24/11

Date Hole Finished: 8/24/11

Client: Arch Coal

Project: Otter Creek Mine Permit (10068)

County: Powder River State: Montana

Property Owner: Great Northern Properties

Legal Description: N 45.53922 E -106.28133 (NAD83) (handheld GPS coordinates)

Location Description: Replacement stock well

for GNP on Bridge Creek

Recorded By: RJL

Drilling Company: Askin Drilling

Driller: Ron Askin

Drilling Method: Air Rotary

Drilling Fluids Used: Water

Purpose of Hole: Install Stock Well

Target Aquifer: Sandstone at ~400' bgs

Hole Diameter (in): 11" (0'-15'), 8" (15'-380')

Total Depth Drilled (ft): 380

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	+2-380
Surface Casing Used?	Y	8" steel	+2-51
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	340-380
Sand Pack?	Y	10/20 Silica Sand	307-380
Annular Seal?	Y	Bentonite Chips	137-307
Surface Seal?	N		

DEVELOPMENT/SAMPLING

Well Developed?	Y	Rig Air
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing:

Easting:

Static Water Level Below MP: 70

Surface Casing Height (ft):

Date: 8/24/2011

Riser Height (ft):

MP Description: Top PVC

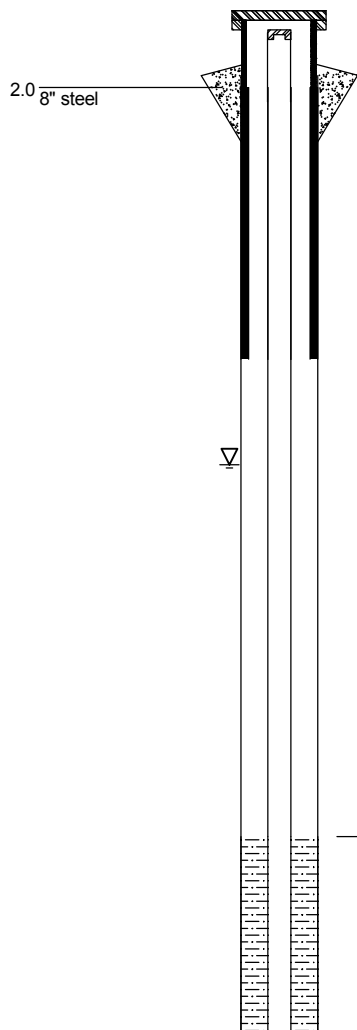
Ground Surface Elevation (ft):

MP Height Above or Below Ground (ft): 0

MP Elevation (ft):

Remarks: Drilled to 15' with 10 7/8" bit; drilled from 15' to 380' with 7 7/8" bit; injecting water at 35' bgs; yield ~20 gpm. Bentonite 3/8" chips poured continuously while setting 8" steel.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 7.0' **Silty clay** [Colluvium/Topsoil]

Dry, pale yellowish brown (10YR 6/2), loose, roots, becomes sandy at 5'

7.0 - 15.0' **Sand and gravel poorly sorted** [Alluvium]

Slightly moist, fines are moderate yellowish brown (10YR 5/4) (sand is fine to medium fine); multi-colored clinker gravels (e.g. light brown, moderate reddish brown 10R 4/6); gravels flat to moderately spherical, sizes up to 4", mostly sub-angular, few sub-round, loose to moderately dense; sand to 10% at 15'

15.0 - 41.0' **Thermally altered siltstone/shale** [Clinker]

Dry, multi-colored (e.g. light browns, reds and reddish browns with light gray N7 and greenish gray 5G 6/1); very hard, some loose silty clay, pale yellowish brown (10YR 6/2) in matrix from 30'-40'; also very hard thin pale orange and pale yellowish orange (10YR 8/6) bed at 30', interbedded with softer clay and ash?

41.0 - 45.0' **Shale, silty** [Bedrock]

Dry, medium light gray (N6), and light olive gray with dusky brown (4YR 2/2) streaks, non-plastic, non-calcareous, soft to moderately firm; color change to grayish orange (10YR 7/4)/grayish orange pink at 42'

45.0 - 47.0' **Sandstone**

Light olive gray, soft, fine medium-grained

47.0 - 48.0' **Coal**

Black (N1), hard, moderately dense, cleated

48.0 - 71.0' **Silty claystone** [Bedrock]

Medium gray (N5), to greenish gray, non-plastic, moderately firm, non-calcareous; very hard cemented zone at 62'-65'

71.0 - 75.0' **Coal** [Local]

Black (N1), hard, moderately dense

75.0 - 96.0' **Siltstone**

Medium light gray (N6), moderately firm, calcareous, trace sandstone intervals at 80'-85' and 85'-90'

96.0 - 102.0' **Coal** [Local]

Black (N1), hard, dense, cleated multiple planes

102.0 - 137.0' **Siltstone**

Medium light gray (N6), moderately firm, calcareous, trace sand at 102'-105', no sand at 110'; rock very hard, cemented at 119'-124', rig chattering, drilling slowly. Very thin coal/carbonaceous shale stringer at 125'

