ARNOLD IRRIGATION DISTRICT NORTH LATERAL - PHASE I CONSERVATION STUDY

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ARNOLD IRRIGATION DISTRICT

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Attachment 1: Reconnaissance-Level Plan and Profile- North Lateral Phase I

I. BACKGROUND

Black Rock Consulting was contracted by the Arnold Irrigation District to evaluate and report on conservation potential and feasibility-level details of the North Lateral Project – Phase I. Phase I was defined by the District as the approximate 2-mile segment of the North Lateral from the head gate at the Main Canal downstream approximately to the Oregon Department of Transportation Bend Parkway. The canal is largely un-piped except at road and drive crossings, and generally has a rocky, basalt, substrate. The Phase I canal segment falls approximately 106-FT and has a total of thirteen patron deliveries along it totaling approximately 30 acres in deliveries. Downstream of Phase I approximately 159 additional acres are served for a total of 189 acres on the North Lateral. At a feasibility level, this study evaluates the conservation potential, seepage mitigation options, pipeline hydraulic analysis, pipeline material recommendation, and cost estimate for piping the North Lateral, Phase I. Base mapping and a reconnaissance-level field survey and profile were also developed and provided herein.

II. FIELD SURVEY

In March, 2015, Black Rock Consulting performed a field visit and centerline survey of the North Lateral Phase I using an engineer's survey level and rod to obtain relative elevations along the canal and a hand-held GPS to identify the horizontal location of the shots. This information was reduced in the office and used to develop a profile for the lateral canal invert as indicated on the attached reconnaissance-level plan and profile sheets. An assumed elevation of 3,900 (at top of ramp flume wall at the North Lateral headworks) was used as the basis of elevation for this survey.

III. SEEPAGE LOSS MEASUREMENT

Seepage loss measurements were performed on two separate occasions, once during the current irrigation season and once during the previous irrigation season. Loss measurements were performed using existing weirs maintained by the Arnold Irrigation District and a Doppler wading rod measurement device (SonTek with digital totalizer). Measurements were taken at various locations along the Phase I segment so as to adequately determine losses incrementally along the canal. Where available, gauge heights were taken at weir locations and District charts (or weir equations) were used to determine the associated flow rate. These were generally validated or over-ridden by wading rod flow measurements. The first and second round of measurements are provided below, followed by an analysis of seepage losses calculated from the measurements.

SEPTEMBER 23, 2014 READINGS:

Reading Loc.:	*AID North Lateral*		
	TOP OF SYSTEM		
Date:	23-Sep-14		
Meter Type:	Sontek		
Channel Width	5 FT		
Sect. Mdpt (Ft)	Section Depth (Ft)	Vel. Average	Q (CFS)
0.5	0.92	0.62	0.43
1.0	0.93	1.5	0.70
1.5	0.94	1.38	0.65
2.0	0.93	1.33	0.62
2.5	0.93	1.46	0.68
3.0	0.93	1.42	0.66
3.5	0.93	1.36	0.63
4.0	0.94	1.38	0.65
4.5	0.94	1.22	0.86
		TOTAL=	5.87

Reading Loc.:	*AID North Lateral*		
	Weir at Rocking Horse Road		
Date:	23-Sep-14		
Meter Type:	Sontek		
Channel Width	9.5 FT		
Sect. Mdpt (Ft)	Section Depth (Ft)	Vel. Average	Q (CFS)
0.5	0.5	0	0.05
1.0	1	0.29	0.15
1.5	1	0.49	0.25
2.0	1.21	0.58	0.35
2.5	1.45	0.61	0.44
3.0	1.5	0.64	0.48
3.5	1.57	0.72	0.57
4.0	1.6	0.68	0.54
4.5	1.6	0.57	0.46
5.0	1.5	0.49	0.37
5.5	1.5	0.42	0.32
6.0	1.5	0.51	0.38
6.5	1.35	0.53	0.36
7.0	1.44	0.5	0.36
7.5	1.41	0.27	0.19
8.0	0.82	0.49	0.20
8.5	0.7	0.39	0.14
9.0	0.67	0.46	0.15
9.5	0	0	0.02
		TOTAL=	5.77
Comparative Reading: 5 FT Weir (Rectangular)			
Reading:	5 7/8"		
Q Per AID Chart	5.78 CFS		

Note: Almost Identical Ratings - Hold Weir Reading (KLC)

