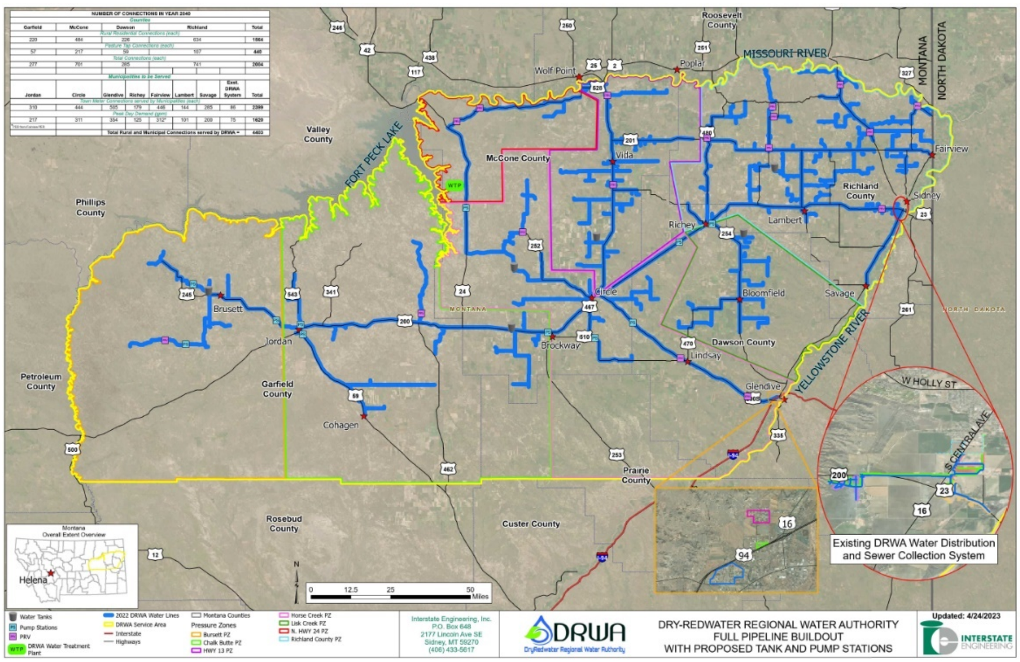
DRY-REDWATER REGIONAL WATER AUTHORITY

PREDESIGN REPORT

MAY 2023



SUBMITTED BY:

INTERSTATE ENGINEERING

HDR

PREDESIGN REPORT

FOR

DRY-REDWATER REGIONAL WATER AUTHORITY

DAWSON, GARFIELD, McCONE AND RICHLAND COUNTY

S2100031

Owner:
106 10th Street
PO Box 276
Circle, MT 59215

Prime Engineer:
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PO Box 648
Sidney, MT 59270

Sub-Consultant:
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REVISIONS			
Date	Description	Preparer	Peer Reviewer

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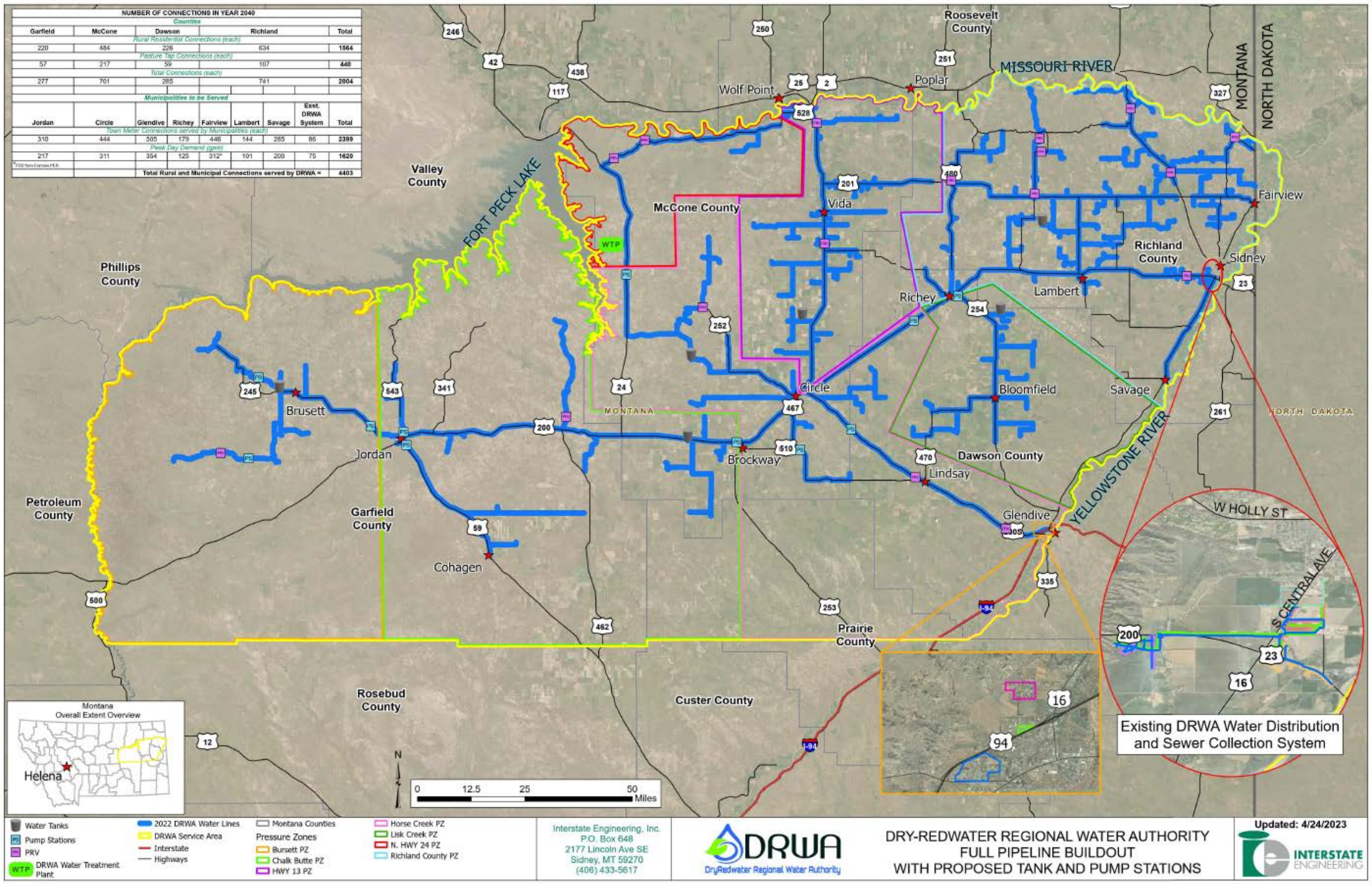
Table of Acronyms

AMI....................................Advanced Metering Infrastructure
AMR...................................Automatic Meter Reading
ARM...................................Administrative Rules of Montana
ASCE ....American Society of Civil Engineers
AWWA...............................American Water Works Association
BLM ....Bureau of Land Management
BNSF ....Burlington Northern Sante Fe Railroad
BOR...................................Bureau of Reclamation
CL ....Lean Clay
DBP ....Disinfection By-Products
DEC...................................Design, Estimating, and Construction Review Report
DNRC................................Montana Department of Natural Resources & Conservation
DPRW ....Dry Prairie Rural Water
DRWA................................Dry-Redwater Regional Water Authority
EPA....................................Environmental Protection Agency
ENR ....Engineering News-Record
FCE ....Field Cost Estimate
GIS....................................Geographic Information System
GPM..................................Gallons per Minute
GWIC ....Montana Ground Water Information Center
HAA5.................................Haloacetic Acids Five
HDPE.................................High Density Polyethylene
HDD ....Horizontal Directional Drilling
IDT ....Informational Data Technologies
kV......................................Kilovolts
MDEQ ....Montana Department of Environmental Quality
MDT ....Montana Department of Transportation
MDU..................................Montana-Dakota Utilities
mg/L..................................Milligrams per Liter
MGD ....Million Gallons per Day
MPDES...............................Montana Pollutant Discharge Elimination System
NEPA ....National Environmental Policy Act
NRCS.................................National Resources Conservation Service
NOI...................................Notice of Intent
NOT ....Notice of Termination
O&M ....Operation and Maintenance
OSHA ....Occupational Safety and Hazard Administration
PID ....Peak Instantaneous Demand
PL ....Public Law
PLS ....Public Land Survey

PPM....................................Parts per Million
PSI......................................Pounds per Square Inch
PVC....................................Polyvinyl Chloride
PDR....................................DRWA Predesign Report
PRV.....................................Pressure Reducing Valve
RWSA..................................2006 Rural Water Supply Act
RWSP..................................BOR Rural Water Supply Program
SWPPP................................Storm Water Pollution Prevention Plan
SC-SM................................Clayey Sand-Silty Sand
SPD....................................Standard Proctor Density
TTHM..................................Trihalomethanes
USDA..................................United States Department of Agriculture
USACE................................United States Army Corps of Engineers
VFD....................................Variable Frequency Drive
WAPA.................................Western Area Power Association
WTP....................................Water Treatment Plant

Executive Summary



NUMBER OF CONNECTIONS IN YEAR 2040

Counties	Garfield	McCone	Dawson	Richland	Total
Rural Residential Connections (each)	220	484	226	634	1564
Pasture Tap Connections (each)	57	217	59	107	440
Total Connections (each)	277	701	285	741	2004

Municipalities to be Served	Jordan	Circle	Glendive	Richey	Fairview	Lambert	Savage	Exst. DRWA System	Total
Town Meter Connections served by Municipalities (each)	310	444	505	179	446	144	285	86	2399
Peak Day Demand (gpm)	217	311	354	125	312*	101	200	75	1620
Total Rural and Municipal Connections served by DRWA =									4403

In October 2022, BOR notified DRWA that $3 million in funding was identified in their FY 22 Spending Plan. This funding will be used to complete a Final Feasibility Study, NEPA and NED by BOR's Contractor for DRWA to receive Federal authorization for their regional water system in FY26.

This Predesign Report has been completed through a Task Order between DRWA and Interstate Engineering and will address most of the comments in the DEC Report. The answers and clarifications in this PDR were prioritized by evaluating what information is most beneficial to the Final Feasibility Study which will be completed by June 30, 2024. The funding for this PDR is paid by DRWA using a grant from DNRC's program.

DRWA was formed in 2005 in anticipation of the 2006 RWSA. DRWA currently holds Board meetings on the third Wednesday of each month in Circle, MT. Since their formation, DRWA has constructed several water and sewer projects south of Sidney. Through an agreement with the City of Sidney, DRWA may purchase a maximum of 500 gpm to service users south of the city limits. DRWA partnered with Richland County and DNRC to construct these improvements beginning in 2013. To date, DRWA serves water to 86 users with 15 of the users being commercial businesses. There are 34 sewer connections providing service to rural homes and commercial businesses.

The remaining communities and homes within DRWA's service area historically have subpar groundwater. The groundwater is so polluted on the west end that Garfield County residents cannot use the water for basic uses such as drinking, washing clothes and dishes, showering, flushing toilets, etc. The Garfield County residents must haul water for these basic uses. The ground water in Garfield County is almost black and cannot be used for human or animal consumption.

The groundwater improves as one moves east across DRWA's service area. The picture below shows ground water samples across the service area. The sample on the right is from Garfield County. The samples from right to left are west to east, respectively.

DRWA is seeking federal authorization and appropriation to construct their regional water system. Their service area is south of the Missouri River and west of the Yellowstone River encompassing Richland, Dawson, Garfield, McCone, and a small part of northern Prairie County and is approximately 11,900 sq. mi. At this time, there is no pipe proposed in Prairie County.

The regional water system is intended to meet the current and future demands of rural customers and several towns. The incorporated towns to be served are Fairview, Circle, Richey, and Jordan. The unincorporated towns are Lambert, Savage, Bloomfield, Brockway, Brusett, Cohagen, Lindsay, and Vida. The water associations of Highland Park, Whispering Trees, and Forest Park in West Glendive will also be served by DRWA.

Currently there are an estimated 1,564 rural users in the service area. The location of pasture taps is unknown until the design of each phase can begin and each landowner can be met with individually. For purposes of this report, 440 pasture tap locations were added to the water model, approximately 30% of the residential users. These were spread evenly across the agricultural areas. The total number of anticipated residential users and pasture taps is 2,004

The table on the next page shows the number of connections in Year 2040. The connections are delineated as rural residential connections, pasture tap connections, and town meter connections. The towns have their own municipal water system and will purchase water from DRWA. Rural connections and pasture taps are spread throughout the four counties.

The total rural residential connections and municipal connections to be served by DRWA is 3,963 connections. The average household occupants are 3.13 persons. DRWA Regional System, when it is fully built out, will serve a minimum of 12,400 persons.

It is expected that a regional system will bring more people into the DRWA service area and DRWA could serve over 15,000 persons by 2050.