137.0 - 143.0' **Coal** [Local]

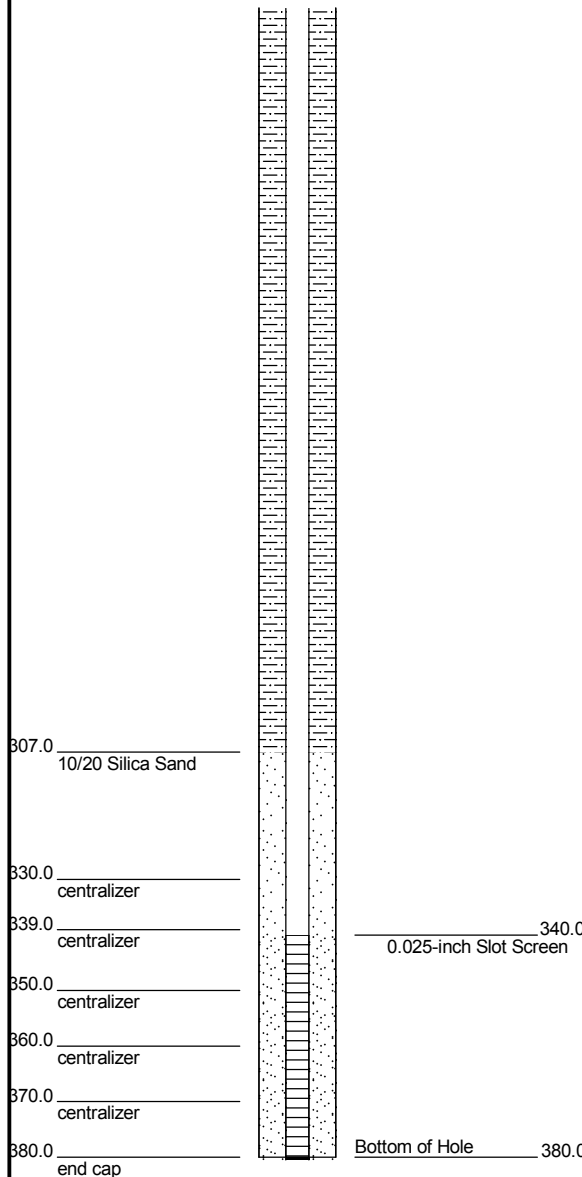
Black (N1), hard, dense, cleated

143.0 - 173.0' **Siltstone**

Medium light gray (N6) to medium gray (N5), moderately firm, non-calcareous. Thin coal stringer at 160'-161'; very clayey at 161'-165'; stiff; some interbedded sand from 170'-173'

GEOLOGICAL DESCRIPTION

GRAPHICS



375.0 - 380.0' **Siltstone** [Bedrock]
Medium bluish gray (5B 5/1), moderately stiff

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Billings, Montana



Monitor Well Log

Hole Name: K-1

Date Hole Started: 11/8/10 Date Hole Finished: 11/8/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15; N 467480.1, E 2825490.64
Location Description: East of Otter Creek 1/2 mile +/-
Recorded By: ajh
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 175

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-175
Surface Casing Used?	Y	8" steel 0.250" wall	
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	110-175
Sand Pack?	Y	10/20 Silica Sand	101-175
Annular Seal?	Y	Bentonite Chips	0-101
Surface Seal?	Y	Concrete Pad	

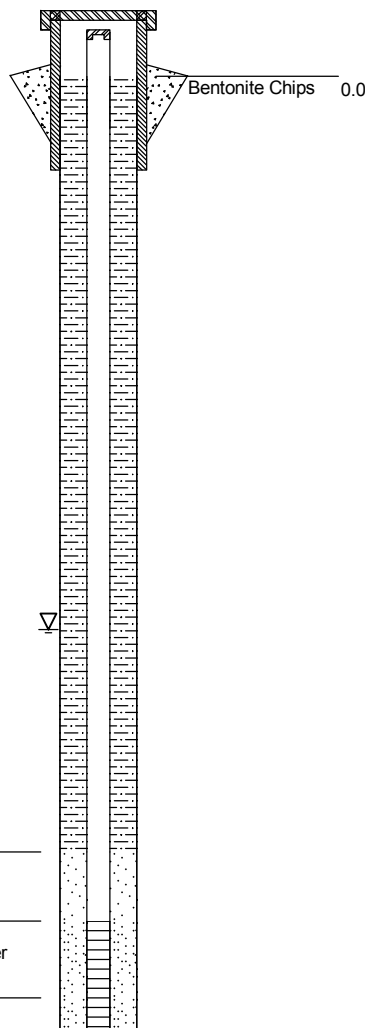
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air lift
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 467480.1	Easting: 2825490.64
Static Water Level Below MP: 73.64	Surface Casing Height (ft): 1.82
Date: 11/10/2010	Riser Height (ft): 1.59
MP Description: Top PVC	Ground Surface Elevation (ft): 3117.44
MP Height Above or Below Ground (ft): 1.59	MP Elevation (ft): 3119.03

Remarks: Open hole SC 2,180 µmhos/cm, pH 8.66, temp 13.2°C, yield open hole with rig air 30gpm +. First bail 2,790 µmhos/cm, last bail 2,180 µmhos/cm pH 8.44.