Reading Loc.:	*AID North Lateral*		
	Weir at 8,240		
Date:	23-Sep-14		
Meter Type:	Sontek		
Channel Width	8.0 FT		
Sect. Mdpt (Ft)	Section Depth (Ft)	Vel. Average	Q (CFS)
0.5	0.35	0	0.00
1.0	0.3	0.6	0.09
1.5	0.6	0.49	0.15
2.0	1.3	0.11	0.07
2.5	1.24	0.6	0.37
3.0	1.4	0.84	0.59
3.5	1.4	0.64	0.45
4.0	1.4	0.71	0.50
4.5	1.4	0.73	0.51
5.0	1.4	0.64	0.45
5.5	1.35	0.51	0.34
6.0	1.25	0.53	0.33
6.5	1	0.3	0.15
7.0	1	0.57	0.29
7.5	0.95	0.92	0.44
8.0	0.75	0	0.10
		TOTAL=	4.82
Comparative Reading: 5 FT Weir (Rectangular)			
Reading:	5"		
Q Per AID Chart	4.36 CFS		

Note: Hold Weir Reading - Weedy Canal Segment (KLC)

Reading Loc.:	*AID North Lateral*		
	Screen at 10,870 (Parkway)		
Date:	23-Sep-14		
Meter Type:	Sontek		
Channel Width	6.0 FT		
Sect. Mdpt (Ft)	Section Depth (Ft)	Vel. Average	Q (CFS)
0.0	0.7	0	0.06
0.5	1	0.57	0.29
1.0	1.18	0.61	0.36
1.5	1.18	0.7	0.41
2.0	1.22	0.64	0.39
2.5	1.16	0.8	0.46
3.0	1.25	0.74	0.46
3.5	1.22	0.81	0.49
4.0	1.14	0.8	0.46
4.5	1.2	0.7	0.42
5.0	1.17	0.5	0.29
5.5	1.15	0.19	0.11
6.0	0	0	0.00
		TOTAL=	4.21

MAY 26, 2015 READINGS:

Reading Loc.:	*AID North Lateral*		
	TOP OF SYSTEM		
Date:	26-May-15		
Meter Type:	Sontek		
Channel Width	5 FT		
Sect. Mdpt (Ft)	Section Depth (Ft)	Vel. Average	Q (CFS)
0.5	1.0	1.52	1.14
1.0	1.0	1.54	0.77
1.5	1.0	1.53	0.77
2.0	1.0	1.53	0.77
2.5	1.0	1.55	0.78
3.0	1.0	1.48	0.74
3.5	1.0	1.48	0.74
4.0	1.0	1.47	0.74
4.5	1.0	1.61	1.21
		TOTAL=	7.64

Reading Loc.:	*AID North Lateral*
	Weir at Rocking Horse Road
Date:	26-May-15
Channel Width	9.5 FT
Weir Type: 5 FT Weir (Contracted Rectangular)	
Reading:	6.5 IN
Q Per Rect. Weir Equation:	6.49 CFS

Reading Loc.:	*AID North Lateral*		
	Weir at 8,240		
Date:	26-May-15		
Meter Type:	Sontek		
Channel Width	8.0 FT		
Sect. Mdpt (Ft)	Section Depth (Ft)	Vel. Average	Q (CFS)
0.5	0.8	0.01	0.00
1.0	0.85	0.05	0.02
1.5	0.9	0.1	0.05
2.0	1.2	0.41	0.25
2.5	1.25	0.38	0.24
3.0	1.5	0.42	0.32
3.5	1.4	0.74	0.52
4.0	1.4	0.76	0.53
4.5	1.4	0.42	0.29
5.0	1.4	0.56	0.39
5.5	1.4	0.64	0.45
6.0	1.4	0.61	0.43
6.5	1.15	0.55	0.32
7.0	1.1	0.45	0.25
7.5	0.9	0.52	0.23
8.0	0.8	0.55	0.12
9.0	0.6	0	0.14
		TOTAL=	4.54
Comparative Reading: 5 FT Weir (Rectangular)			
Reading:	5.5 IN		
Q Per AID Chart	5.07 CFS		

Note: Hold Weir Reading - Weedy Canal Segment (KLC)