NUMBER OF CONNECTIONS IN YEAR 2040

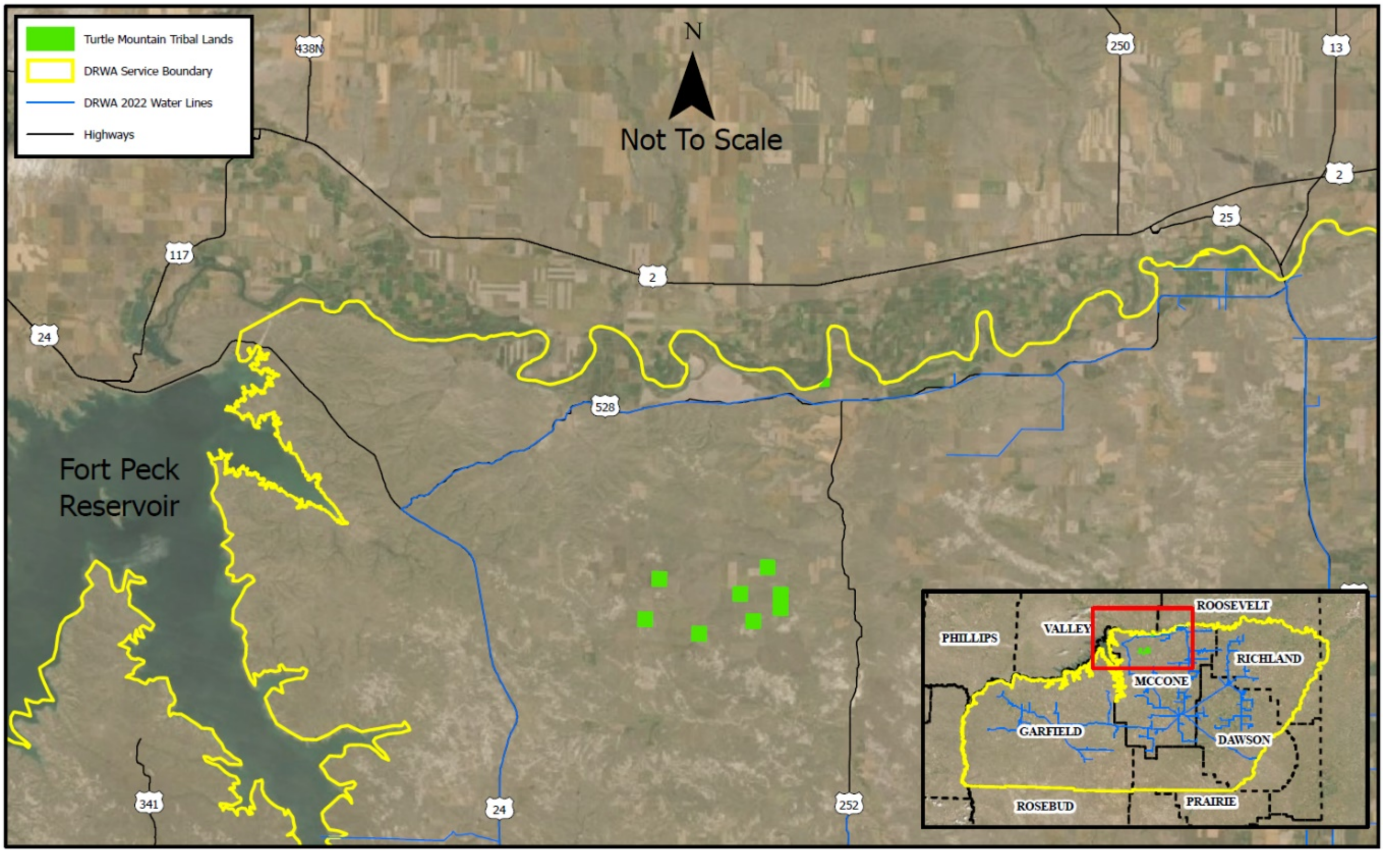
Counties to be Served

Garfield	McCone	Dawson	Richland	Total
Rural Residential Connections (each)				
220	484	226	634	**1564**
Pasture Tap Connections (each)				
57	217	59	107	**440**
Total Connections (each)				
277	701	285	741	**2004**

Municipalities to be Served

Jordan	Circle	Glendive	Richey	Fairview	Lambert	Savage	Exst. DRWA System	Total
Town Meter Connections served by Municipalities (each)								
310	444	505	179	446	144	285	86	**2399**
Peak Day Demand (gpm)								
217	311	354	125	312*	101	200	75	**1620**
*PDD from Fairview PER								
Total Rural and Municipal Connections served by DRWA =								**4403**

There is 1,280 ac of undeveloped land owned by the Turtle Mountain Tribe in McCone County. It is unknown at this time if the tribe will develop these lands. The map below provides an overview of Turtle Mountain Tribal lands within DRWA's service area.



Several water source alternatives were evaluated in the 2012 Feasibility Study, but one alternative was preferred by the DRWA Board and BOR due to its central location. The preferred intake location is in Dry Arm of Fort Peck Reservoir south of Rock Creek State Park at the west end of North Rock Creek Road.

Coordination with government and nongovernment agencies will be necessary for the project to progress through the design and construction phases and a variety of permits are required to construct each phase. However, public meetings were not held for this PDR. Solicitation letters were mailed to federal, state, and local agencies and municipalities to update them on the progress of this project. The letters, and responses received, are found in Appendix A.

DRWA has a Water Marketing Permit for water from the Missouri River with the point of diversion in Fort Peck Reservoir for an annual volume of 3,990 ac-ft and a maximum daily rate of 4,200 gpm (over 6 MGD) which far exceeds the 2040 system peak demand of 3,062 gpm.

At build-out, this regional water system will include over 1,277 miles of pipe ranging in diameter from 3" to 20", 6 tanks, 12 pump stations, 16 PRVs, 323 Air/Vacs, 335 Blowoffs, 7 Meter Manholes, 2,004 water services with a flow meter, and other associated appurtenances.

Typical drawings and draft specifications are created and provide the level of detail needed for an accurate FCE.

The proposed Dry-Redwater Regional Water Authority (DRWA) Fort Peck Water Treatment Plant (WTP) will treat water from the Big Dry Arm/Rock Creek area of Fort Peck Reservoir. The basic design criteria for a water treatment plant are established to address water quality challenges, to comply with current and future regulations, and to reliably operate to meet water demands. Water quality data has been collected for 1 year, intake designed, treatment technology has been developed, and Fort Peck WTP process and layout has been designed meeting EPA and MDEQ regulations.

An alignment change was made with McCone County's aid to the transmission pipe. The 2022 transmission line begins on Highway 24 at North Rock Creek Road runs south along Hwy 24 and turns east on Horse Creek Road, eliminating 13.0 miles of pipeline along Hwy 24 from Horse Creek Road to Flowing Wells. The diameter of the transmission line is decreased to 20 inches due to using the PID and allowing for growth. The air/vac and air releases are reduced to 73 units. PVC and HDPE pipe will be the only pipe materials used on this project. See Appendix 7.2 for the plan set.

Ninety-five percent of the soils within the service area are classified as lean clay (CL) and clayey sand-silty sand (SC-SM) using USDA Web Soils Survey. No organic soil was found. It is anticipated that minimal groundwater may be encountered in pipe trenches, if any. No geotechnical engineering was completed.

Main pipe alignments will initially follow highways, county roads and their rights-of-way. During final design for each phase, DRWA's consultant will meet with each landowner to discuss if the landowner wants a rural residential connection and/or pasture tap. Each landowner that requests a connection will fill out and sign a DRWA User Agreement, an example of this form is in Appendix 10.0. When signed, the document requires the landowner to provide an easement across their property for installation of DRWA's pipelines and appurtenances along with ingress/egress rights. This will move DRWA's system out of road and highway rights-of-way. There is no cost to DRWA for these easements.

If a landowner does not want to purchase a rural residential connection and/or pasture tap, then DRWA's pipeline and appurtenances will remain in the road or county right-of-way and trigger a permit from the correct governmental entity. However, residents that do not want to connect to DRWA's regional water system may allow an easement across their property at no charge to DRWA. It is anticipated that minimal pipe will be routed in road rights-of-way.

For permanent structures such as tanks and pump stations, land purchase will be negotiated with the landowner beginning with the county assessor's valuation.

Currently, DRWA and MEC are working together to determine the best power line routing for DRWA's project. The estimates are preliminary and DRWA/MEC will refine routing and costs over Summer 2023. The final routing costs will include design, construction, easements, and all mitigation required. The final routing costs will be transmitted to BOR by Fall 2023.

MEC proposes to upgrade their 33-mile power line from Circle to Flowing Wells Substation at Hwy 24/Hwy 200 intersection from 69 kV to 115 kV with a 25 kV three-phase underbuild line. Along this upgraded route, the Brockway and Flowing Wells Substations would be upgraded to 115 kV.

A new 35 mile, 115 kV three phase transmission line would be constructed from Flowing Wells Substation to North Rock Creek Rd. A new 115 kV substation at North Rock Creek Rd would be constructed. A distribution line to the WTP and intake from the North Rock Creek Substation would be constructed. The cost for easements and Sage Grouse migration, along Hwy 24 from Flowing Wells to North Rock Creek Road, are not included.

DRWA 115 KV LINE FROM CIRCLE TO ROCK CREEK COST ESTIMATE			
Location	Price Per Mile	# Of Miles	Total
Building New 115KV line from Circle to Flowing Wells	$450,000.00	33	$14,850,000.00
Building New 115KV Line from Flowing Wells to Rock Creek	$450,000.00	35	$15,750,000.00
Building 25 KV 3Ø Underbuild from Circle to Flowing Wells	$80,000.00	33	$2,640,000.00
New 115 KV Substation Transformer @ Brockway Sub			$1,000,000.00
New 115 KV Substation Transformer @ Flowing Wells Sub			$1,000,000.00
New 115 KV Substation @ Rock Creek			$1,500,000.00
Upgrade Flowing Wells Sub to 115 KV (switches, Clothes Line, Etc.)			$500,000.00
Upgrade Brockway Sub to 115 KV (switches, Clothes Line, Etc.)			$500,000.00
		Total	$37,740,000.00

MEC provided the costs for extending power to the BPS. The easement costs were calculated using the average land cost from several real estate websites and multiplying by 10%.

The table on the next page shows the phase and cost for extending power.

Pump Station	Location	HP	Phase	Coordinates	Distance to Power (miles)	Direction to Power from Pump Station	UG or OH	Pump Station Type
Loomis & Clark	Loomis & Clark Rd	2.2	Single	Lat: 47º27'28.80"N Long: -107º23'34.80"W	0.7	West	OH	Distribution
N. Lodge Pole	N. Lodge Pole Rd	0.9	Three	Lat: 47º16'26.40"N Long: -107º25'30"W	0.6	East	OH	Distribution
Brusett Rd	Brusett Rd	24	Three	Lat: 47º20'52.80"N Long: -107º00'50.40"W	Adjacent	NE	OH	Transmission (2-Pump)
Hell Creek Rd	Hwy 541/Hell Creek Rd	1.3	Three	Lat: 47º20'02.40"N Long: -106º54'32.40"W	0.5	South	OH	Distribution
Hwy 59	Hwy 59N	4.3	Single	Lat: 47º17'24"N Long: -106º52'55.20"W	0.7	NW	OH	Distribution
Brockway	Hwy 200E	37	Three	Lat: 47º18'39.59"N Long: -105º47'01.85"W	Adjacent	North	OH	Transmission (2-Pump)
S. Hwy 24	S Hwy 24	310	Three	Lat: 47º40'58.80"N Long: -106º09'18"W	32.3	SE	OH	Transmission (3-Pump)
Union Rd	Union Rd	2.5	Single	Lat: 47º17'38.40"N Long: -105º34'22.80"W	Adjacent	NE	OH	Distribution
Hwy 200S	Hwy 200S	48	Three	Lat: 47º23'24.16"N Long: -105º28'37.39"W	Adjacent	SW	OH	Transmission (2-Pump)
Hwy 200	Hwy 200	227	Three	Lat: 47º32'59.80"N Long: -105º16'37.14"W	9.5	NE	OH	Transmission (3-Pump)
Hwy 254	Hwy 254	52	Three	Lat: 47º38'31.20"N Long: -105º02'34.80"W	Adjacent	NE	OH	Transmission (2-Pump)

Pump Station Power Costs (MEC Option)				
Location	Dist. to Existing Power Line (ft)	Cost to Extend Power Line	Cost for Easement	Total Cost to Deliver Power
Loomis and Clark Road	3,696	$45,000	$10,200	$55,200
North Lodgepole Road	3,168	$36,000	$8,800	$44,800
Brusett Road	317	$0	$0	$0
Hell Creek Road	2,640	$30,000	$7,300	$37,300
Highway 59	3,696	$42,000	$10,200	$52,200
Brockway	264	$90,000	$800	$90,800
South Highway 24	1,320	$0	$6,000	$6,000
Union Road	158	$120,000	$500	$120,500
Highway 200 South	528	$570,000	$1,500	$571,500
Highway 200	50,160	$1,380,000	$138,200	$1,518,200
Highway 254	1,056	$0	$3,000	$3,000
Totals		$2,313,000	$186,500	$2,499,500

Interstate Engineering has prepared a detailed Field Cost Estimate, a Construction Cost Estimate, a Phasing Plan, and a Project Cost Estimate.

A summary of Major Field Items was developed by gathering past bid tabulation from similar projects, seeking vendor pricing, establishing labor and equipment pricing, and gathering quantities. Bid items from previous projects were inflated to 2022 dollars using the BOR's cost trend tables. Local vendors were contacted for current material pricing. With the current economy, price of materials, and labor shortage, the price quotes provided for materials exceeded the costs gathered from bid tabulations. To establish a more accurate price for each bid item, Interstate Engineering developed a labor and equipment price that was added to the current material prices. The labor and equipment prices were created by subtracting the material price from the total cost of the corresponding bid item, leaving a price for labor and equipment. The remaining labor and equipment price for each bid item was inflated to 2022 dollars using the BOR cost trend tables. Bid items were quantified using the updated hydraulic model and DRWA's GIS.