WELL CONSTRUCTION



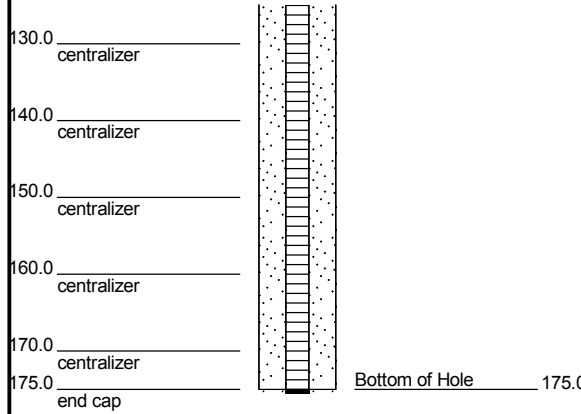
GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 9.0'	Clay, silty [Topsoil & Colluvium]	Dry to slightly moist, grayish orange, cohesive when wet, calcareous, few roots
9.0 - 11.0'	Clay, silty [Colluvium]	Dry to slightly moist, light brown (5YR 5/6), cohesive when wet, calcareous, few roots
11.0 - 15.0'	Clay, silt [Colluvium]	Slightly moist, pale yellowish brown (10YR 6/2), cohesive, non-calcareous
15.0 - 17.0'	Siltstone [Bedrock]	Slightly moist, dark yellowish orange (10YR 6/6), very soft
17.0 - 21.0'	Claystone [Bedrock]	Slightly moist, dark yellowish orange (10YR 6/6), very soft, calcareous
21.0 - 22.0'	Claystone	Slightly moist, light brown (5YR 6/4), very soft, non-calcareous
22.0 - 30.0'	Very fine silty sandstone	Dry to slightly moist, grayish orange (10YR 7/4), soft, hard layer at 29'
30.0 - 31.0'	Very fine silty sandstone	Dry to slightly moist, slightly cohesive, yellowish gray (5Y 8/1), soft, calcareous
31.0 - 37.0'	Siltstone	Slightly moist, yellowish gray, calcareous
37.0 - 39.0'	Siltstone	Slightly moist, dark yellowish orange (10YR 6/6), soft
39.0 - 41.0'	Shale	Dry, medium gray (N5), soft
41.0 - 42.0'	Clay and baked shale	Dry to slightly moist, moderate yellowish brown (10YR 5/4)
42.0 - 43.0'	Siltstone, clayey	Dry to slightly moist, moderate yellowish brown (10YR 5/4)
43.0 - 44.0'	Claystone	Dry, moderate yellowish brown (10YR 5/4), soft
44.0 - 45.0'	Claystone	Dry, more orange staining, iron
45.0 - 48.0'	Silty claystone	Slightly moist, dark yellowish orange (10YR 6/6), very soft, weakly calcareous
48.0 - 52.0'	Claystone	Slightly moist, dark yellowish orange (10YR 6/6), very soft, weakly calcareous
52.0 - 55.0'	Shale	Dry, medium gray (N5)
55.0 - 61.0'	Shale	Dry, light olive gray (5Y 5/2), soft. At 56-59' cemented shale/claystone, dry, calcareous, hard
61.0 - 68.0'	Siltstone with claystone inclusions	Moist, medium gray (N5), soft, non-calcareous
68.0 - 70.0'	Shale	Slightly moist, brownish gray (5YR 4/1), soft, non-calcareous



WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

70.0 - 74.0'	Sandy siltstone Moist, medium gray (N5), soft, non-calcareous
74.0 - 75.0'	Silty shale Slightly moist, light olive gray (5Y 6/1), soft
75.0 - 79.0'	Siltstone Moist to very moist, medium dark gray (N4), non-calcareous, soft
79.0 - 83.0'	Silty shale Wet at top, more water in cuttings, light olive gray (5Y 6/1), hard at bottom of interval, trace water on top of hard layer
83.0 - 102.0'	Shale Dry, dark gray (N3), soft, coal stringer at 93'
102.0 - 174.0'	Knobloch Wet, black (N1), dense, cleated 3x, trace gypsum, no pyrite observed, partly laminated brownish gray siltstone from 151 to 152', coal unit making combined 30gpm+ open hole, more water apparently below siltstone parting
174.0 - 175.0'	Silty shale Dry, light gray (N7)