Reading Loc.:	*AID North Lateral*		
	Screen at 10,870 (Parkway)		
Date:	26-May-15		
Meter Type:	Sontek		
Channel Width	6.0 FT		
Sect. Mdpt (Ft)	Section Depth (Ft)	Vel. Average	Q (CFS)
0.0	0.7	0	0.02
0.5	1	0.2	0.10
1.0	1.3	0.43	0.28
1.5	1.35	0.61	0.41
2.0	1.4	0.75	0.53
2.5	1.45	0.74	0.54
3.0	1.45	0.69	0.50
3.5	1.5	0.76	0.57
4.0	1.4	0.75	0.53
4.5	1.4	0.7	0.49
5.0	1.35	0.44	0.30
5.5	1.3	0.31	0.20
6.0	0.9	0.05	0.05
		TOTAL=	4.51

Each of the two measurement sequences were reduced to a seepage loss analysis as follows:

ARNOLD IRRIGATION DISTRICT - NORTH LATERAL
LOSS MEASUREMENT DATA
23-Sep-14

Measurement Number	Measurement Description	Measurement Type	Measurement	Flow Rate CFS	Seepage Loss Total Estd CFS
1	Head End	Sontek Wading Rod		5.87	
2	Weir at Rocking Horse Road	Sontek Weir Reading	 5 7/8" - 5 FT	5.77 5.78	 0.09
3	Weir at 8,240	Sontek Weir Reading	 5" - 5 FT	4.82 4.36	 1.42
4	Screen at 10,870	Sontek		4.21	0.15
			TOTAL LOSS		1.67

ARNOLD IRRIGATION DISTRICT - NORTH LATERAL LOSS MEASUREMENT DATA 26-May-15					
Measurement Number	Measurement Description	Measurement Type	Measurement	Flow Rate CFS	Seepage Loss Total Estd CFS
1	Head End	Sontek Wading Rod		7.64	
2	Weir at Rocking Horse Road	Weir Reading	6 1/2" - 5 FT	6.49	1.14
3	Weir at 8,240	Sontek Weir Reading	5" - 5 FT	4.54 5.07	1.42
4	Screen at 10,870	Sontek		4.51	0.56
			Patron Usage Total		0.13
			TOTAL LOSS		3.00

Seepage loss estimates ranged from 1.67 CFS to 3.00 CFS for the Phase I segment of the North Lateral. The higher loss estimate in the second set of readings was during a higher flow rate in the canal and therefore with water depth higher on the canal banks. It is likely that the loss rate in the canal does range higher during higher flow periods. The peak canal flow rate exceeds what was passed down the canal on May 26, 2015. For the purposes of this study and in the absence of additional seepage loss data, I would recommend using a range of 1.2 CFS to 3.2 CFS over the irrigation season for the canal segment evaluated.

IV. BASE MAPPING

Initial base mapping was developed using freeware and District aerial imagery products, utilization of Deschutes County GIS mapping.

V. RECONNAISSANCE-LEVEL PLAN AND PROFILE

From the base mapping, District aerial imagery obtained from GIS Direct, and profile from the reconnaissance-level survey performed as described above, the reconnaissance-level plan and profile for the Phase I area were developed in AutoCAD. Stationing was developed along the canal to try to follow the existing stationing system incorporated by the District that starts with the head of the lateral and increases downstream on a foot by foot scale. This mapping is included below in Attachment A.

VI. PIPING VERSUS LINING DISCUSSION

LINING CONSIDERATIONS

Canal lining is a challenging proposition that is even more difficult in Central Oregon. The significant seasonal and daily temperature swings, solar impacts, frost heave, wild and domestic animal impacts, and presence of shallow basalt all impact lining alternatives and selection. The U.S. Department of the Interior, Bureau of Reclamation prepared a report addressing a multitude of lining alternatives that were tested locally in

Central Oregon. What the report indicates is that Geomembrane with Concrete Cover, followed by Concrete alone, and then Exposed Geomembrane are in order of decreasing benefit/cost ratio.

In addition to this Bureau report, I have personally witnessed many of the test sites and issues with the various lining products on the local canals, including a Bureau lining failure site where a District's main canal was temporarily out of service as a result. Also, we prepared the fiber-mesh entrained shotcrete solution for an area of concern in another Central Oregon District. This system was installed about 15 years ago and I have visited that site from time to time during that period. About that same time period the North Unit Irrigation District installed approximately 11 miles of roller compacted concrete and shotcrete on its main canal from Bend toward Redmond that has also been observed from time to time.

Based upon the Bureau report, and other experiences with Central Oregon projects as noted above, there are three primary alternatives that may be considered for lining the North Lateral – Phase I: Exposed Geomembrane, Concrete/Shotcrete, or Polyurea Over Geotextile.