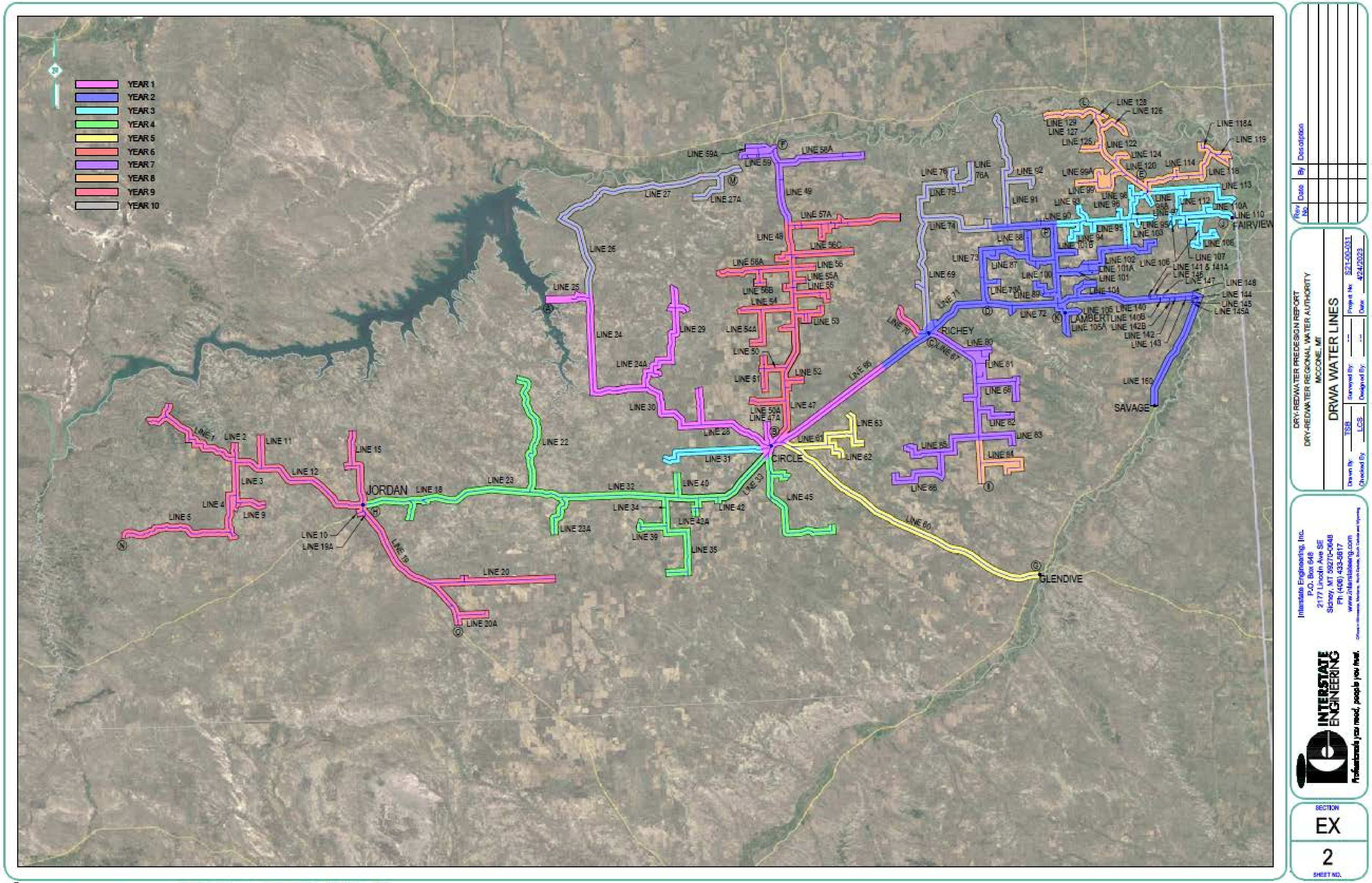
The Field Cost Estimate is an estimate of the capital costs of a project from award to construction closeout and includes a sum of all major field items, mobilization, procurement strategies, and contingencies. The total cost of all major field items is $433,471,500. Mobilization is set for the project at 5% and is the industry standard for rural water projects in the area. Design contingencies account for minor unlisted items, design and scope changes, and cost estimate refinements. Based on the considerable effort spent by Interstate Engineering to minimize the amount of design and scope changes on the project, the design contingencies have been set at 10% of the total cost of major field items plus mobilization. A 3% contingency has been added to the project to cover any change in procurement strategies. Construction contingencies account for minor differences in actual and estimated quantities, unforeseeable difficulties on site, change in site conditions, possible minor changes in plans, and other uncertainties. Interstate Engineering has established construction contingencies at 20% for the project. The total FCE for the project is $586,490,000.

The Construction Cost Estimate was developed by adding non-contract costs to the FCE. Non-contract costs include items for services provided in support of the project. Percentages for each non-contract cost were set using engineering judgement in conjunction with the recent DRWA Culbertson-Lambert-Fairview Project, the current DRWA Highway 200 West Project, and other recent Interstate Engineering rural water projects in North Dakota. The total non-contract costs for the project are 29.25% of the FCE. The total CCE for the project is $753,640,000. The table on the next page provides a summary of costs and percentages used to develop this estimate.

Master CCE		
Subtotal Major Field Items		**$412,830,000.00**
Mobilization	5%	$20,641,500.00
Subtotal with Mobilization		**$433,471,500.00**
Design Contingencies (2%-20%)	10%	$43,347,150.00
Subtotal with Design Contingencies		**$476,818,650.00**
Procurement Strategies	3%	$14,304,560.00
Subtotal with Procurement Strategies		**$491,123,210.00**
Construction Contingencies (20%-25%)	20%	$95,363,730.00
Subtotal with Construction Contingencies		**$586,490,000.00**
Total Field Costs		**$586,490,000.00**
Non-Contract Costs		
USBR Facilitating Services	4.00%	$23,459,600.00
Environmental	0.50%	$2,932,450.00
Easements/Right-of-Way/Land Purchases	0.75%	$4,398,675.00
Geotechnical Investigation	0.50%	$2,932,450.00
Archeological	0.25%	$1,466,225.00
Design Surveys	2.00%	$11,729,800.00
Design	6.50%	$38,121,850.00
Project Management	1.50%	$8,797,350.00
Construction Observation	9.00%	$52,784,100.00
Construction Management	1.50%	$8,797,350.00
Other (Office)	2.00%	$11,729,800.00
Subtotal Non-Contract Costs		$167,149,650.00
Total Construction Cost		**$753,640,000.00**

The construction duration for the project is set for 10 years, beginning from the notice to proceed, as is recommended by and typical of Reclamation's rural water projects. The phasing plan was developed by Interstate Engineering to assure project completion within ten years. The project was split into 141 individual line numbers and consists of 16 phases. Phases were established using a combination of cost estimates for each line number, pipeline lengths and quantity of residential users. Phases were organized to capture the bulk of revenue from the project's bulk users in the first years of the project to cover OM&R costs and provide coverage for construction loans. The timeliness of the project's phases and overall completion is contingent on availability of federal funding. The table on the next page provides a breakdown of the phases and year in which it will be constructed and placed into service. The map on the following page provides a visual of the total project and is color coded to show the corresponding year and which phases will be constructed.

Phasing Plan Costs								
Location	Installation Year	Phase		Install Rate (miles/day)	Length of Pipe (miles)	Installation Time (days)	$/Day	Total $
Ft. Peck→Circle	1	A→B	=	0.35	84.5	239	$575,504.81	$137,489,173.67
Circle→Richey	2	B→C	=	0.13	27.7	222	$72,972.28	$16,179,988.02
Richey→HWY 200/RD 317		C→D	=	0.10	12.3	122	$54,440.51	$6,644,554.55
HWY 200/RD 317→Lambert	3	D→K	=	0.60	87.2	145	$243,351.05	$35,223,423.28
HWY 200/RD 317→HWY 201/RD 328	4	D→P	=	0.25	63.5	254	$60,940.31	$15,459,033.55
HWY 201/RD 328→HWY 16	5	P→E	=	1.09	52.9	48	$293,616.98	$14,223,295.69
HWY 16→Fairview		E→J	=	0.47	49.9	106	$105,086.82	$11,127,420.60
Circle→Jordan	6	B→H	=	1.30	174.6	134	$327,984.68	$43,886,340.19
Circle→Glendive	7	B→G	=	0.28	66.9	237	$93,696.84	$22,227,479.18
Circle→Missouri River		B→F	=	3.16	186.9	59	$547,649.37	$32,417,751.57
Richey→S. Richey	8	C→I	=	1.04	98.4	95	$153,133.97	$14,509,940.02
Hwy 16→Culbertson		E→L	=	1.33	82.2	62	$189,884.08	$11,710,733.64
Jordan→Lodge Pole Rd	9	H→N	=	1.43	102.2	71	$245,710.28	$17,555,191.67
Jordan→Cohgen		H→O	=	0.44	50.0	115	$61,565.99	$7,061,167.60
Richey→HWY 201/RD 328	10	C→P	=	0.80	86.8	108	$153,961.65	$16,639,186.56
Ft. Peck→HWY 528		A→M	=	1.72	51.3	30	$351,091.55	$10,472,027.10
					1277.3	2046		$412,826,706.89



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Construction of the project will take more than 10 years should federal funding not be available in accordance with the phasing plan. Therefore, it is prudent for DRWA and Reclamation to work together to advocate for the necessary funding to complete the project as shown in the phasing plan.

The total cost used for seeking congressional authorization and funding is known as the Project Cost Estimate. The CCE for each installation year is escalated using an inflation rate of 4%, beginning in 2026. The escalated construction cost for each installation year is then discounted back to the year 2026 to calculate the total PCE using a discount rate of 2.50%. The discount rate was taken from OMB Circular No. A-94. The PCE for the project is estimated at $891,957,210.33 in 2026 dollars. The table on the following page shows the FCE, CCE, and PCE broken out by installation year.

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		YEAR 1 (2026)	YEAR 2 (2027)	YEAR 3 (2028)	YEAR 4 (2029)	YEAR 5 (2030)	YEAR 6 (2031)	YEAR 7 (2032)	YEAR 8 (2033)	YEAR 9 (2034)	YEAR 10 (2035)
Subtotal		$116,255,938.10	$35,348,201.21	$17,810,824.93	$36,691,612.95	$17,531,218.64	$42,081,925.39	$36,294,493.13	$48,804,844.41	$40,131,468.98	$21,876,179.14
Mobilization	5.00%	$5,812,796.91	$1,767,410.06	$890,541.25	$1,834,580.65	$876,560.93	$2,104,096.27	$1,814,724.66	$2,440,242.22	$2,006,573.45	$1,093,808.96
Subtotal with Mobilization		$122,068,735.01	$37,115,611.27	$18,701,366.18	$38,526,193.60	$18,407,779.57	$44,186,021.66	$38,109,217.79	$51,245,086.63	$42,138,042.43	$22,969,988.10
Design Contingencies (2%-20%)	10.00%	$12,206,873.50	$3,711,561.13	$1,870,136.62	$3,852,619.36	$1,840,777.96	$4,418,602.17	$3,810,921.78	$5,124,508.66	$4,213,804.24	$2,296,998.81
Subtotal with Design Contingencies		$134,275,608.51	$40,827,172.40	$20,571,502.79	$42,378,812.96	$20,248,557.53	$48,604,623.83	$41,920,139.57	$56,369,595.29	$46,351,846.67	$25,266,986.91
Construction Contingencies (20%-25%)	20.00%	$26,855,121.70	$8,165,434.48	$4,114,300.56	$8,475,762.59	$4,049,711.51	$9,720,924.77	$8,384,027.91	$11,273,919.06	$9,270,369.33	$5,053,397.38
Subtotal with Construction Contingencies		$161,130,730.21	$48,992,606.88	$24,685,803.35	$50,854,575.55	$24,298,269.04	$58,325,548.59	$50,304,167.48	$67,643,514.35	$55,622,216.01	$30,320,384.29
Total Field Costs		$161,130,730.21	$48,992,606.88	$24,685,803.35	$50,854,575.55	$24,298,269.04	$58,325,548.59	$50,304,167.48	$67,643,514.35	$55,622,216.01	$30,320,384.29
Non-Contract Costs											
USBR Facilitating Services	4.00%	$6,445,229.21	$1,959,704.28	$987,432.13	$2,034,183.02	$971,930.76	$2,333,021.94	$2,012,166.70	$2,705,740.57	$2,224,888.64	$1,212,815.37
Environmental	0.50%	$805,653.65	$244,963.03	$123,429.02	$254,272.88	$121,491.35	$291,627.74	$251,520.84	$338,217.57	$278,111.08	$151,601.92
Easements/Right-of-Way/Land Purchases	1.50%	$2,416,960.95	$734,889.10	$370,287.05	$762,818.63	$364,474.04	$874,883.23	$754,562.51	$1,014,652.72	$834,333.24	$454,805.76
Geotechnical Investigation	0.50%	$805,653.65	$244,963.03	$123,429.02	$254,272.88	$121,491.35	$291,627.74	$251,520.84	$338,217.57	$278,111.08	$151,601.92
Archeological	0.25%	$402,826.83	$122,481.52	$61,714.51	$127,136.44	$60,745.67	$145,813.87	$125,760.42	$169,108.79	$139,055.54	$75,800.96
Design Surveys	2.00%	$3,222,614.60	$979,852.14	$493,716.07	$1,017,091.51	$485,965.38	$1,166,510.97	$1,006,083.35	$1,352,870.29	$1,112,444.32	$606,407.69
Design	6.50%	$10,473,497.46	$3,184,519.45	$1,604,577.22	$3,305,547.41	$1,579,387.49	$3,791,160.66	$3,269,770.89	$4,396,828.43	$3,615,444.04	$1,970,824.98
Project Management	1.50%	$2,416,960.95	$734,889.10	$370,287.05	$762,818.63	$364,474.04	$874,883.23	$754,562.51	$1,014,652.72	$834,333.24	$454,805.76
Construction Observation	9.00%	$14,501,765.72	$4,409,334.62	$2,221,722.30	$4,576,911.80	$2,186,844.21	$5,249,299.37	$4,527,375.07	$6,087,916.29	$5,005,999.44	$2,728,834.59
Construction Management	1.50%	$2,416,960.95	$734,889.10	$370,287.05	$762,818.63	$364,474.04	$874,883.23	$754,562.51	$1,014,652.72	$834,333.24	$454,805.76
Other (Office)	2.00%	$3,222,614.60	$979,852.14	$493,716.07	$1,017,091.51	$485,965.38	$1,166,510.97	$1,006,083.35	$1,352,870.29	$1,112,444.32	$606,407.69
Subtotal Non-Contract Costs		$47,130,738.59	$14,330,337.51	$7,220,597.48	$14,874,963.35	$7,107,243.69	$17,060,222.96	$14,713,968.99	$19,785,727.95	$16,269,498.18	$8,868,712.40
Total Phase Cost		$208,261,468.79	$63,322,944.39	$31,906,400.83	$65,729,538.90	$31,405,512.73	$75,385,771.55	$65,018,136.47	$87,429,242.30	$71,891,714.19	$39,189,096.69
Construction Cost (with Escalation to NTP, Price Level 2026)		$243,636,461.99	$77,042,044.08	$40,371,775.79	$86,495,589.07	$42,980,612.74	$107,297,459.14	$96,242,724.92	$134,593,301.70	$115,100,950.68	$65,252,726.67
2026 Present Value		$237,694,109.26	$73,329,726.66	$37,489,207.22	$78,360,734.69	$37,988,598.86	$92,522,262.74	$80,965,658.60	$110,466,990.83	$92,164,595.67	$50,975,325.79

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1.0 Project History

1.1 Federal Funding

DRWA was formed in 2005 as a Water Authority in anticipation of the Federal 2006 RWSA.

The 2006 RWSA intention was to provide a consistent framework for Appraisal Reports and Feasibility Studies and provide a consistent and inclusive report process for new rural water systems which were seeking federal funding authorization and appropriation. Prior to the 2006 RWSA, the method for studies and construction costs for authorized rural water systems was inconsistent which made it difficult for applicants to write quality engineering reports and for BOR to review the engineering reports for completeness. The 2006 RWSA intended to alleviate the difficulty between receiving applicants' requests for rural water systems and BOR's approval of feasibility studies to achieve Federal authorization in the 17 western states where rural areas either had poor quality water or no water at all. The 2006 RWSA is attached as Appendix 1.0.

The 2006 RWSA was passed by Congress on September 30, 2006 and was to remain in effect for 10 years. In the RWSA, Congress tasked BOR with publishing the criteria for Appraisal Reports and Feasibility Studies in the Federal Register not later than 18 months after enactment. The criteria were to outline exactly what information was to be included in Appraisal Reports and Feasibility Studies, eligibility of a rural community, and how to prioritize requests for assistance.