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Monitor Well Log

Hole Name: K-2

Date Hole Started: 1/6/2011 Date Hole Finished: 1/6/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T4S, R45E, Sec. 26; N
460975.69, E 2828132.5
Location Description: East of Otter Creek
paired with K-6
Recorded By: ajh
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used: Water
Purpose of Hole: Install Monitor Well
Target Aquifer: Lower Knobloch
Hole Diameter (in): 7 7/8" (12 3/4" to 38")
Total Depth Drilled (ft): 209

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-209
Surface Casing Used?	Y	8" steel 0.250" wall	0-38
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	189-209
Sand Pack?	Y	10/20 Silica Sand	185-209
Annular Seal?	Y	Bentonite Chips	0-185
Surface Seal?	Y	Bentonite Chips	

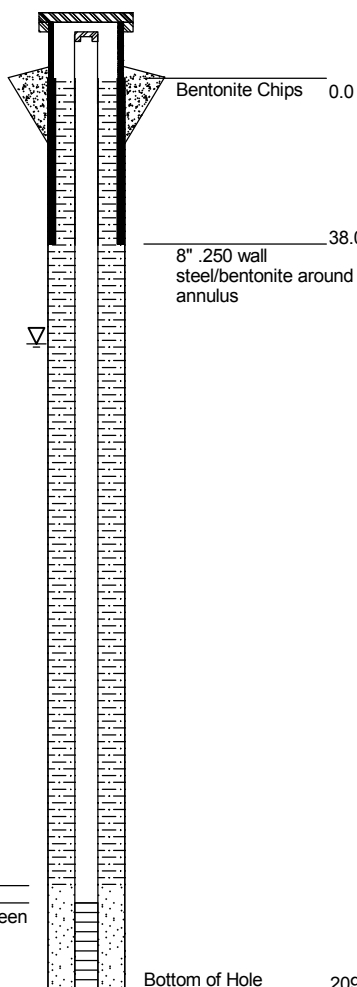
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air lift
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 460975.69	Easting: 2828132.5
Static Water Level Below MP: 62.41	Surface Casing Height (ft): 1.84
Date: 1/7/2011	Riser Height (ft): 1.52
MP Description: Top PVC	Ground Surface Elevation (ft): 3137.39
MP Height Above or Below Ground (ft): 1.52	MP Elevation (ft): 3138.91

Remarks: Water injection at 65', test for water at 80', no flow from boring at 104', 3-5 gpm (base of sandstone). SC open hole 1750 µmhos/cm 40-50 gpm. First water 15-20 gpm, turbid SC=1260 µmhos/cm, temp 10.4°C.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 24.0' **Silty, fine sandstone** [Fort Union Formation]
Moderate yellowish brown, dry to slightly moist, very soft, calcareous, some soft calcareous cemented zones

24.0 - 27.0' **Silty shale**
Gray with orange fines, dry, soft

27.0 - 29.0' **Very fine silty sandstone, trace claystone**
Tan, moist, very soft, calcareous

29.0 - 32.0' **Siltstone**
Light gray with orange streaks, moist, laminated

32.0 - 34.0' **Claystone**
Orange, dry

34.0 - 37.0' **Claystone**
More orange, dry

37.0 - 71.0' **Sandstone, very fine**
Coarsening with depth to medium, poorly sorted at top to well sorted near base, moist to wet at ~65', calcareous; iron stained at 43', moist at 50'. Possibly wet at 65' but no water from open hole, thin carbonaceous shale at 62-62.3', sandstone coarser b

71.0 - 73.0' **Siltstone**
Dark yellowish orange, dry, laminated

73.0 - 104.0' **Fine medium sandstone**
Gray, wet, poor to moderately sorted; cemented 73-90', uncemented or poorly cemented at 90-104', approximately 3-5 gpm estimated at base of sandstone

104.0 - 148.0' **Knobloch Coal**
Black, cleated 3x, note that no shale or siltstone observed, abrupt contact with overlying sandstone, note also that sandstone from upper hole and siltstone from upper hole sloughing during drilling, strong sulphur odor in upper coal

148.0 - 186.0' **Shale**
Dark olive gray, firm interburden, woven tight, very hard CaCO₃ cemented layers at 166', 167-168', and 178-179', carbonaceous shale at 165-166', fetid odor at 178-179'

186.0 - 190.0' **Sandstone**
Sub lithic arenite, gray, non-calcareous, poorly sorted, weakly cemented

190.0 - 208.0' **Coal**
Black, cleated, dense, very faint sulphur odor

208.0 - 209.0' **Siltstone**
Estimate 30% clay, laminated, medium gray

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Monitor Well Log

Hole Name: K-3

Date Hole Started: 1/24/2011 Date Hole Finished: 1/24/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T4S, R45E, Sec. 26; N
459323.03, E 2827589.55
Location Description:

Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Upper Knobloch
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 75

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-75
Surface Casing Used?	Y	8" steel	+2-38
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	55-75
Sand Pack?	Y	10/20 Silica Sand	43-75
Annular Seal?	Y	Bentonite Chips	+1-43
Surface Seal?	N		