Three specific lining alternatives were evaluated as indicated above based upon the Bureau findings and our personal experience with Central Oregon canal lining and piping projects:

- **Exposed Geomembrane** – exposed geomembranes are simply tarp-type liners. They are typically installed by smoothing out the bottom and sides of the canal with equipment and in some instances adding ¾"-0" gravel to prevent basalt rock protrusions from piercing the liner. The liner is typically anchored by digging trenches on each side of the canal about 1-2 feet back from the top of the bank and placing the tarp in those trenches and then backfilling them. Typically the millage thickness of the liner is 40-100 mils.

  The benefit of such liner is that it is fairly simple to install with minimal equipment and outside contractor assistance. Geomembranes are flexible and therefore are not affected by the movements caused by frost heave. Also the initial cost of the material is low.

  The issue that detracts from this material is its relative short life, potential for failure given lack of base support, its propensity to tear in the presence of animal hoof contact, and that its chemical properties diminish, causing it to fail more readily. Also, any liner will generally increase canal flow velocities and personnel exit risk. We used a 15-year life span for this product and have used the Firestone product as a typical lining example that has been readily used by irrigation districts in the West. Additionally, we estimate approximately 10 man-days per mile per year for maintenance of this product.

- **Concrete/Shotcrete** – Concrete and shotcrete have been used readily for canal liners in the West. The Central Oregon Irrigation District has experience with such liners in several locations within its systems. This product is typically installed by smoothing out the bottom and sides of the canal to some extent with equipment. Less preparation is typically necessary for hose-applied shotcrete than traditional structural concrete. The thickness of application and need for reinforcement will vary depending upon the canal substrate.

  The benefit of concrete or shotcrete liners is that they are fairly simple to install, although typically outside contractor assistance is necessary. The other benefit of concrete over geomembranes is that concrete is more tolerant to ultraviolet light from the sun. It is also more resistant to animal hoof damage than geomembranes.

  The issues that detract from concrete or shotcrete liners is that the initial cost of these materials is higher than tarp-type liners. Secondly, concrete is a rigid material that tends to crack when surrounding ground moves or reduces support. With the annual freeze-thaw cycle present in Central Oregon, the canal ground, especially at the canal banks, tends to heave and recede, causing stress fractures in the concrete liner. These are typically mitigated by annual placement of elastomeric caulking in the cracks to prevent irrigation water from entering them, getting behind the concrete and ultimately causing concrete liner failure. For this reason, we disagree with the Bureau report's estimated concrete liner longevity. In our opinion, shotecrete liners in Central Oregon canals will last about 20-25 years and structural concrete liners will last about 30-35 years. We also estimate approximately 10 man-days per mile per year for maintenance of this product.

- **Polyurea over Geotextile Membrane** – Polyurea is an elastomeric spray applied product that is gaining popularity for use on canals. In a basaltic/rocky canal installation such as the North Lateral- Phase I, the canal invert would be evaluated and smoothed by excavator mounted hydro-hammer or similar device, and crushed gravel would be installed to develop a trapezoidal canal section. Next, trenches would be excavated on each side of the top of the bank, a geotextile membrane would be installed across the canal and into the trenches on each side (and then trenches backfilled), and finally, the polyurea would be spray applied to the geotextile membrane.

  Polyurea (90 mil +/-) is a two part product that must be applied by someone certified and/or trained in the application. In a canal situation the build-up would be to an approximate minimum of 90-mils and thicker at the geomembrane seams.

  The benefit of Polyurea, especially in the Central Oregon area with severe temperature swings and winter frost heave is that the product will elongate over 600%. This allows the bridging of moving gaps and adjustment of substrate without tearing the product. The additional benefit of sprayed-on liner is that it

ends up being a monolithic product versus a product with many seams as in tarp-type liners.

The issues that detract from polyurea are its cost in comparison to other liners and that due to its exposure it is likely to deteriorate due to UV and it is susceptible to animal damage as an exposed flexible liner. For these reasons, we have estimated a similar maintenance interval of 10 man days per mile per year for this product. Maintenance would include the repair of any damaged liner sections due to animals (beef animals are present in this project area as well as elk and deer), and repairs of sections damaged due to sediment removal operations.