The Interim Final Rule establishing programmatic criteria for RWSP was published in the Federal Register Vol. 73, No. 222, November 17, 2008. The Interim Rule is attached as Appendix 1.1. BOR implemented the RWSP in 2010, 4 years after the 2006 RWSA, on a pilot basis. Between 2009 and 2012, Congress provided BOR with $7.9 million for the RWSP. After 2012, BOR no longer requested Congressional funding for the RWSP.

During the 10 years of the RWSA, BOR reported studying 22 rural water projects to varying extents. Of these 22 feasibility studies only two were completed with the level of detail BOR required in their Interim Final Rule. They are Central Montana (Musselshell-Judith Rural Water System) and Payson-Cragin Reservoir Water Supply project in Colorado. However, BOR did not recommend the two projects for authorization due to the many outstanding rural water construction obligations appropriated before 2006 RWSA. BOR personnel were stretched thin and wanted to complete the outstanding projects before adding more projects to their busy schedules. Therefore, the two projects were not recommended for authorization under the 2006 RWSA. See Appendix 1.2 for the history of BOR rural water projects including discussion of the 2006 RWSA and rural water projects under construction in FY2020.

For Montana, the Musselshell-Judith Rural Water System and DRWA Feasibility Study received authorization for funding in Public Law 116-260 enacted December 27, 2020. The portion of the PL for these two projects is attached as Appendix 1.3.

1.2 DRWA Reports

DRWA and Interstate Engineering have completed many analyses and reports from 2006 through 2022 to keep DRWA regional water project moving forward. Beginning in 2002, DRWA began their information campaign consisting of mailings, public notices in newspapers, and public meetings to determine interest in a rural water system. The result was overwhelmingly positive and DRWA began collecting Good Intention Fees from interested landowners. A Good Intention Fee of $100 was paid by interested landowners and public water suppliers to show their commitment to a rural water system. DRWA collected $73,525 to-date.

In 2006, Interstate Engineering authored for DRWA a June 2006 Feasibility Study in anticipation of the 2006 RWSA enactment. The landowner response to this feasibility study was overwhelmingly positive and many additional rural residents paid their Good Intention Fee. At the direction of DRWA, Interstate Engineering provided an addendum to the 2006 Feasibility Study to include the new users titled 2007 Final Feasibility Study.

In April 2010, an Appraisal Investigation/Report was completed by Interstate Engineering as required by the 2006 RWSA. In April 2010, BOR authored a Value Engineering Report based on the Appraisal Investigation/Report. In July 2010, BOR authored their Appraisal Report and delivered to DRWA a letter informing DRWA they could now progress to a Feasibility Study.

In Sept 2012, at the request of DRWA, Interstate Engineering updated the 2007 Final Feasibility Study and authored a Final Feasibility Report. At this time, the 2006 RWSA final feasibility guidelines had not been published in the Federal Register. From 2010 to 2012, DRWA and Interstate Engineering attempted to work with BOR to produce a suitable Feasibility Study. However, BOR was inundated with Feasibility Studies and the existing rural water construction obligations prior to the 2006 RWSA which made it challenging for all entities to provide input.

BOR provided a review of the 2012 Feasibility Study. BOR produced a DEC report in October 2012 of their review. The purpose of the DEC review is to provide independent BOR oversight to ensure products related to design, cost estimating, and construction are technically sound and provide a credible basis for decision making by BOR leadership and other decision makers. This includes an emphasis to ensure cost estimates for the project are appropriate for their intended purpose and major risk and uncertainties have been fully addressed in the estimates. The DEC report provided five Findings and Recommendations that need to be further developed and/or clarified in this PDR.

BOR's final report for DRWA under the RWSA was in September 2016. BOR authored their Feasibility Study Concluding Report which provided an overview of DRWA's 2012 Feasibility Study and the reason for deferring the study primarily due to the economics of the proposed alternative and the RWSA ending.

In May 2018, DRWA and Interstate Engineering wrote the Draft Economic and Financial Analysis (NED) Report of the 2012 Feasibility Study. DRWA funded this report to keep DRWA's project moving forward while awaiting appropriation for their authorized feasibility study. BOR did provide a high level review of this document in 2020 even though RWSA had sunset in 2016.

DRWA was encouraged by DNRC to continue progress on this project knowing that federal authorization would be likely. DNRC recommended to DRWA they use DNRC funding for this Predesign Report. This PDR answers most of the DEC report's Findings and Recommendations.

On October 26, 2022, BOR notified DRWA was closer to receiving funds for completion of the feasibility study and that $3 million of funding had been identified on BOR's FY 22 Spend Plan.[1]

The feasibility study will be completed by a consultant hired by BOR, beginning in 2023 and concluding in 2024. The PDR and prior reports will be used by BOR and their consultant to complete a NEPA, a Final Feasibility Study and Report, and a NED meeting BOR guidelines.

2.0 Project Description

2.1 Service Area

DRWA's boundary encompasses 11,874 square miles in a rural area in the southern portion of northeastern Montana. There are approximately 1,564 (in 2020) rural homes that will be served by DRWA. The towns of Circle (2020 population 511), Fairview (2020 population 898), Richey (2020 population 167), Lambert (2020 population 84) and Jordan (2020 population 412) will receive water from DRWA. These towns will be responsible for continuing to maintain their municipal water systems and delivering water to their users. DRWA will deliver water to each town's tank. The unincorporated towns of Savage, Bloomfield, Brockway, Brusett, Cohagen, Lindsay, and Vida will also be served by DRWA. The unincorporated towns do not have a municipal water system except for Lambert which has a sewer and water district. The towns' homes are on individual wells. DRWA will provide piping throughout the unincorporated towns to provide individual services to each home.

The cities of Glendive and Sidney declined to take part in this project.

[1] https://www.usbr.gov/bil/docs/spendplan-2022/Reclamation-BIL-Spend-Plan-Storage-Addendum-09-30-2022.pdf

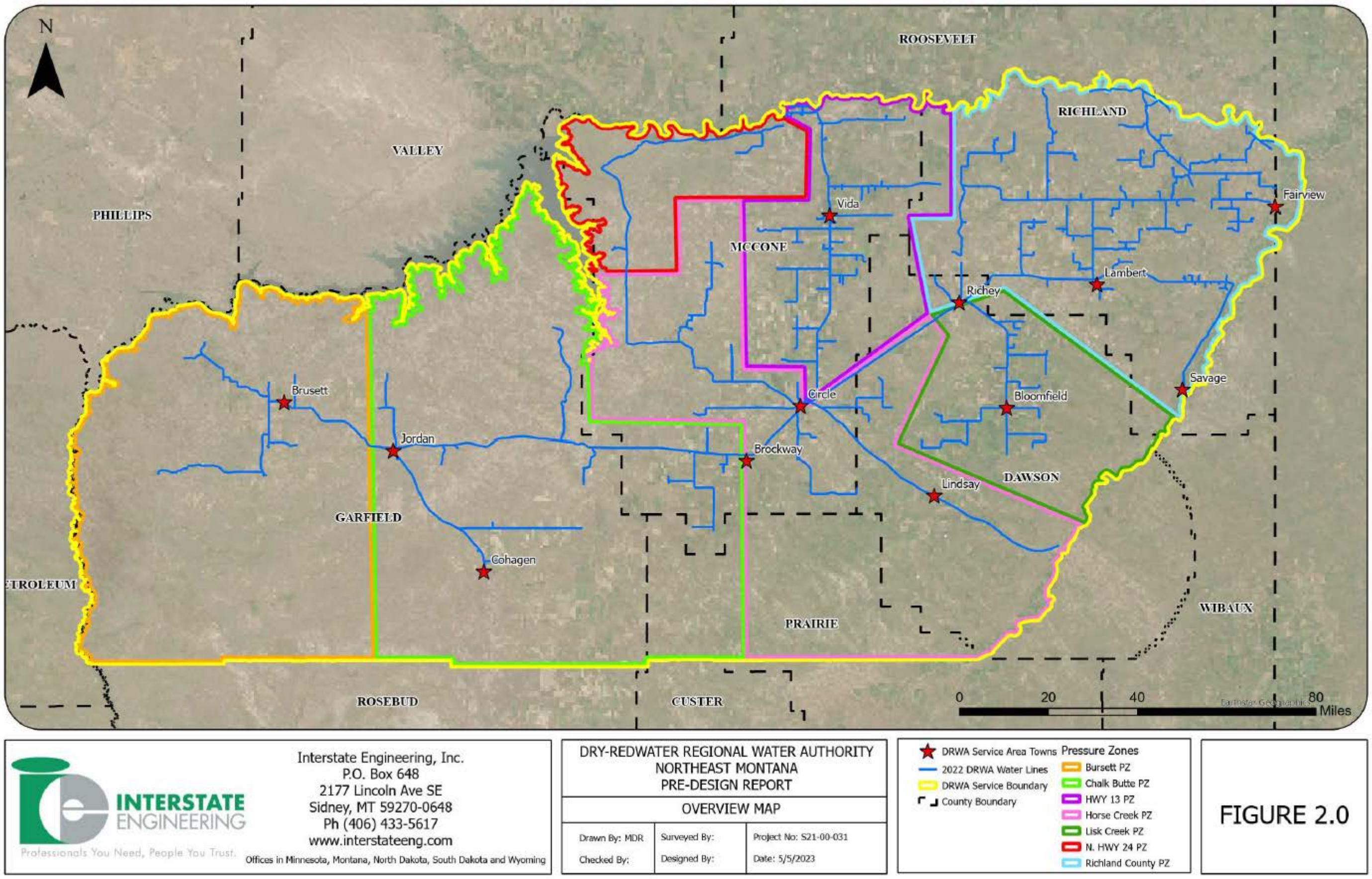

Figure 2.0 Overview Map with 2022 Piping

Figure 2.0 above is also shown in Appendix 2.0 as an 11 x 17 map with 2022 piping.

There are tribal trust lands within DRWA's service area. These lands belong to the Turtle Mountain Tribe, are located east of Fort Peck and south of Remuda Road and are 1,280 ac in size. Should these tribal lands be developed, DRWA's regional water system will have the capacity to serve them.

Figure 2.1 below shows the location of Turtle Mountain Tribe's lands. Currently these parcels are undeveloped.

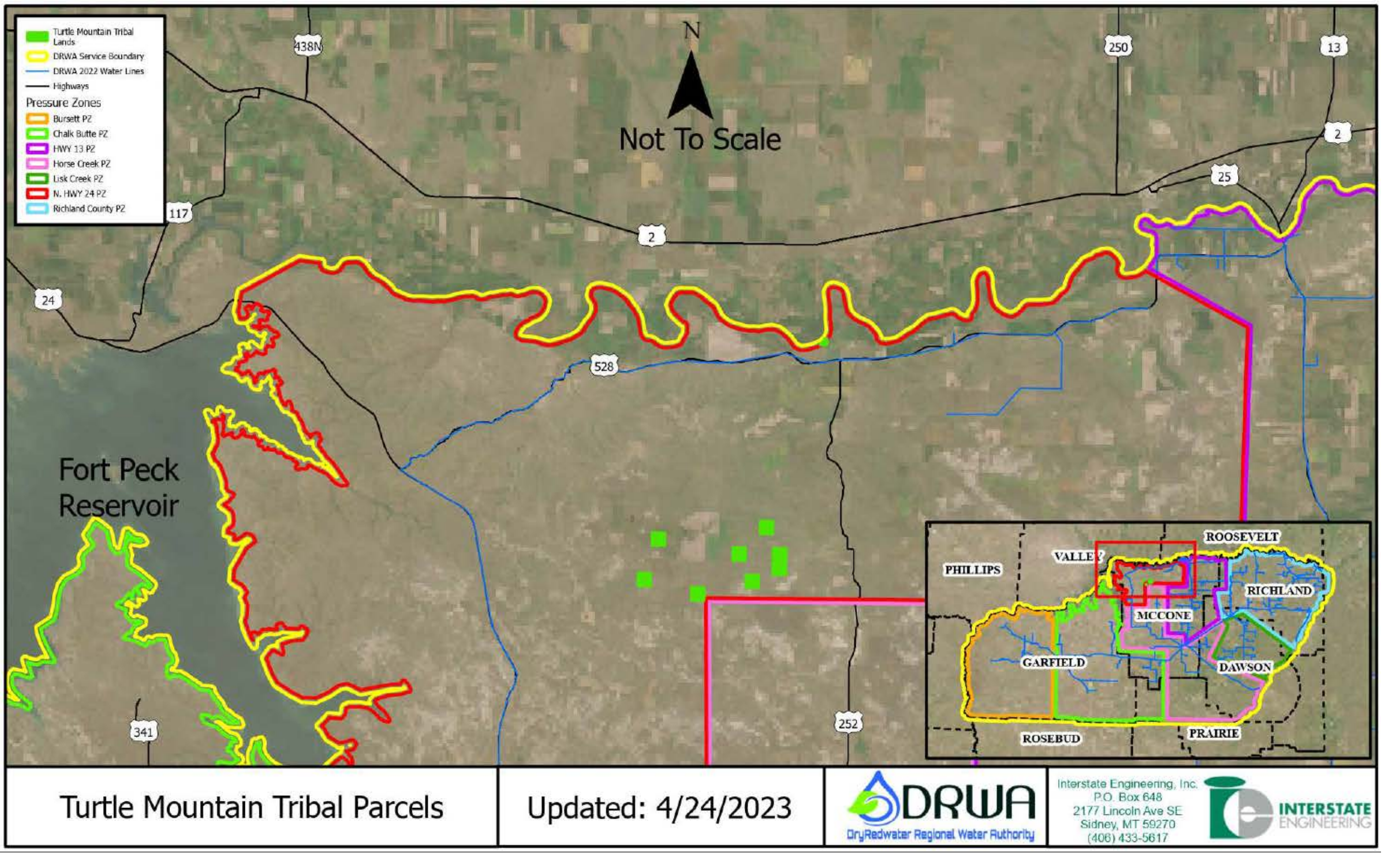

Figure 2.1 Turtle Mountain Tribal Parcels

2.2 Water Rights

DRWA has a Provisional Permit No. 40E 30064997 from Montana DNRC to withdraw water from the Missouri River with the Point of Diversion in Fort Peck Reservoir to serve their system. The purpose of the permit is for Water Marketing with the Place of Use (Point of Sale) at the future Water Treatment Plant. The permit withdrawal rate is a maximum flow of 4,200 gpm (over 6 MGD) with a maximum annual withdrawal volume of 3,990 ac-ft (over 1 billion gallons per calendar year). DRWA's water right has a priority date of December 10, 2012, for Municipal & Domestic Water Supply. The deadline for the Project Completion Notice is December 31, 2025. This deadline will not be met due to lack of federal funding. The funding process DRWA has been participating in with the BOR and the State of Montana since 2005 is ongoing. Before December 31, 2025, DRWA must file with DNRC a Form 607 – Application for Extension of Time. Form 607 is in Appendix 2.1.