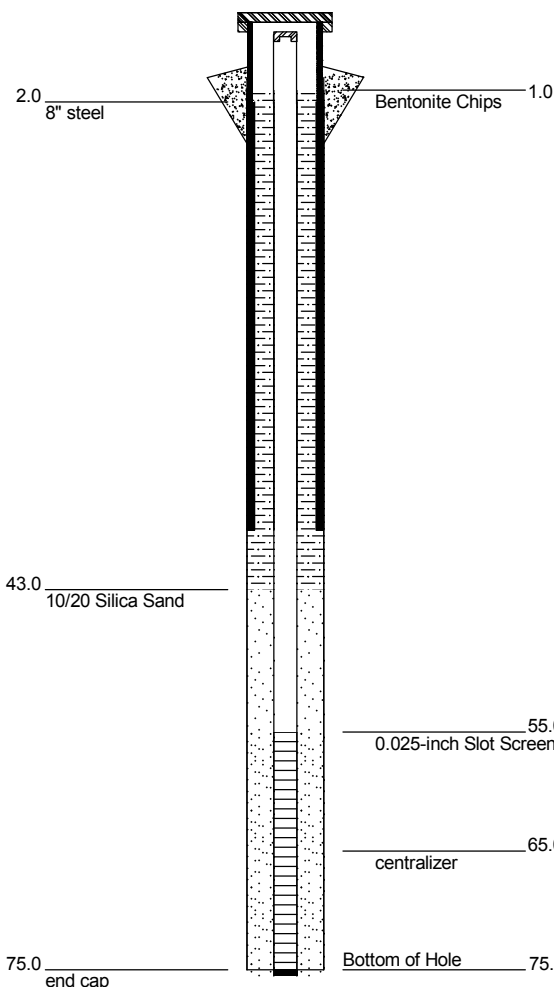
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air lift
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 459323.03	Easting: 2827589.55
Static Water Level Below MP: 62.5 (rising)	Surface Casing Height (ft): 2.27
Date: 1/24/2011	Riser Height (ft): 1.83
MP Description: Top PVC	Ground Surface Elevation (ft): 3127.83
MP Height Above or Below Ground (ft): 1.83	MP Elevation (ft): 3129.66

Remarks: Inject water at total depth to stimulate flow, developed with bailer for 20 minutes, yield ~2.5 - 3 gpm, SC=2140 µmhos/cm, pH=7.46, temp=11.6°C

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0'	Silt and fine sand [Topsoil] Slightly moist, moderate brown (5YR 3/4), roots, loose, soft
1.0 - 30.0'	Silty fine to very fine sandstone [Fort Union Formation/ Bedrock] Dry, moderate yellowish brown (10YR 5/4), soft to very soft, some thin cemented beds from 27-30'
30.0 - 30.5'	Shale [Bedrock] Dry, gray with orange fines, very hard
30.5 - 61.0'	Coal [Upper Knobloch] Dry, dusky brown to black, firm to stiff, mild sulfur odor, slightly moist at 61', becomes hard at 52'
61.0 - 61.5'	Silty shale Dry, pale yellowish brown to brownish gray, firm, moderately calcareous, reacts with acid
61.5 - 75.0'	Coal Dry, dusky brown to black, firm to stiff, mild sulfur odor, wet at 67', yield ~2.5 - 3 gpm when completed

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Monitor Well Log

Hole Name: K-4

Date Hole Started: 1/24/2011 Date Hole Finished: 1/24/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T4S, R45E, Sec. 26; N 459331.02, E 2827583.15
Location Description: paired with K-3
Recorded By: RJL
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Lower Knobloch
Hole Diameter (in): 7 7/8" to 40' then 11 3/4"
Total Depth Drilled (ft): 150

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-150
Surface Casing Used?	Y	8" steel	+2-130
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	130-150
Sand Pack?	Y	10/20 Silica Sand	127-150
Annular Seal?	Y	Bentonite Chips	+1-127
Surface Seal?	N		