PIPING CONSIDERATIONS

Piping is a viable and much used solution to canal seepage mitigation. In Central Oregon, buried piping provides a stable environment much more protected from the harsh climate than exposed liner alternatives. Although many varieties of pipe materials have been used on canals in Central Oregon over the years including reinforced concrete, corrugated metal, ductile iron, spiral rib metal, coated and lined steel pipe, and reinforced concrete box culverts, the advent of High Density Polyethylene (HDPE) pipe has provided a product that works very well as a solution to large and small diameter and low and high head canal piping situations. HDPE is more abrasion resistant than steel, it is light weight, may be arced into a radius during installation, and may be welded into a fully sealed and watertight installation. For the purposes of this study, HDPE was assumed as the piping material of choice although other alternatives may be considered during final design and project bidding.

Lining alternatives require routine maintenance and periodic replacement. A detailed cost analysis of lining versus piping was developed by Black Rock Consulting for the COI I-Lateral project and it was found that over a 50-year project cycle, piping was the least cost solution to seepage mitigation (largely due to the fact that HDPE piping will not require replacement within the 50-year period). A copy of this analysis is available upon request and lining was not further evaluated in this summary report.

VII. PIPE MATERIAL SELECTION

As indicated above, high density polyethylene solid wall pipe (HDPE) with 4710 resin was selected as the piping material of choice for the North Lateral – Phase I project. This product is being used extensively in Central Oregon within other District piping projects as well as the water supply project for the City of Bend. The product will work well in the sinuous canal system as it will mitigate the need for multiple bend fittings along the canal. Due to the rocky nature of the canal bottom, some smoothing work will be required and the additional of gravel pipe bedding will be critical for protection of the pipe.

VIII. HYDRAULIC ANALYSIS

Given that the North Lateral is proposed to be a non-branching, single pipeline, a simple hydraulic analysis was performed using the Hazen Williams equation. A hazen-williams coefficient of 130 was used for the HDPE as a conservative value for friction loss of the product. Although manufacturer's will report a higher coefficient, my experience is that with bends, fittings and the bead that results from weld joining of the pipe, the actual frictional loss is more accurately represented at just above HWC=130. The North Lateral serves approximately 189 acres of irrigated area with 30 of those acres being served by the Phase I segment. Although the actual normal delivery to each acre under the District's water right ranges from 5 GPM/Acre to 6.5 GPM/Acre, I used 9 GPM/Acre as agreed with the District to insure capacity for extreme events and design safety factor.

Given the past 10-year delivery history, we found that approximately 5.0 CFS of water is being delivered over and above the 3.8 CFS required to meet the demand at 9 GPM/Acre for the total system's 189 acres of irrigated area. This 5.0 CFS is an estimated loss number assuming a conservative 1.2 CFS of seepage loss in the Phase I system area. Upon implementation of the Phase I project, additional seepage loss assessment should be performed on the balance of the system prior to future phase implementation to confirm actual anticipated losses in the balance of the system.

The following chart provides the full hydraulic analysis performed for the Phase I segment.

NORTH LATERAL

Arnold Irrigation District

May, 2015	Black Rock Consulting				9 GPM/Acre		132 HWC						
Segment Description	**Station Start (FT)**	**Elevation Start (FT)**	**Station End (FT)**	**Elevation End (FT)**	**Segment Length (FT)**	**Total Length (FT)**	**Elevation Differential (FT)**	**Current HGL Slope**	**Turnout Acres**	**Segment Flow Rate (CFS)**	**Hydraulic Segment Length**	**Pipe Material**	**Inside Diameter (IN)**
Start at Lateral Head-End	0	3899.0	80	3896.2	80	80	2.8	0.035		8.8	80	24" HDPE	22.44
Invert	80	3896.2	400	3893.6	320	400	2.6	0.008125		8.8	320	24" HDPE	22.44
Invert	400	3893.6	824	3893.6	424	824	0.0	0		8.8	424	24" HDPE	22.44
13-00824	824	3893.6	1332	3893.6	508	1332	0.0	0	5	8.8	508	24" HDPE	22.44
13-01332	1332	3893.6	1894	3891.0	562	1894	2.6	0.00462633	1	8.7	562	24" HDPE	22.44
13-01894	1894	3891.0	3950	3847.0	2056	3950	44.0	0.02140078	2	8.7	2056	24" HDPE	22.44
13-03950	3950	3847.0	4984	3842.0	1034	4984	5.0	0.00483559	4.36	8.6	1034	20" HDPE	18.7
13-04984/86	4984	3842.0	5457	3841.0	473	5457	1.0	0.00211416	5.5	8.5	473	20" HDPE	18.7
13-05457/59	5457	3841.0	5789	3841.0	332	5789	0.0	0	4	8.4	332	20" HDPE	18.7
13-05789	5789	3841.0	5828	3841.0	39	5828	0.0	0	1.3	8.3	39	20" HDPE	18.7
13-05828	5828	3841.0	8623	3828.0	2795	8623	13.0	0.00465116	3.54	8.3	2795	20" HDPE	18.7
13-08623	8623	3828.0	9589	3808.0	966	9589	20.0	0.02070393	0	8.2	966	18" HDPE	16.83
13-09589	9589	3808.0	10443	3801.0	854	10443	7.0	0.00819672	3.4	8.2	854	18" HDPE	16.83
13-10443	10443	3801.0	10870	3793.3	427	10870	7.7	0.01793911	1.9	8.2	427	18" HDPE	16.83
Inv. Of PVC at Parkway Screen	10870	3793.3											
DELIVERIES BELOW PHASE I									156.68	3.1			
DESIRED TAIL CAPACITY										5.0			
						TOTAL	105.7		188.68		10,870		