An update to the permit was issued on June 15, 2015, by the Water Rights Bureau Chief for the DNRC. This update informs DRWA that the June 4, 2015, Final Order issued in the Matter of Application for Beneficial Use Permit Application No. 40S 30066181 by Atlantis Water Solutions, LLC has implications for the type of evidence DRWA must submit when filing a Form 617 Project Completion Notice for their marketing permit. DRWA's Project Completion Notice, when submitted, will require DRWA to have firm contractual agreements for all water claimed to be perfected. DNRC will only consider the water right perfected up to the amount of the water described in each contractual agreement for water that was diverted. Water measurement reports must be included, as well. Form 617 is in Appendix 2.2.

DRWA will use the water year around to supply water within their service boundary. The place of use (point of sale) for water marketing purposes will be the proposed water treatment plant that will be constructed in portions of Section 9 and Section 16, T23N, R43E in McCone County. Figure 2.2 below shows the location of the intake and the property where the future WTP will be constructed.

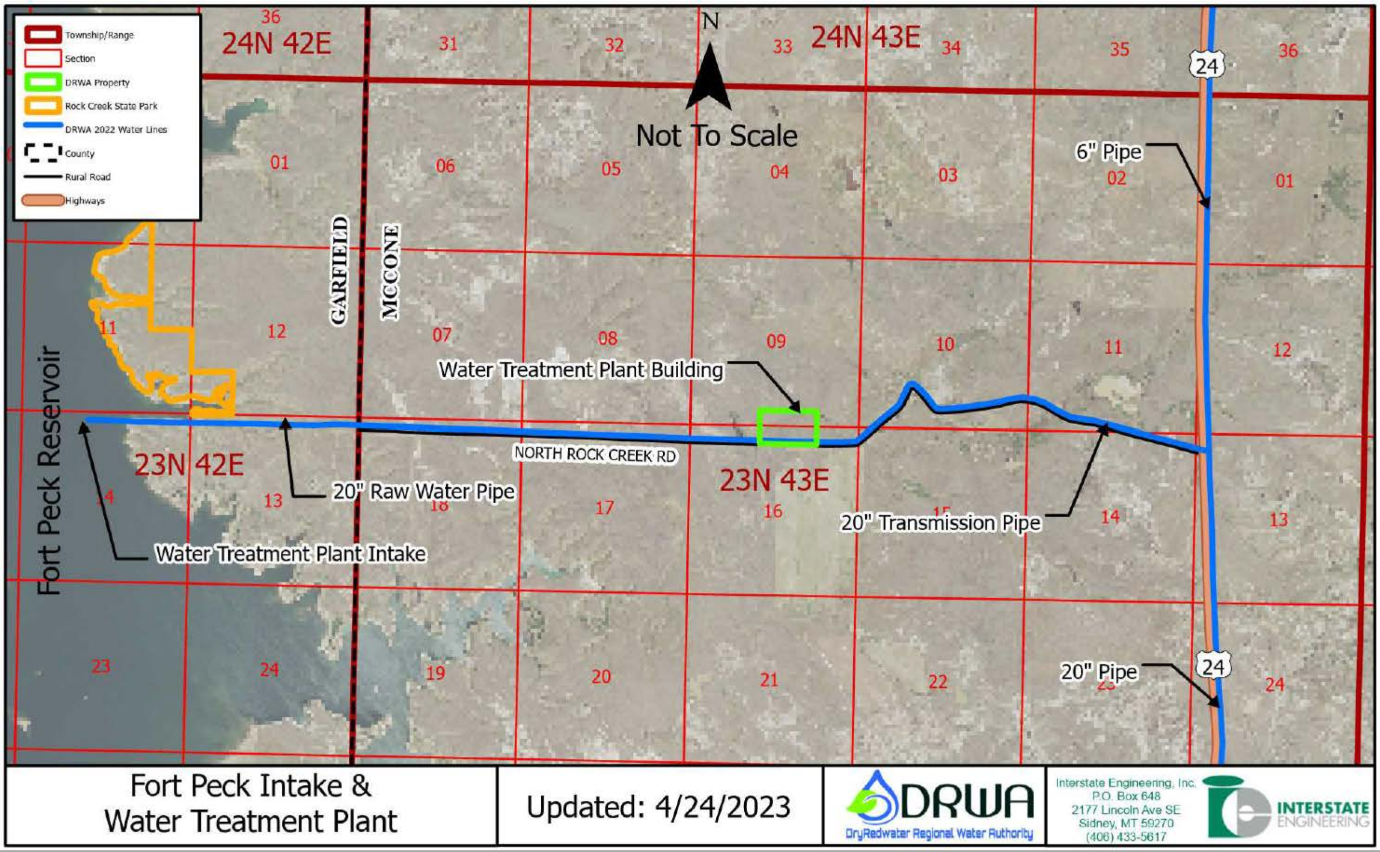

Figure 2.2 Fort Peck Intake and Water Treatment Plant

3.0 Existing Facilities

DRWA began with very determined beginnings and since then has constructed several water and sewer projects south of Sidney. Through an agreement with the City of Sidney, DRWA may purchase up to a maximum of 500 gpm to service users south of the city limits. DRWA partnered with Richland County and DNRC to construct these improvements. DRWA has a metering station south of the city limits along Central Avenue where Sidney's water flows into DRWA's system. These projects have provided water and sewer to residents that previously had tainted wells with little flow and failing septic systems and supported growth in Richland County during a time of increased oil activity. See Figure 3.0 below for the location of DRWA's sewer and water projects.

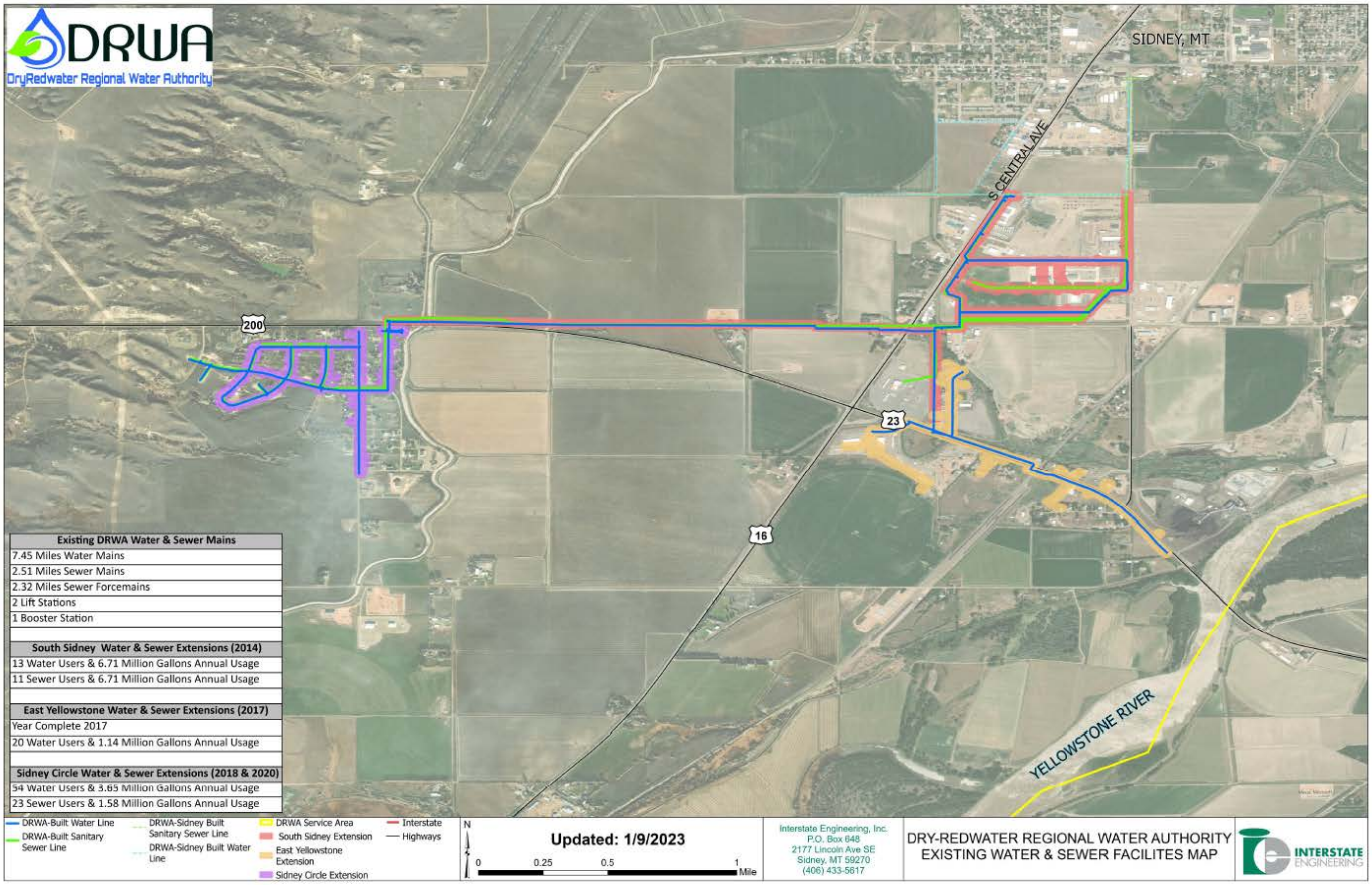

Figure 3.0 Existing DRWA Water & Sewer Facilities Map

The first DRWA project was a water and sewer extension project constructed in 2014 south of Sidney. This project was intended to bring in the foundational infrastructure from the City of Sidney to deliver water to the current 86 users. This project had only 3 commercial water connections and over 10,000 lf of 12" water line (2,300 lf of trenchless 12" water line), over 3,000 lf of 10" water line, fire hydrants, flushing hydrants, master meter house, meter pits and other appurtenances.

In 2016, DRWA constructed the East Yellowstone Water Extension project. This project included 2,700 lf of 8" water pipe, 200 lf of 2" water pipe and 5400 lf of 1-1/2" water service lines. The water lines crossed under Hwy 200 and under BNSF tracks using directional drill methods. This project included air/vacs, flushing hydrants, sample stations, meter pits and other appurtenances.

In 2018, DRWA constructed Sidney Circle Water and Sewer System Improvements. The water system improvements included a booster pump station, 600 lf of 12" water pipe, 1,200 lf of 6" water pipe (trenchless method), 9,000 lf of water pipe, 2,600 lf of 1" water service lines, as well as flushing hydrants, meter pits, and other appurtenances.

These improvements serve water to 86 users with 15 of the users being commercial businesses. There are 34 sewer connections providing service to rural homes.

4.0 Coordination Requirements with Governments & Non-Government Agencies

Coordination with government and nongovernment agencies will be necessary for the project to progress through the design and construction phases.

Table 4.0 below is a list of utility companies and state and federal government agencies that have been contacted by Interstate Engineering concerning their permitting processes. Each agency listed includes a contact person, the type of permit required, the associated fee for the permit, and the estimated review time for each permit. The Table's four columns are the counties where DRWA's regional water system will be constructed. At this time, Prairie County was not included since there is no pipe proposed. A variety of permits are required to construct each phase. Permits and related information can be found in Appendix 4.0.

PERMITS				
ROW / Utility Permit				
	Richland County	Dawson County	McCone County	Garfield County
Permit Type	Encroachment	Encroachment	Encroachment	--
Required Fee	Varies	Varies	$75	--
Contact Person	Public Works Dept	John Schreiber, Road & Bridge Dept	Cary Phillips, Road Dept	Dave Awbery, Road Dept
Phone	406.433.2407	406.939.2878	406.485.3421	406.977.9704
Email	permits@richland.org	schreiberj@dawsoncountymontana.com	mcconerds@midrivers.com	County.shop@yahoo.com
Req. Review Time	30 days	2-4 weeks	1-2 weeks	---
Comments				Does not have any permits at this time. County Commissioners will create installation guidelines when project design approaches.
MONTANA DEPARTMENT OF TRANSPORTATION (MDOT)				
	Richland County	Dawson County	McCone County	Garfield County
Permit Type	Occupancy / Encroachment	Occupancy / Encroachment	Occupancy / Encroachment	Occupancy / Encroachment
Required Fee	$100 / permit / road	$100 / permit / road	$100 / permit / road	$100 / permit / road
Contact Person	Zach Miles, Glendive District	Zach Miles, Glendive District	Zach Miles, Glendive District	Zach Miles, Glendive District
Phone	406.345.8227	406.345.8227	406.345.8227	406.345.8227
Email	zmiles@mt.gov	zmiles@mt.gov	zmiles@mt.gov	zmiles@mt.gov
Req. Review Time	1 month	1 month	1 month	1 month
Comments	Use Utilities Permitting Administration System (UPAS) for MDOT's only permitting process applications.			