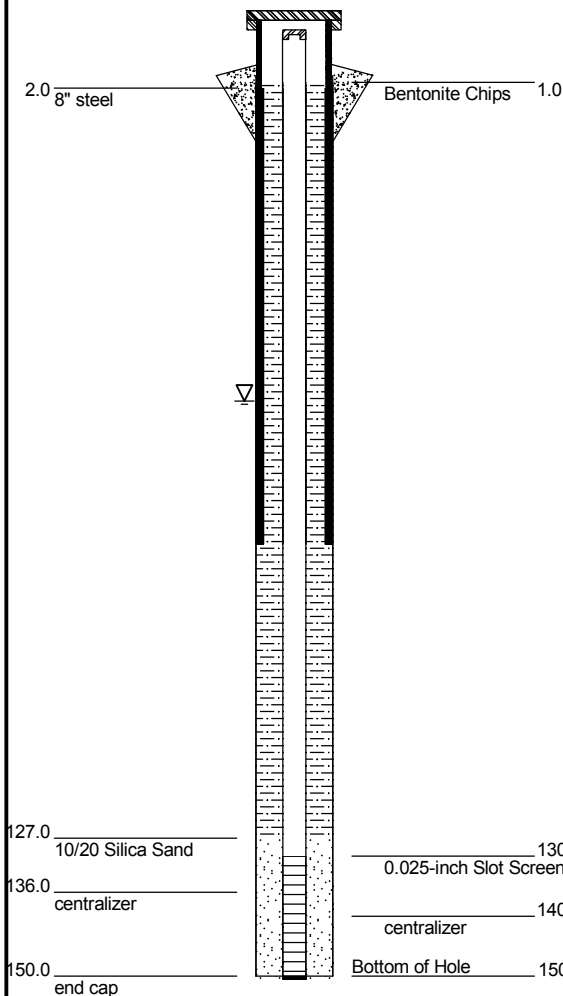
DEVELOPMENT/SAMPLING

Well Developed?	Y	Air lift
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 459331.02	Easting: 2827583.15
Static Water Level Below MP: 55.83	Surface Casing Height (ft): 1.96
Date: 1/24/2011	Riser Height (ft): 1.71
MP Description: Top PVC	Ground Surface Elevation (ft): 3127.76
MP Height Above or Below Ground (ft): 1.71	MP Elevation (ft): 3129.47

Remarks: Drive 40' of 8" steel casing, bentonite in annulus, injecting water at 75', developed with bailer 20 minutes. Yield ~4.5 gpm, SC=1873 µmhos/cm, pH=8.64, temp=12.7°C

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 1.0'	Silt to fine sand [Topsoil] Slightly moist, moderate brown (5YR 3/4), roots, loose, soft
1.0 - 30.0'	Silty very fine sandstone [Fort Union Formation/Bedrock] Dry, moderate yellowish brown (10YR 5/4), soft to very soft, minor cemented zone from 27-30'
30.0 - 30.5'	Shale Dry, gray with orange fines, very hard
30.5 - 61.0'	Coal [Upper Knobloch] Dry, dusky brown to black, very dusky at surface, firm to stiff, mild cleats possibly 1x, mild sulfur odor, becomes hard at 52', slightly moist at 61'
61.0 - 61.5'	Silty shale Dry, pale yellowish brown to brownish gray, firm, moderately calcareous interburden, reaction to acid
61.5 - 75.0'	Coal Dry, dusky brown to black, very dusky at surface, firm to stiff, mild cleats possibly 1x, mild sulfur odor, wet at 67', SC=2300 µmhos/cm, yield=3-5 gpm
75.0 - 95.0'	Shale intercalated and strong Moist (from above) to dry, medium light gray to medium gray, cemented, very hard sandstone at 84-85' and 91-92'
95.0 - 130.0'	Sandstone, minor shale intercalated Very soft to firm, medium gray with thinly bedded dark yellowish brown streaks
130.0 - 147.5'	Coal [Lower Knobloch] Stiff, black, cleating not distinct
147.5 - 150.0'	Silty shale Soft, medium light gray

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Billings, Montana



Monitor Well Log

Hole Name: K-5

Date Hole Started: 11/10/10 Date Hole Finished: 11/10/10

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: Great Northern Properties
Legal Description: T4S, R45E, Sec. 15; N 4469707.66, E 2825301.24
Location Description: 115 yards East of well C-4 on hill
Recorded By: ajh
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Knobloch Coal
Hole Diameter (in): 7 7/8"
Total Depth Drilled (ft): 186

WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-186
Surface Casing Used?	Y	8" steel 0.250" wall	-3.5 to 1.5'
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	126-186
Sand Pack?	Y	10/20 Silica Sand	110-186
Annular Seal?	Y	Bentonite Chips	1-110
Surface Seal?	Y	Concrete Pad	