IX. RECONNAISSANCE-LEVEL DESIGN CONSIDERATIONS

The North Lateral Phase I project involves piping approximately 2-miles (10,870 LF) of open channel canal that currently conveys water through a sinuous and basalt substrate

channel. The canal falls approximately 106 feet over the Phase I segment. Following the Phase I area, the canal enters a piped system that consists of a variety of pipe materials and diameters to the east side of 3rd Street beyond that, the lateral conveys water through open channel canal and some piped sections. Although it is anticipated that the entire lateral will at some point be piped, this study focuses on the first Phase starting at the head-end of the system. As a result, this study must account for constraints of the remaining lateral system downstream. The piped section downstream of Phase I includes some corrugated metal pipe sections and other low-head piping. Given this, Phase I must either discharge at low-head or pressurized piping must be installed downstream to accommodate Phase I developed pressures. For the purposes of this study, it was assumed that no changes to the downstream system would be implemented, therefore Phase I pressures must be dissipated prior to entering them into the downstream piped section of the North Lateral.

It was assumed that high density polyethylene pipe material (HDPE) would be used at a DR 32.5 wall thickness that will withstand operating pressures up to 63 PSI and will withstand temporary pressure spikes up to 126 PSI. The anticipated peak static pressure of Phase I is 46 PSI. At the discharge of Phase I an energy dissipation device would be installed to reduce pressures to atmospheric and introduce flows back into the piped segment of the North Lateral below Phase I. This device is a valve, perforated pipe and flooded vault system that has been used to successfully reduce pressures over 85 PSI in other situations.

Patron deliveries from the system are anticipated to include a tee or clamp saddle with turnout diameter appropriately sized to serve the delivery acres. Tee or saddle will have a flanged outlet that will connect to a regulating valve such as a sewage plug valve that is tolerant of irrigation water-born debris. Downstream of the valve will be a pressure relief valve in the higher pressure areas of the system, a mag-meter to read flow rates, and a connection to the patron piped delivery or discharge to a gravity system. For higher pressure areas of the lateral an energy dissipation device will be included to reduce pressures to atmospheric when patrons do not have pressurized irrigation systems.

Venting will be included on the system just downstream of the head-works and approximately every 2,500 LF downstream and at significant vertical changes in pipe orientation. Vents will include pressure regulating features including air and vacuum relief when in pressurized areas of the pipeline.

X. COST ESTIMATE

The following cost estimate for the project is based upon the assumption that the Arnold Irrigation District will advertise the project for construction under a competitive bid process. Savings may be realized by the District self-performing the work however it generally taxes staff to perform a piping project while addressing the many other needs of an irrigation district.

The cost estimate includes design and construction management services as well as a 6% contingency. The estimate includes contractor overhead, profit and mobilization. Construction estimates include clearing, grubbing of the canal, excavation of some rock from the invert of the canal, procuring, shipping, welding and placing pipe, installation of patron delivery turnouts, vents and air/vacuum valves, and backfill and compaction of imported materials. Lastly, it includes the construction of a new intake structure with automated head-gate and trash rack and an outlet structure that includes energy dissipation features.