ELECTRICAL COMPANIES				
	Richland County	Dawson County	McCone County	Garfield County
Company	LYREC	McCone Electric	McCone Electric	McCone Electric
Permit Type	No Permit Required	No Permit Required	No Permit Required	No Permit Required
Required Fee	n/a	n/a	n/a	n/a
Contact Person	Eric McPherson	Steve Tilton	Steve Tilton	Steve Tilton
Phone	406.488.1602	406.485.3430	406.485.3430	406.485.3430
Email	ericm@lyrec.coop	manager@mcconeelectric.coop	manager@mcconeelectric.coop	manager@mcconeelectric.coop
Req. Review Time	n/a	n/a	n/a	n/a
Comments	--	--	--	--
Company	MDU	MDU		MDU
Permit Type	No Permit Required	No Permit Required		No Permit Required
Required Fee	n/a	n/a		n/a
Contact Person	Michael Mills	Michael Mills		Michael Mills
Phone	406.359.3126	406.359.3126		406.359.3126
Email	Michael.mills@mdu.com	Michael.mills@mdu.com		Michael.mills@mdu.com
Req. Review Time	n/a	n/a		n/a
Comments	---	---		---
WESTERN AREA POWER ADMINISTRATION (WAPA)				
	Richland County	Dawson County	McCone County	Garfield County
Permit Type	Crossing	Crossing	Crossing	Crossing
Required Fee	n/a	n/a	n/a	n/a
Contact Person	Cami Graham	Cami Graham	Cami Graham	Cami Graham
Phone	406.230.0681 / 605.431.3632	406.230.0681 / 605.431.3632	406.230.0681 / 605.431.3632	406.230.0681 / 605.431.3632
Email	graham@wapa.gov	graham@wapa.gov	graham@wapa.gov	graham@wapa.gov
Req. Review Time	1 week	1 week	1 week	1 week
Comments	Stay 50' from electrical poles. Submit detailed map to start permit process.	Stay 50' from electrical poles. Submit detailed map to start permit process.	Stay 50' from electrical poles. Submit detailed map to start permit process.	Stay 50' from electrical poles. Submit detailed map to start permit process.
INTERNET / TELEPHONE COMPANIES				
	Richland County	Dawson County	McCone County	Garfield County
Company	MidRivers Communications	MidRivers Communications	MidRivers Communications	MidRivers Communications
Permit Type	No Permit Required	No Permit Required	No Permit Required	No Permit Required
Required Fee	n/a	n/a	n/a	n/a
Contact Person	Shannon Geiger	Shannon Geiger	Shannon Geiger	Radley Dempewolf
Phone	406.687.3336	406.687.3336	406.687.3336	406.687.3336
Email	Shannon.geiger@midrivers.coop	Shannon.geiger@midrivers.coop	Shannon.geiger@midrivers.coop	radley.dempewolf@midrivers.coop
Req. Review Time	n/a	n/a	n/a	n/a
Comments	---	---	---	---

INTERNET / TELEPHONE COMPANIES (Continued)				
	RICHLAND COUNTY	DAWSON COUNTY	MCCONE COUNTY	GARFIELD COUNTY
Company	Nemont	Nemont	Nemont	Nemont
Permit Type	No Permit Required	No Permit Required	No Permit Required	No Permit Required
Required Fee	n/a	n/a	n/a	n/a
Contact Person	Chad Fishell	Chad Fishell	Chad Fishell	Chad Fishell
Phone	406.783.7975	406.783.7975	406.783.7975	406.783.7975
Email	Chad.fishell@nemont.coop	Chad.fishell@nemont.coop	Chad.fishell@nemont.coop	Chad.fishell@nemont.coop
Req. Review Time	n/a	n/a	n/a	n/a
Comments	Call in locates and use hydro vac equipment.			
GAS COMPANIES				
	RICHLAND COUNTY	DAWSON COUNTY	MCCONE COUNTY	GARFIELD COUNTY
Company	WBI Energy	WBI Energy	WBI Energy	WBI Energy
Permit Type	Crossing	Crossing	Crossing	Crossing
Required Fee	n/a	n/a	n/a	n/a
Contact Person	William Hanley	William Hanley	William Hanley	William Hanley
Phone	406.359.7265	406.359.7265	406.359.7265	406.359.7265
Email	William.hanley@wbienergy.com	William.hanley@wbienergy.com	William.hanley@wbienergy.com	William.hanley@wbienergy.com
Req. Review Time	2 days	2 days	2 days	2 days
Comments	---	---	---	---
Company	MDU	MDU		MDU
Permit Type	No Permit Required	No Permit Required		No Permit Required
Required Fee	n/a	n/a		n/a
Contact Person	John Cross	John Cross		John Cross
Phone	406.359.3121	406.359.3121		406.359.3121
Email	John.cross@mdu.com	John.cross@mdu.com		John.cross@mdu.com
Req. Review Time	n/a	n/a		n/a
Comments	---	---		---
BNSF RAILROAD				
	RICHLAND COUNTY	DAWSON COUNTY	MCCONE COUNTY	GARFIELD COUNTY
Permit Type	Pipeline Crossing and/or Longitudinal	Pipeline Crossing and/or Longitudinal	Pipeline Crossing and/or Longitudinal	
Required Fee	$800 / submission	$800 / submission	$800 / submission	
Contact Person	Melissa Leal	Melissa Leal	Melissa Leal	
Phone	817.230.2626	817.230.2626	817.230.2626	
Email	Melissa.leal@am.jll.com	Melissa.leal@am.jll.com	Melissa.leal@am.jll.com	
Req. Review Time	4 weeks	4 weeks	4 weeks	
Comments	Safety Training & Insurance is Required	Safety Training & Insurance is Required	Safety Training & Insurance is Required	

OIL COMPANIES				
	RICHLAND COUNTY	DAWSON COUNTY	MCCONE COUNTY	GARFIELD COUNTY
Company	Continental Resources, Inc.		Continental Resources, Inc.	
Permit Type	Crossing		Crossing	
Required Fee	n/a		n/a	
Contact Person	Jennifer Hill		Jennifer Hill	
Phone	405.774.5778		405.774.5778	
Email	Jennifer.hill@clr.com		Jennifer.hill@clr.com	
Req. Review Time	1-2 weeks		1-2 weeks	
Comments	--		--	
Company	Hiland Partners			
Permit Type	No Permit Required			
Required Fee	n/a			
Contact Person	Ryan Farmer			
Phone	701.339.6090			
Email	Ryan.farmer@kindermorgan.com			
Req. Review Time	n/a			
Comments	---			
Company	Kinder Morgan			
Permit Type	Encroachment			
Required Fee	n/a			
Contact Person	Mitch Weigt			
Phone	580.749.0703			
Email	Mitchell_weigt@kindermorgan.com			
Req. Review Time	1-2 weeks			
Comments	---			
Company	Oneok Rockies Midstream			
Permit Type	Crossing			
Required Fee	n/a			
Contact Person	Tom Giltner			
Phone	406.433.8505			
Email	Tom.giltner@oneok.com			
Req. Review Time	2 weeks			
Comments	---			

OIL COMPANIES (Continued)				
	Richland County	Dawson County	McCone County	Garfield County
Company	Plains Pipeline, Inc.			
Permit Type	No Permit Required			
Required Fee	n/a			
Contact Person	Brent Smith			
Phone	701.993.5098			
Email	tbsmith@paalp.com			
Req. Review Time	n/a			
Comments	---			
SHPO				
	Richland County	Dawson County	McCone County	Garfield County
Permit Type	File Database Search	File Database Search	File Database Search	File Database Search
Required Fee	$25 / PLS section	$25 / PLS section	$25 / PLS section	$25 / PLS section
Contact Person	Damon Murdo	Damon Murdo	Damon Murdo	Damon Murdo
Phone	406.444.7767	406.444.7767	406.444.7767	406.444.7767
Email	dmurdo@mt.gov	dmurdo@mt.gov	dmurdo@mt.gov	dmurdo@mt.gov
Req. Review Time	1-2 days	1-2 days	1-2 days	1-2 days
Comments	---	---	---	---
FLOODPLAIN ADMINISTRATORS				
	Richland County	Dawson County	McCone County	Garfield County
Permit Type	Floodplain	Floodplain	None	Floodplain
Required Fee	n/a	n/a	n/a	n/a
Contact Person	Adam Smith	Forrest Sanderson	Allen Rosaaen	Eric Miller
Phone	406.433.2407	406.373.7240	406.974.3421	406.557.2770
Email	asmith@richland.org	Forrest.sanderson@kljeng.com	mcconerds@midrivers.com	garextn@midrivers.com
Req. Review Time	2 months	180 days from when all applications are in. If completed applications, then 15 days for public comment.	n/a	2 months
Comments	---	Only need Joint Application	---	---

CONSERVATION DISTRICTS				
Company	Richland County Conservation District	Dawson County Conservation District	McCone County Conservation District	Garfield County Conservation District
Permit Type	310 Permit – Joint Application	310 Permit – Joint Application	310 Permit – Joint Application	310 Permit – Joint Application
Required Fee	n/a	n/a	n/a	n/a
Contact Person	Julie Goss	Unknown	Diane Black	Dusty Olsen
Phone	406.433.2103	406.377.5566	406.485.2744 Ext 100	406.557.2232
Email	Julie.goss@mt.nacdnet.net	dawsoncountycd@macdnet.org	mcconecd@macdnet.org	garfieldcd@madcnet.org
Req. Review Time	2 months	n/a	Uncertain	60 days
Comments	---	No Specific Contact	---	---

FEDERAL PERMITS	
Permit Type	U.S. Army Corps of Engineers – Nationwide 404 Permit
Required Fee	None
Contact Person	Marena Gilbert
Phone	406.200.2689
Email	Montana.reg@usace.army.mil
Req. Review Time	60 days
Comments	---
Permit Type	U.S. Army Corps of Engineers – Section 10 Permit
Required Fee	None
Contact Person	Marena Gilbert
Phone	406.200.2689
Email	Montana.reg@usace.army.mil
Req. Review Time	60 days
Comments	---
Permit Type	U.S. Army Corps of Engineers – Civil Works Section 408
Required Fee	Review fee may be required depending on project size.
Contact Person	Michele Fromdahl
Phone	406.526.3411 Ext 4274
Email	Michele.l.fromdahl@usace.army.mil
Req. Review Time	Several Months
Comments	---
Permit Type	MDEQ – General Permit for Storm Water Discharge Associated with Construction Activities (SWC)
Required Fee	$900 for 1-5 acres – See fee schedule on website
Contact Person	Cathy Culver
Phone	406.444.0574
Email	Catherine.culver@mt.gov
Req. Review Time	1 month
Comments	Requires public signage, notice of intent form, SWPPP form, SWPPP certification, and Sage Grouse program consultation

FEDERAL PERMITS (Continued)	
Permit Type	MDEQ – 401 Water Quality Certification
Required Fee	Minimum fee of $400 of 1% of gross value of the proposed project, not to exceed $20,000
Contact Person	Keenan Storrar
Phone	406.444.2734
Email	Keenan.storrar@mt.gov
Req. Review Time	1 month – depends on project size
Comments	May be programmatically granted through Army Corp or an individual Section 401 would be required through MDEQ
Permit Type	MDEQ – 318 Temporary Turbidity Authorization
Required Fee	$250 / Subbasin
Contact Person	Keenan Storrar
Phone	406.444.2734
Email	Keenan.storrar@mt.gov
Req. Review Time	1 month – depends on project size
Comments	This permit may not be required since project will be boring under streams and wetlands.

Table 4.0 List of Utility Companies, State & Federal Agencies Contacted

4.1 Federal Permits – United States Army Corps of Engineers

The USACE permits application process should begin early in the design process. Due to the lengthy review times, and the possibility of USACE returning the permit applications and requesting additional information, obtaining the USACE permits may take 6 months to a year. The goal of submitting these permit applications early is to prevent the bidding of the project to be delayed while awaiting permit approval.

4.1.1 Section 408 Permit

The Fort Peck Dam and Reservoir are owned and operated by USACE. Even though the water right permit grants use of Missouri River Water, DRWA still needs permit approval from the USACE to construct the raw water intake in the reservoir.

The 408 permit authorizes the applicant to make alterations to land flooded by Fort Peck Reservoir. Section 408 assures the proposed alterations will not impair or change the usefulness of the original Fort Peck Dam and Reservoir project.

The authority to grant permission for the alteration or use of a USACE Civil Works project falls under Section 14 of the Rivers and Harbors Act of 1899 and codified in 33 U.S.C. § 408.

Section 408 requests must have a written statement of No Objection from the non-federal sponsor (DRWA) before review by USACE. The Engineer of Record must demonstrate the proposed alteration does not adversely affect the operation of Fort Peck Dam and Reservoir.

The overall USACE review process involves 4 main steps:

1. Completeness determination. USACE will provide written notification to DRWA within 30 days of receipt. The submittal will either be determined complete or additional information will be

requested. If additional information is requested, the clock is reset to 30 days from when USACE receives the additional information.

2. Review and decision. USACE will provide a final decision within 90 days. However, USACE does have the latitude to extend this review time to 120 days upon written notification to DRWA. Upon completion of this step, USACE will provide DRWA with their Summary of Findings to serve as a decision document.

3. Final decision notification approves the Section 408 permit.

4. Construction oversight includes DRWA incorporating district costs for construction oversight and closeout. One hundred and eighty days after construction completion, DRWA will submit As-Builts to USACE. USACE may need to conduct a post construction on-site inspection to document the final condition of the project.

   The Section 408 permit requires twenty-six signatures from various departments within the USACE. If one of the designated signatories has a question, concern or comment on the permit, the applicant is contacted, and further information is requested. This process creates additional time which is added to the Section 408 process. Conflicts with cultural clearances and tribal interests may subject the permit to several returns back to the applicant thus increasing the time it takes to receive an approved permit.

For more information, see Appendix 4.1 USACE 408 Permit Circular EC_1165-2-220.

4.1.2 Section 10 Permit

A Section 10 permit is also required to work in Fort Peck Lake since the lake spans the Missouri River. The Missouri River is classified as a Navigable Waters of the United States and therefore falls under Section 10 of the Rivers and Harbors Act.

Section 10 of the Rivers and Harbors Act of 1899 requires authorization from the Secretary of the Army, acting through the USACE, for the construction of any structure in or over any navigable water of the United States. Structures or work outside the limits defined for navigable waters of the United States require a Section 10 permit if the structure or work affects the course, location, or condition of the water body.

The law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of a navigable water of the United States, and applies to all structures, from the smallest floating dock to the largest commercial undertaking.

It further includes, without limitation, any wharf, dolphin, weir, boom breakwater, jetty, groin, bank protection (e.g., riprap, revetment, bulkhead), mooring structures such as pilings, aerial or subaqueous power transmission lines, intake, or outfall pipes, permanently moored floating vessel, tunnel, artificial canal, boat ramp, aids to navigation, and any other permanent, or semi-permanent obstacle or obstruction.[2]

The intake construction for the WTP in Fort Peck Reservoir requires this permit.

4.1.3 Section 404 Permit

A Section 404 permit is required for the discharge of dredged or fill material into water of the United States per Section 404 of the Clean Water Act. The project's proposed modifications to Fort Peck Lake will determine if this permit and/or a Section 10 permit is required for the WTP intake.

The intake structure may be covered by USACE Nationwide Permit 58 – Utility Line Activities for Water and Other Substances. Effective Date: March 15, 2021; Expiration Date: March 14, 2026 (NWP Final Notice, 86 FR 2744). A 404 permit must be accompanied by Section 401 permit and processed by MDEQ. This permit application can be submitted jointly with state and local permits through the respective county's Conservation District. See Section 4.2.1 for more information. This joint application and NWP58 can be found in Appendix 4.2.

4.2 State and Local Permits

There are several state and local permits that DRWA will need to apply for throughout design and construction.

4.2.1 310 Permit, 318 Authorization, 401 Certification, Floodplain Permit

DNRC county conservation districts provide a joint application that is used to apply for permits from multiple agencies using one application process. County conservation districts require a 310 permit when excavating in perennial rivers and streams. Per MDEQ, a perennial river or stream is a river or stream that flows more than 180 days per year. The purpose of the 310 permit is to keep rivers and streams in their natural condition. The additional permits that may be included in a 310-permit application are floodplain permit, USACE Section 404/Section 10 permits, and MDEQ 318 authorization and 401 Certification depending on the type of 404 permit required. This joint application is attached in Appendix 4.2.