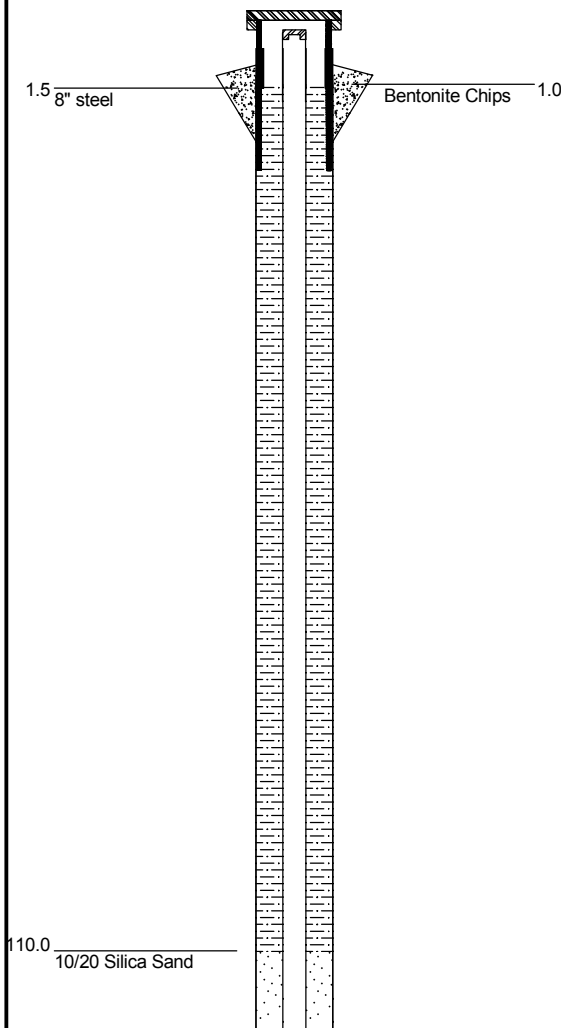
DEVELOPMENT/SAMPLING

Well Developed?	Y	Bailed
Water Samples Taken?	N	
Boring Samples Taken?	N	

Northing: 469707.66	Easting: 2825301.24
Static Water Level Below MP: 105.16 (Rising)	Surface Casing Height (ft): 1.77
Date: 11/10/2010	Riser Height (ft): 1.54
MP Description: Top PVC	Ground Surface Elevation (ft): 3146.44
MP Height Above or Below Ground (ft): 1.54	MP Elevation (ft): 3147.98

Remarks: Knobloch Coal making +/- 20-25gpm open hole, SC when blowing from open hole 1,394 μ mhos/cm, pH 8.41, temp 11.2°C. Install 20' of 8" steel for hole sloughing and cutting control, pulled after well installed..

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

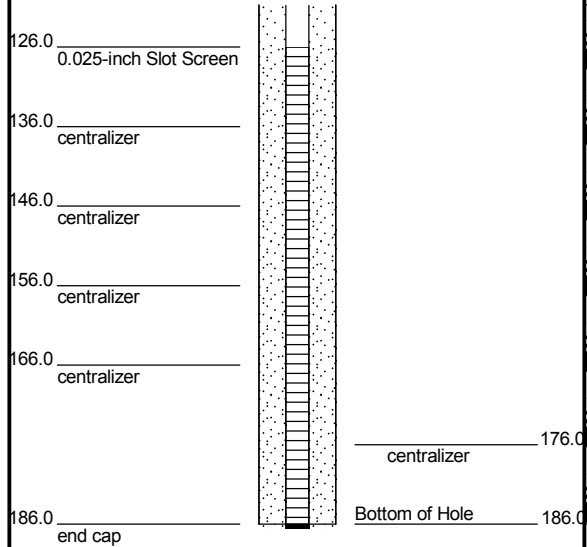
0.0 - 2.5' Shale [Bedrock] Dry, olive gray changing to dark yellowish orange (10YR 6/6), soft, non-calcareous
2.5 - 5.0' Cemented shale Dry, light gray (N8), calcareous cement, hard
5.0 - 20.0' Claystone Slightly moist, dark yellowish orange (10YR 6/6), very soft, non-calcareous
20.0 - 20.5' Shale, cemented with CaCO₃ Dry, hard
20.5 - 25.0' Claystone Slightly moist, dark yellowish orange (10YR 6/6), calcareous, soft
25.0 - 33.0' Siltstone with interbedded shale Slightly moist, dark yellowish orange (10YR 6/6) to moderate yellowish brown (10YR 5/4), calcareous, soft
33.0 - 74.0' Shale Dry, medium gray (N5) to dark yellowish orange (10YR 6/6), non-calcareous, very soft, trace silt-rich zones, siltstone layer at 43-43.5', 57-57.5', and 65.5 to 66'
74.0 - 76.0' Shale, CaCO₃ cemented Dry, light gray (N7), hard
76.0 - 82.0' Siltstone Dry to moist, dark yellowish orange (10YR 6/6), clay vari-colored, calcareous, stratified 1mm, soft
82.0 - 83.0' Shale Dry, various colors, gray to dark yellowish orange (10YR 6/6), hard CaCO ₃ cemented zone at 83'
83.0 - 85.5' Shale, CaCO₃ cemented Dry, light gray (N8), hard, marker bed
85.5 - 91.0' Sandy siltstone Moist, dark yellowish orange (10YR 6/6), weakly calcareous, soft
91.0 - 95.0' Siltstone Moist, dark yellowish orange (10YR 6/6), weakly calcareous, soft
95.0 - 107.0' Shale becoming silty at 100' Slightly moist, medium gray (N5), soft, weakly calcareous
107.0 - 114.5' Shale Dry, grayish brown (5YR 3/2) (top foot) to dark yellowish brown (10YR 4/2), soft, carbonaceous shale



WELL CONSTRUCTION

GRAPHICS

GEOLOGICAL DESCRIPTION



114.5 - 186.0' **Coal** [Knobloch]
Dry at top, wet at 134', dusky yellowish brown (10YR 2/2), cleated, no pyrite observed, making 5-7gpm (estimate) at 160' open hole, very few impurities, trace silt which appears to be white precipitate, but very minor.