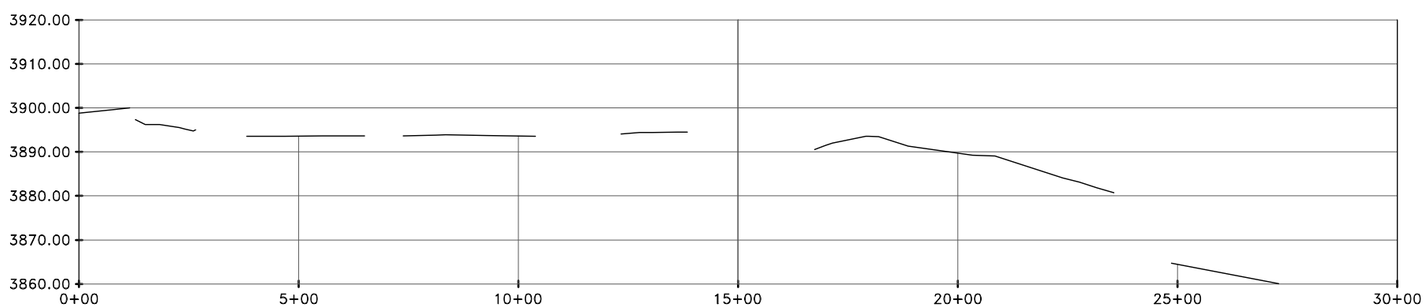
ARNOLD IRRIGATION DISTRICT
NORTH LATERAL PHASE I
RECONNAISSANCE LEVEL COST ESTIMATE

BLACK ROCK CONSULTING/COI REVIEW 06/17/2015 - Assumes Contractor Construction

Construction Item	**Quantity**	**Units**	**Cost/Unit**	**Subtotal Cost**
Earthwork and General Construction				
1. Mobilization, Bonds, Insurance, Profit	12	%	of Total	$167,850.00
2. Clearing and Grubbing	1	LS	$20,000.00	$20,000.00
3. Rock Removal	1,500	CY	$50.00	$75,000.00
4. Backfill, Compaction of Pipeline	12,500	CY	$20.00	$250,000.00
5. Restoration/Seeding	1	LS	$15,000.00	$15,000.00
Pipe (HDPE)				
6. 24" Dia. DR 32.5 Pipe Incl Delivery, Welding, Placing	3,950	LF	$95.00	$375,250.00
7. 20" Dia. DR 32.5 Pipe Incl Delivery, Welding, Placing	4,700	LF	$80.00	$376,000.00
8. 18" Dia. DR 32.5 Pipe Incl Delivery, Welding, Placing	2,250	LF	$72.00	$162,000.00
Pipe Appurtenances				
9. Misc. Fittings, Venting, Automated Headgate	1	LS	$30,000.00	$30,000.00
10. Furnish and install turnout assemblies, complete	13	EA	$3,500.00	$45,500.00
Inlet/Outlet Structures				
11. Reinforced Concrete Inlet/Trash Rack	1	LS	$25,000.00	$25,000.00
12. Reinf. Conc. Outlet Structure with Energy Dissipation	1	LS	$25,000.00	$25,000.00
SUBTOTAL				**$1,566,600.00**
Engineering Design	3.2	%	of Subtotal	$49,974.54
Engineering Construction Management (Part-Time)	2.5	%	of subtotal	$39,165.00
Contingency	6	%	of subtotal	$93,996.00
TOTAL				**$1,749,735.54**