A 318 authorization must be obtained prior to initiating a project. The authorization may be obtained from DEQ or may be included in the DNRC 310 Permit Joint Application.

A 318 authorization allows for the release of sediment into a perennial river or stream from construction activities.

The authorization will include conditions that minimize the magnitude of any change in water quality and the length of time the change will occur and ensures the sediment release will not have any long-term impact on existing or beneficial uses of state water.

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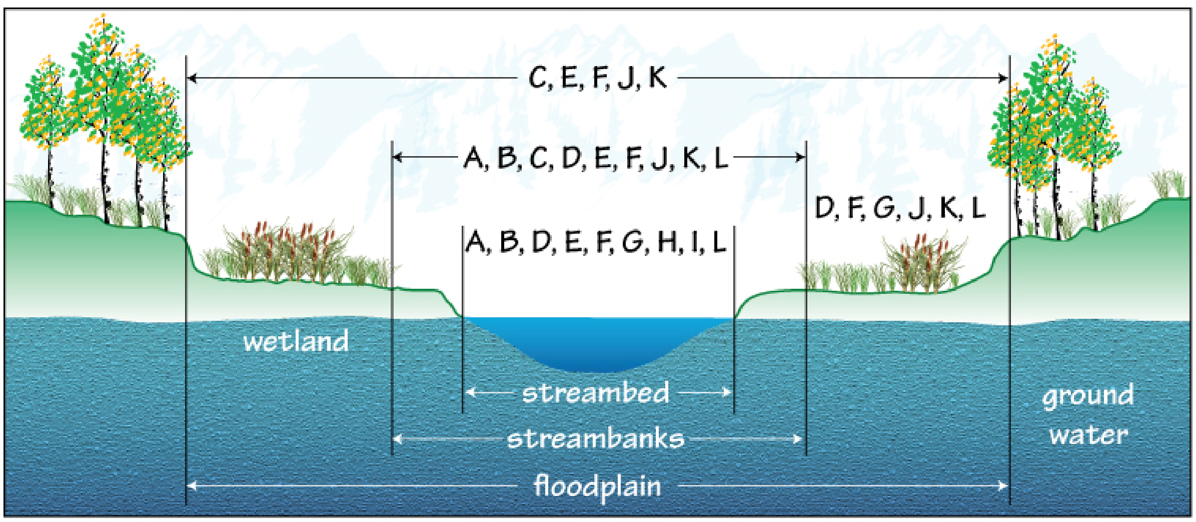
[2] https://www.spl.usace.army.mil/Missions/Regulatory/Jurisdictional-Determination/Section-10-of-the-Rivers-Harbors-Act/

A 401 Water Quality Certification requires state certification for any permits issued by a federal agency for activities that may result in a discharge to state waters, including wetlands. This requirement allows Montana to have input into federally approved projects that may affect Montana's waters. Utilities fall under this certification.

A floodplain permit may be required. Floodplain boundaries have been officially delineated near most Montana cities but rarely delineated in rural areas. A floodplain in a rural area are rough approximations of the 100-year flood plain associated with major rivers and may not exist at all. Floodplain permits are reviewed by the County Floodplain Administrator if the county has one.

Whether needing some or all these permits depends on the crossing location and type of construction at that location. At this time, Interstate Engineering does not anticipate needing these permits since the plan is to bore under streams and wetlands to minimize the impact due to construction activities. Figure 4.1 below provides a graphic representation of which permits may be needed when crossing a river or stream.



NOTE: The above graphic is only meant as a guide, please consult the permit descriptions to determine which permits are needed.

Figure 4.1 Permits Needed When Crossing Rivers/Streams

A. Montana Natural Streambed and Land Preservation Act (310) which minimizes soil erosion and sedimentation and protects the natural state of streams and rivers.

B. Montana Stream Protection Act (SPA 124 Permit) which protects and preserves fish and wildlife resources and to maintain streams and rivers in their natural state.

C. City or County Floodplain Development Permit which promotes the publics' health, safety and general welfare and minimize public/private losses due to floods in regulated flood hazard areas.

D. Federal Clean Water Act (404 Permit) which restores and maintains the chemical, physical, and biological integrity of the nations' water.

E. Federal River and Harbors Act (Section 10 Permit) which protects a federally listed navigable water of the U.S. from a temporary or permanent structure that may affect the course, location, condition, or capacity of the waters.

F. Short-Term Water Quality Standard for Turbidity (318 Authorization) which provides short term water quality turbidity standard for construction activities and to protect water quality and minimize sedimentation.

G. Montana Land-Use License or Easement on Navigable Waters which protects riparian areas and the navigable status of the water body.

H. Montana Water Use Act (Water Right Permit and Change Authorization) which is not applicable for any streams within DRWA's boundary since they have already received their provisional permit in 2012 as their source water.

I. Montana Water Use Act (Water Reservation) which is not applicable for any streams within DRWA's boundary since they have already received their provisional permit in 2012 as their source water.

J. Stormwater Discharge General Permits which prevent degradation of surface waters from pollutants during storm events.

K. Streamside Management Zone Law which is not applicable to DRWA.

L. Other Laws that May Apply. DRWA will review the laws as each phase moves to design for construction.

4.2.2 Storm Water Construction (SWC) – MTR100000

MDEQ requires a General Permit for Storm Water Discharge Associated with Construction Activities (SWC), Permit Number MTR100000 effective January 1, 2018. This permit and application can be found in Appendix 4.3. This permit requires the development of a storm water pollution prevention plan (SWPPP) prepared by a certified SWPPP Administrator per MDEQ for construction activity that disturbs 1-acre or more. A SWPPP is a site specific, written document that identifies potential sources of stormwater pollution at a construction site and describes practices to reduce pollutants in stormwater discharges from the construction site. Reduction of pollutants is often achieved by controlling the volume of stormwater runoff by taking steps to allow most of the stormwater runoff to infiltrate into the soil instead of leaving the construction site and flowing into an adjacent stream or creek. A SWPPP also identifies the procedures the Administrator will implement to comply with the terms and the conditions of a construction general permit. The specifications for the design documents requires the contractor to apply for this permit.

For new authorizations, contractors can obtain first-time coverage under the general permit by submitting a complete Notice of Intent (NOI-SWC) package to MDEQ. The NOI is in Appendix 4.3. This package must include a completed NOI-SWC form provided by MDEQ.

A separate SWPPP form, including all associated maps, diagrams, details, and plans, must be completed in accordance with the requirements identified in Part 3 of this permit and a copy of the consultation letter from the Montana Sage Grouse Habitat Conservation Program, if applicable, and an application fee.

The contractor is required to post a sign at the construction site or other form of public notice to show confirmation of coverage under MDEQ General Permit. The verbiage on the sign shall be large enough that it is readable and include the MPDES authorization number or a copy of the confirmation letter and a statement "Contact Montana DEQ Water Protection Bureau about this project."

At the completion of construction and after achieving final stabilization for the construction site, the contractor must remove temporary storm water conveyances and BMPs, remove construction equipment and vehicles and stop all potential pollutant-generating activities due to construction activity. The contractor must submit the standard Notice of Termination (NOT-SWC) form to terminate coverage under this permit. The MDEQ NOT form is in Appendix 4.4. Additional information and fees for this permit can be found online.[3]

4.2.3 Utility Crossing Permits

Utility companies may have a crossing application or require a crossing agreement. Typically, no fee is charged, and the review time is minimal, and some are completed in the field by the contractor. For example, the crossing application for Kinder Morgan is in the Appendix 4.5. There may be additional crossing permits required by other utilities. During design of each phase, DRWA will contact each known utility it crosses to determine if a permit is needed.

BNSF Utility License Agreements are expensive and time consuming. There is a small reach about 6 miles long that is an active BNSF track outside of Glendive parallel to Highway 200S. The track does continue northwesterly into Circle but per MDT's Rail System map, this reach of track is inactive but will still require a permit application. The distance between the centerline of Highway 200 and centerline of BNSF track is over 125'. Locating the regional pipeline 40' from centerline of Highway 200 will keep DRWA's pipeline out of BNSF's right-of-way. There may be less than 5 homes that DRWA would need to apply for a BNSF Utility License Agreement for their service lines to cross perpendicular to BNSF's track. BNSF charges an $800 submission fee with their permit application and each resubmittal is $800. Their agreement processing time per their Utility Accommodation Policy say 30 to 60 days, or longer depending on plan revisions, complexity of the project and/or permit redlines. If a Utility License Agreement application needs to be rushed, that fee is $4,250 and can only be requested for a perpendicular crossing. BNSF may require the utility owner to obtain insurance coverage as determined by BNSF. A copy of the Permit and Utility Accommodation Policy is included in Appendix 4.6.

4.2.4 Encroachment Permits for County and State

Encroachment permits will be needed when DRWA's pipeline is adjacent and parallel to or crosses a state highway or county road. This permit is required whether pipe installation is performed by boring or open cut. The preferred alternative is boring under all roads and highways.

Usually, 3 attempts at boring are required before the permit holder can open cut. If open cut is needed, then DRWA is required to notify the county road and bridge supervisor.

Garfield County's permit is a Utility Permit but is the same as the other 3 counties' encroachment permits. The applications are in Appendix 4.0.

[3] https://www.deq.mt.gov/water/assistance

4.2.5 Oil & Gas

Current shapefiles have been requested from each utility company and have been updated in DRWA's GIS. Montana-Dakota Utilities gas and electric divisions were unable to provide shapefiles due to inconsistent data and clarity in their GIS. During the design phase, locates will be called in for utilities to verify locations and updated shapefiles will be requested.

Most oil and gas companies are in Richland County. Very few companies have distribution lines within McCone County, Dawson County and Garfield County. Montana Liquid & Gas Pipeline Association provides a list of oil and gas companies within each county.[4]

5.0 Environmental Considerations

Ryan Colloton, Civil Engineer and Native American Affairs Coordinator, Billings, Montana Area Bureau of Reclamation Office is preparing a Statement of Work to obtain Architect-Engineer Services to support the BOR'S determination of feasibility of the Dry-Redwater Regional Water System in Eastern Montana. This feasibility study is led by Reclamation's Montana Area Office in Billings, Montana in partnership with DRWA.

The work will require a multi-disciplinary approach and requires expertise in engineering and the natural, economic, and environmental (including Endangered Species Act (ESA), Section 106, National Environmental Policy Act (NEPA) compliance, and other Federal laws and regulations. The NEPA's anticipated completion date is February 2024.

6.0 Design & Operating Criteria / Design Standards

At build-out, this regional water system will include over 1,277 miles of pipe ranging in diameter from 3" to 20", 6 tanks, 12 pump stations, 16 PRVs, 323 Air/Vacs, 355 Blowoffs, 7 Meter Manholes, 2,005 water services with a flow meter, and all appurtenances to properly operate a water system.

The design of this project follows Circular DEQ 1, Standards for Water Works, 2022 Edition published by Montana Department of Environmental Quality. This is Montana's governing document for public water system design and construction. This document outlines design and installation criteria for source development, water treatment, disinfection equipment, pumping facilities, water storage, transmission, distribution mains, building piping, water service connections, and all appurtenances. This document is found in Appendix 6.0.

Before any phase can begin construction, MDEQ requires submission of a final design package for their review. If MDEQ has comments, the final design package is returned to the consultant for clarification. Statutorily, MDEQ has 60 days to review the original consultant submission and each subsequent re-submission. An approval letter will not be sent from MDEQ until the plans and specifications have met DEQ-1 criteria. When funding is provided, each funding agency will review the final design package for

[4] https://mlgpa.pipelineawareness.org/

concurrence with their criteria. Upon receipt of MDEQ's approval letter and approval from the funding agencies, the Advertisement for Bids can be placed in the local newspaper.

Documents submitted to MDEQ for approval must include, but are not limited to:

- Engineer's Report
- Summary of Design Criteria
- General system layout
- Detailed Plans
- Specifications
- Water Purchase Contracts
- Easements or lease agreements
- Evaluation of technical, managerial, and financial capacity which includes:
    - Discussion of the system's current capacity including any system changes that may be required upon project completion.
    - Current area and future areas to be served and operation requirements
    - Description of site conditions, groundwater, soil type for water main trenches
    - Foundation conditions for proposed structures
    - Supporting data justifying automatic equipment, including operator training. Manual override must be provided for any automatic controls.
    - Discussion of the current system management and how the management will be impacted by the project, including if the system has an asset management plan and how the project components will be incorporated into that plan
    - Discussion of the water system's overall financial capacity along with projected user water rates including the system's outstanding obligations combined with the anticipated debt from the project under review, and overall operation and maintenance.
    - Documentation that DRWA is committed to providing as-built drawings of the project by a registered professional engineer and the certification letter required in ARM 17.38.10.1

The Engineer's Report must include a description of the rural water system, identification of the area served, name and mailing address of DRWA, and be sealed by a professional engineer in Montana.

Water use data shall be included along with a description of the estimated population trends which will be served by the proposed water supply system, a minimum of 20 years in the future in 5-year intervals or over the useful life of critical structures and equipment. Present water consumption data and the projected average and maximum daily demands or peak instantaneous demands/rural use curve. Present and/or estimated source of supply yields, any unusual occurrences, and current estimated percent of unaccounted water for the system and the estimated reduction of unaccounted water after project completion. Flow demands and pressure requirements shall be provided and substantiated by the hydraulic model.

DRWA will need to provide financial information for the new system or significant improvements with economic impacts. The purpose of this information is to allow evaluation of a new system for proper system management, operation, and maintenance (O&M), and financial planning that provide long-term stability of the new system. A summary of planning for future needs and services shall also be included. MDEQ may require additional information that is not part of the construction drawings, such as head loss calculations, proprietary technical data, copies of deeds, contracts, etc. Environmental Assessments and permits for construction, to take water, for waste discharges, for stream crossing, etc. may be required from other federal, state or local agencies.

The DEC report has listed concerns regarding the design of the pipeline and appurtenances and by using Circular DEQ 1 for the feasibility design presented in this predesign report, it ensures the design and construction, and corresponding cost estimates will be accurate for the Bureau of Reclamation to present for federal funding.

6.1 Reviewing Existing Hydraulic Design & Assumptions

DRWA's system is a typical rural system and will not provide fire flow. Rural systems can be correlated to a tree where the trunk of the tree is the main pipelines, and the branches are branch pipelines. Rural systems are made up mostly of branch pipelines or dead-end lines. Branch lines can be many miles long and if oversized water will become stagnant due to not enough water being used. If undersized, users will experience flow and pressure too low to sustain a home. A monthly flushing schedule of dead-end pipelines to improve water quality is a time consuming and expensive endeavor for any rural water district. Additionally, access to flush the pipes in winter and during a wet spring is challenging, at best. Most branch lines are routed along gravel and dirt roads. When these roads get wet, the rural water district operator will encounter tough-to-drive or impassible roads which makes following a flushing plan difficult or impossible.