Silty shale, light gray (N7), sof

Hydrometrics, Inc.

Consulting Scientists and Engineers
Billings, Montana



Monitor Well Log

Hole Name: K-6

Date Hole Started: 1/7/2011 Date Hole Finished: 1/7/2011

Client: Arch Coal
Project: Otter Creek Mine Permit (10068)
County: Powder River State: Montana
Property Owner: R. Denson
Legal Description: T4S, R45E, Sec. 26; N 460962.39, E 2828129.62
Location Description: 12' South of K-2, paired with K-2
Recorded By: ajh
Drilling Company: Askin Drilling
Driller: Ron Askin
Drilling Method: Air Rotary
Drilling Fluids Used:
Purpose of Hole: Install Monitor Well
Target Aquifer: Upper Knobloch
Hole Diameter (in): 7 7/8" (11 3/4" upper)
Total Depth Drilled (ft): 149

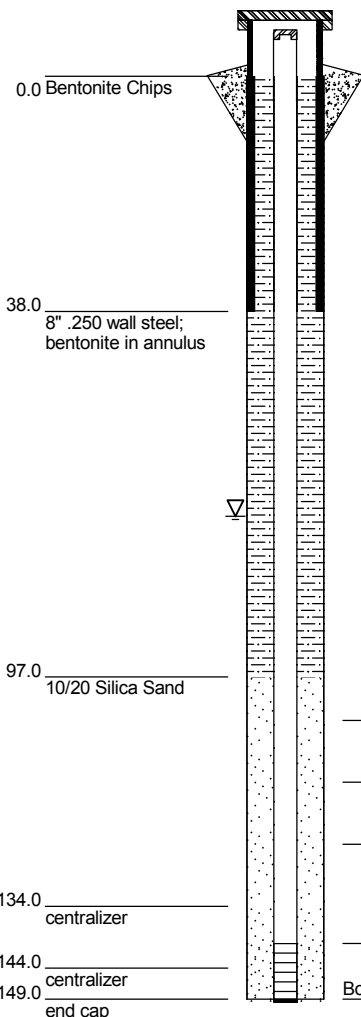
WELL COMPLETION	Y/N	DESCRIPTION	INTERVAL
Well Installed?	Y	4.5" Sch 40, PVC	0-149
Surface Casing Used?	Y	8" steel 0.250" wall	0-38
Screen/Perforations?	Y	0.025-inch slot, Sch 40 PVC	140-149
Sand Pack?	Y	10/20 Silica Sand	97-149
Annular Seal?	Y	Bentonite Chips	0-97
Surface Seal?	Y	Bentonite Chips	

DEVELOPMENT/SAMPLING

Well Developed?	Y	Air lift
Water Samples Taken?	N	
Boring Samples Taken?	N	
Northing: 460962.39	Easting: 2828129.62	
Static Water Level Below MP: 73.54	Surface Casing Height (ft): 2.72	
Date: 1/22/2011	Riser Height (ft): 2.48	
MP Description: Top PVC	Ground Surface Elevation (ft): 3137.97	
MP Height Above or Below Ground (ft): 2.48	MP Elevation (ft): 3140.45	

Remarks: Set 8" steel to 38', upper portion of hole sloughing 11 3/4" pilot, water injected at 63'. Well making +/- 5 gpm during development, rod at 100'; 3 min. SC=3070 µmhos/cm, turbidity med.-high, pH 8.02, 30 min. SC=3270 µmhos/cm, turbidity med., pH 8.28.

WELL CONSTRUCTION



GRAPHICS

GEOLOGICAL DESCRIPTION

0.0 - 24.0'	Silty, fine sandstone [Fort Union Formation] Moderate yellowish brown, dry to slightly moist, very soft, calcareous, some soft calcareous cemented zones
24.0 - 27.0'	Silty shale Gray with orange fines, dry, soft
27.0 - 29.0'	Very fine silty sandstone, trace claystone Tan, moist, very soft, calcareous
29.0 - 32.0'	Siltstone Light gray with orange streaks, moist, laminated
32.0 - 34.0'	Claystone Orange, dry
34.0 - 37.0'	Claystone More orange, dry
37.0 - 73.5'	Sandstone, very fine Coarsening with depth to medium, poorly sorted at top to well sorted near base, moist to wet at ~65', calcareous; iron stained at 43' and shale at 43-43.5', carbonaceous shale at 64-64.5'
73.5 - 75.0'	Siltstone Dark yellowish orange, dry, laminated
75.0 - 79.0'	Sandstone Shale stringer at 77-77.5'
79.0 - 104.0'	Fine medium sandstone Gray, wet, poor to moderately sorted; cemented 73-90', uncemented or poorly cemented at 90-104', approximately 3-5 gpm estimated at base of sandstone; intercalated shale/sandstone at 79-80', cemented sandstone at 81-94'; less concentration below 89-89.5'
104.0 - 149.0'	Coal Weak sulphur odor, cleated in up to 3 directions, but not distinct, approximately 10-15 gpm open hole