ATTACHMENT 1

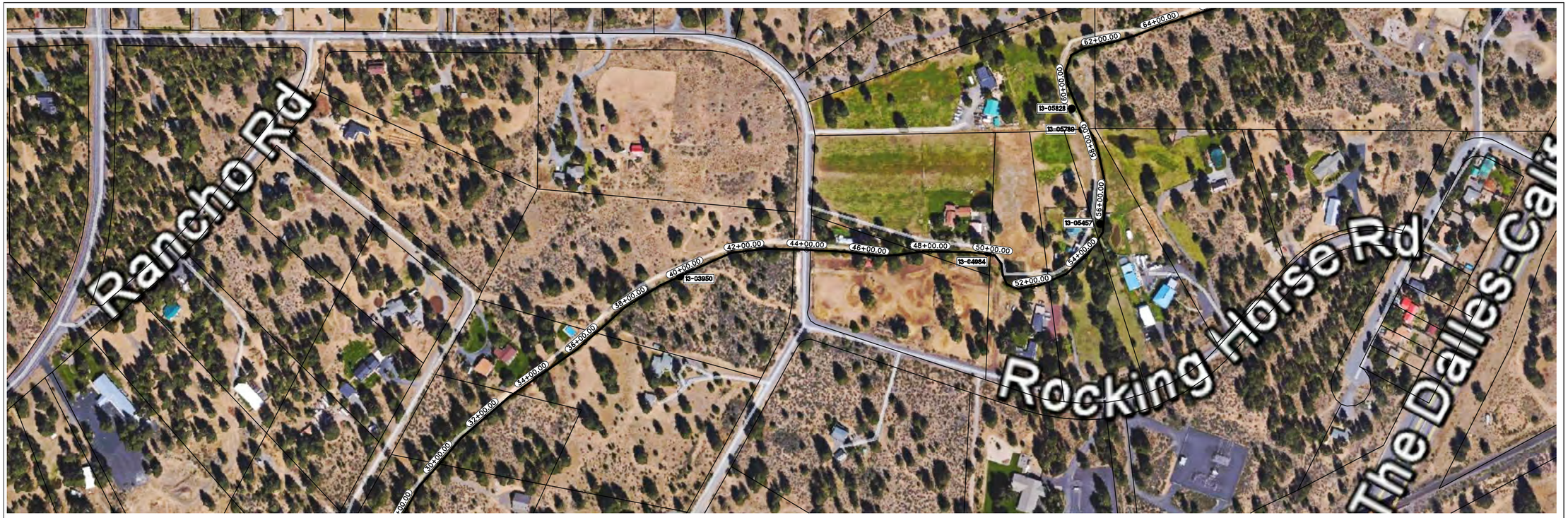
RECONNAISSANCE-LEVEL PLAN AND PROFILE SHEETS



BLACK ROCK CONSULTING INC
20380 HALFWAY ROAD STE. #1
BEND, OREGON 97701
(541) 480-6257

ARNOLD IRRIGATION DISTRICT
NORTH CANAL

Exhibit A1
06.19.15



HORZ. SCALE:1"=150'
VERT. SCALE: 1"=10'
0 150

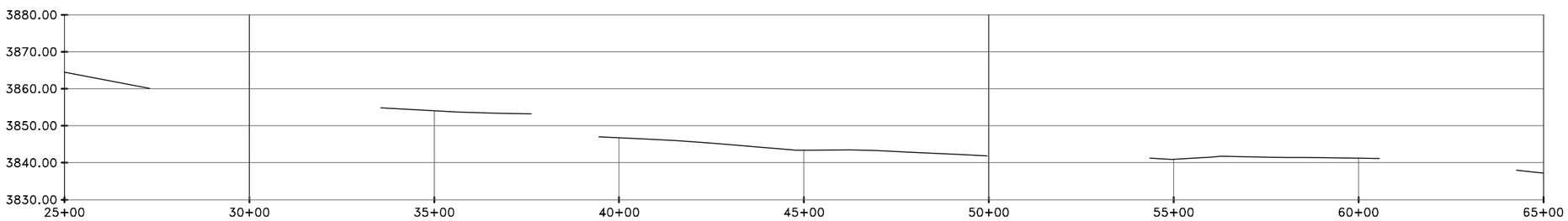


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Exhibit A2
06.19.15

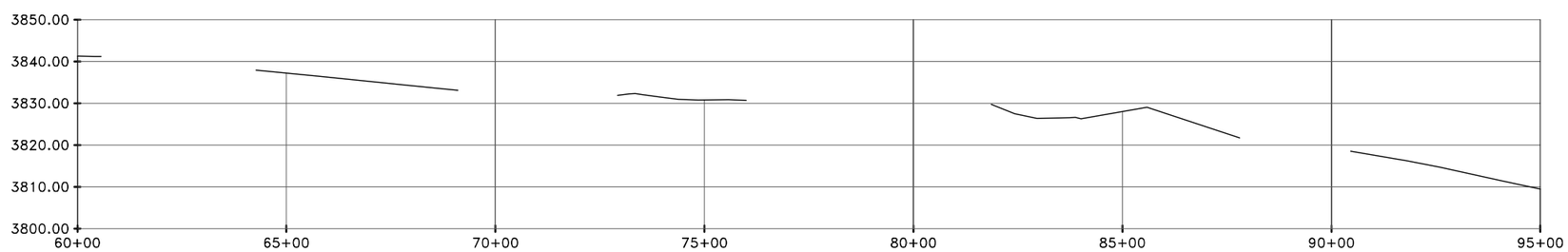

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Exhibit A3
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Exhibit A4
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