Therefore, pipe diameters and user demands must have a workable balance to ensure delivery of quality water at a pressure that can sustain a home and meet MDEQ criteria.

In a municipal water system, pipelines are looped and have minimal dead-end pipelines. Looped pipelines provide dual direction for water supply and allow smaller diameter pipes to be used. Looping increases water turnover in the pipelines which minimizes stagnant water. The length of municipal dead-end lines should not be longer than 300'. Municipalities place dead end pipelines on a flushing schedule to maintain water quality. Flushing schedules are easily adhered to in a municipal system due to the small geographical area.

A municipal water system is modeled differently than a rural water system, as well. When modeling a municipal system, fixed demands are placed on junctions. Fixed demands are usually calculated using an average per-capita consumption rate. The average demand is usually multiplied by a factor of 2.25 to calculate the maximum day demand at each node. Then fire flow is added to the simulation to determine minimum pipe diameters while providing the required fire flow to the various zoning areas. Pipes are sized based on fixed demands plus fire flow. The looped system minimizes pipe diameter and ensures fire flow can get to its needed destination.

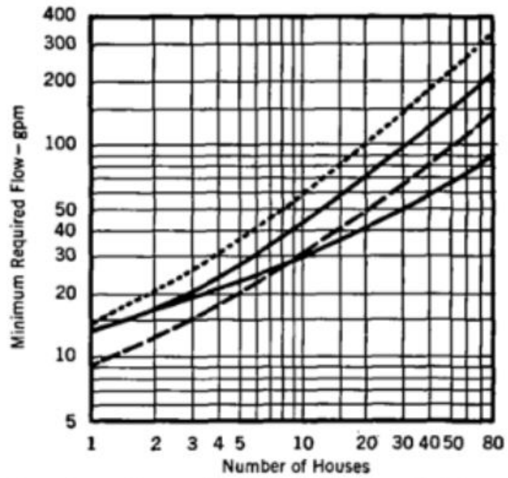
Rural systems typically do not provide fire flow because adding fire flow protection to rural areas would require the branch pipelines to be oversized which creates water stagnation and increases construction costs.

If the fixed demand method used for municipal system design were used in rural system design, even without fire flow, the branch lines would be oversized or undersized depending on the number of users on each branch.

A more efficient way to model rural water systems is to create a Peak Instantaneous Demand curve and to add a residential meter per home to represent one connection. PID curves are used to properly size branch pipelines depending on the number of users that will connect to a branch pipeline. A PID curve hypothesizes that the total demand in the branch line is higher when there are fewer users calling for water and as the number of users increases, the demand requirement per user decreases. The probability of every rural user on a branch line using a municipal fixed demand at the same time decreases significantly.

The idea for designing a rural water system differently than a municipal system was proposed in a paper submitted to AWWA Journal on August 15, 1966, authored by H.W. Ginn, M.W. Corey, and E.J. Middlebrooks. This study was predicated on the fact that rural communities do not need, nor could they afford to build, elaborate rural water systems. During the early 1960s, farms and rural communities were finally receiving clean water through rural water systems which allowed rural homes to install "modern" conveniences such as indoor bathrooms, washing machines and hot water heaters. Therefore, the design of a rural system differed greatly from an urban system and the design needed to be unique to rural water systems.[5] At this time, the leading water system design authority was Community Water Systems Source Book by Joseph S. Ameen, 1965. This standard required 15 gpm/residence; however, this flow was impossible to meet given that rural home plumbing couldn't deliver this much flow. The Farmer's Home Administration required 14 gpm/residence which was still too high and restricted by indoor plumbing. Using these high flows per residence for a rural water system led to an oversized and expensive water system which was cost-prohibitive for rural communities. A new standard was needed for rural water systems to make them affordable. The premise was that rural water systems should be based upon predicted flow requirements of residences and allowing for future expansion of the system should be a separate design problem. This study provided a better, more efficient way to design rural water systems by looking at the probabilities of one residence using water, two residences using water, and so on, thus creating PID curves which are unique to each rural system. The conclusion of this study showed that average daily demands of a rural system is less than a municipal system where the peak instantaneous flow of 9.5 gpm for a single residence has a 1 in 10,000 occurrence. Figure 6.0 below is from the 1966 study and shows the comparison of minimum flow requirements vs number of houses on a branch pipe.

[5] AWWA Journal August 15th, 1966, By: H.W. Ginn, M.W. Corey, and E.J. Middlebrooks



Minimum flow against number of houses is plotted according to requirements proposed by Ameen, the dotted curve; by the FHA, the solid curves; and by the flow rates at the 0.0001 probability level. The FHA requirements will probably be adequate for many years, whereas those proposed by Ameen appear to be too high.

Figure 6.0 Comparison of Flow Requirements

This 1966 study is included in Appendix 6.1.

In the ASCE Journal of Water Resources Planning and Management, September/October 1998 appeared the article Modified Pipe Network Model and Incorporating Peak Demand Requirements by Srinivasa Lingireddy, Don J. Wood, and Alan Nelson. This article further developed the design of a rural water system. Based on several prior articles researched for this article, the authors found a report on a study by P.J. Williams of the Farmers' Home Administration written in 1968. The 1968 study utilized extensive field measurements of several rural water systems to determine peak flow requirements.

The resulting recommendation was the maximum residential flow requirement (Peak Instantaneous Demand curve) for each pipe is based on the number of residential connections served by that pipe. This requirement can be accurately quantified using a PID curve equation:

$$Q_D = A\sqrt[2]{N_C} + BN_C + C \quad (EQ\ 6.0)$$

Where N_c = number of domestic connections served by that pipe, and the coefficients A, B, and C are determined using field data of a current system. For a new system, the designer uses curves from existing systems and develops the coefficients. After the system comes online, field data should be measured to refine the coefficients. Designs should be based on the pressure drops associated with delivering an expected instantaneous peak residential flow in each pipeline dependent on the number of connections. As the number of residential connections increases, the peak flow requirement per connection decreases because the probability of all users simultaneously requiring maximum demand decreases. The following Table 6.0 is excerpted from the above article.

Typical Instantaneous Peak Flow Requirements						
Number of Connections	Peak Flow Requirements			Requirement per Connection		
	Curve 1 (gpm)	Curve 2 (gpm)	Curve 3 (gpm)	Curve 1 (gpm)	Curve 2 (gpm)	Curve 3 (gpm)
1	11.3	9	12.3	11.3	9	12.3
2	13.3	13	15.6	6.7	6.5	7.8
3	14.8	16.1	18.2	4.9	6.3	6.1
4	16.2	18	20.4	4.1	4.5	5.1
5	17.4	20	22.3	3.5	4	5.5
10	22.6	26	30	2.3	2.6	3.6
20	30.9	33.5	41.6	1.5	1.7	2.1
30	37.9	38.3	51.2	1.3	1.3	1.7
40	44.3	44.3	59.6	1.1	1.1	1.5
50	50.3	49.5	67.4	1	1	1.3
100	77	70	101	.8	.7	1
Curve 1 – A=4, B=0.3, C=7. Curve 2 – A=9.78, B=-0.273, C=-0.51 Curve 3 – A=7.2, B=0.242, C=4.82						

Table 6.0 Typical Instantaneous Peak Flow Requirements

Curves 1 and 2 are actual requirements currently utilized for the design of some Midwest rural water systems recommended by Iowa Rural Development Association and Curve 3 is for the state of Mississippi recommended by Mississippi State Department of Health.

The Requirement per Connection columns shows the demand per connection decreasing as the Number of Connections increases. For Curve 1, one connection on a branch line would demand a peak flow requirement of 11.3 gpm for that pipe. If there are two connections on the same branch line the demand would be 13.3 gpm for that pipe.

The authors of this article further found that using the municipal peak per-capita consumption requirement when designing a rural system leads to the total system demand being overstated while overestimating or underestimating branch line flows with many or few users, respectively.

An example using Table 6.0 above, if the designer used the per capita peak demand of 1.0 gpm per connection then two connections would equal only 2 gpm. If there were 10 connections on the single branch line, using the criteria of 1.0 gpm/connection the total demand for this line would be 10 gpm. However, using Curve 1 the demand should be 22.6 gpm. Therefore, this branch line would be greatly undersized.

Conversely, if there were 100 connections on the same branch line, using the 1.0 gpm/connection criteria, the total demand would be 100 gpm. Looking at Curve 1, the demand should be 77 gpm, making the branch line oversized.

These two examples show the traditional demand method used on municipal systems obviously does not work for rural systems. Using a PID curve minimizes the under and oversizing of branch lines. See Appendix 6.2 for the Modified Pipe Network Model for Incorporating Peak Demand Flows full article.

In 1995, Aquacraft, Inc. of Boulder, CO conducted a 4-week study (2 weeks in summer and 2 weeks in winter) of 1,188 single-family households in 14 cities across the United States. The average family size was 2.8 persons. More than 1.9 million water use events were recorded, equating to about 30,000 logged days. The total flow of each household was recorded, as well as individual appliances, faucets, and toilets were monitored. Irrigation and swimming pool use was excluded. The results showed 1% of actual usage by an average household exceeded 7.5 gpm, 5% exceeded 5 gpm, 25% exceeded 3 gpm, and 50% exceeded 1.5 gpm. 1 in 2,000 recorded events had flows up to 12 gpm. Nearly half of the flows above 7.5 gpm were from washing machines and about 25% from toilet flushes. Interestingly, water usage patterns varied little by location across the United States. Further breaking down the recorded information, the study found that 90% of flows greater than 7.5 gpm only last 3 ½ minutes or less and 95% lasted 5 minutes or less. This study is included in Appendix 6.3.

When a single household is using a peak flow of at least 7.5 gpm, the probability other nearby households simultaneously using a peak flow of 7.5 gpm is unlikely. This study further supports the rural water analysis that as the number of connections increase on a branch line, the flow requirement per connection decreases.

Fortunately, there is hydraulic modeling software that can run an analysis using a PID. Before the development of rural analysis software, calculating the PID for each branch line in a rural system water model was laborious and time consuming. For this model, Interstate Engineering used KY Pipe.

DRWA's PID curve should consider the type of rural users that DRWA will serve. If rural users are primarily livestock operations, water will be delivered to homes and there will be pasture taps to account for livestock watering, not all in use at the same time. Livestock taps on other rural water systems include a flow restrictor installed to limit flow to either 5 or 7 gpm, which keeps the demand at the livestock tap consistent and prevents large withdrawals of water when producers are attempting to fill their livestock tanks.

If rural users are primarily growing agricultural crops, where large amounts of water will be drawn from the system to fill large sprayers for spraying fields, the rural curve should account for this additional demand.

The 2012 model used Extended Period Simulation with fixed demands at every node and a diurnal curve to determine the maximum pipe flows and the minimum pipe flows. The 2012 model also had a rural curve PID. The 2012 PID was:

$$Q_D = 1.521\sqrt[2]{N_C} + 0.279N_C + 5.198 \quad (EQ\ 6.1)$$

The 2012 PID coefficients were A = 1.521, B = 0.279, and C = 5.198 and N_c is the number of connections. When compared to several South Dakota rural systems' coefficients, DRWA's 2012 PID coefficients were too low to simulate the type of agricultural operations in DRWA's service area and could size pipes smaller than needed. A new PID curve was needed.

KY Pipe generates the A, B and C coefficients by inputting three pairs of numbers in the Rural Analysis Set Up menu. The first number of the pair is the number of connections, and the second number of the pair is the flow required for that number of connections.

The following pairs were:

CONNECTIONS	FLOW (GPM)
1	7
25	35.8
50	58.9

which generated the following coefficients of A = 3.274, B = 0.653, and C = 3.072.

DRWA updated 2022 PID equation is:

$$Q_D = 3.274 \sqrt[2]{N_C} + 0.653 N_C + 3.072 \quad (EQ\ 6.2)$$

See the rural curve graph in Appendix 6.4 showing the South Dakota PIDs, the 2012 DRWA PID and the 2022 DRWA PID.

It is important that as each constructed phase is placed into use, actual pressure and flow data is collected. The collected data is used to refine the DRWA's PID curve. The refined DRWA PID curve will be used when modeling future phases for design and construction.

The only fixed demands in the 2022 model are the towns that have their own municipal system and DRWA will deliver water to their tanks. The towns' fixed demands are their Peak Day Demand.

The next step was to determine the total number of residential connections for the 2022 model beginning with the 2012 model's pipe layout. For inclusion in the 2022 model, Interstate Engineering used 1.5 miles of maximum pipe length to an existing home. For example, if the pipe length was equal to or less than 1.5 miles to an existing home, that home was included in the 2022 model. If there were 4 existing homes along a road, the maximum distribution pipe length cannot exceed 6 miles for those homes to be included.

Using DRWA's GIS, the 2012 pipe layout was imported into DRWA's GIS from KY Pipe and Montana Cadastral and NG911 layers, and aerial photography were used to locate every existing home in DRWA's service area. 2012 pipelines were modified, added, and removed using the maximum distance of 1 ½ miles criteria to arrive at the 2022 piping. Line numbers were assigned to each 2022 pipe segment beginning with Line 1 at the west end and increasing numerically to the east. Every road and highway was "walked" in DRWA's GIS to locate existing homes that will be served by DRWA. The existing homes were added to a spreadsheet by line number and can be found in Appendix 6.5. A map showing the line numbers and their locations is found in Appendix 6.6.

The DEC Report wanted pipeline easement costs included in the CCE. DRWA users are required to provide an easement, at no charge, in exchange for receiving water. This is discussed further in Section 10. Therefore, eliminated from the model were pipes that crossed private ground where there weren't existing homes along the pipe, and pipes that ended where there wasn't a house. The routing for the 2022 pipes is along dirt and gravel county roads and along highways.

In KY Pipe, the existing homes found in DRWA's GIS are represented by placing a residential meter on the pipes. Pasture taps were added to the model for the purposes of this report, but the location is unknown at the feasibility level. Pasture taps will be located during the design phase by meeting individually with each landowner so they can decide where they want their pasture taps. The number of pasture taps were determined by multiplying the residential meters by 30% and adding to the KY Pipe model. The value of each pasture tap is set to 0.7 to simulate a 7 gpm flow restrictor.

The 2022 water model is 100% saturated, meaning every existing house that met the 1 ½ miles criteria are added to the water model. The general rule for a rural water model is 80% saturation, i.e., 8 out of 10 homes will connect. Therefore, the 2022 water model which is 100% saturated is equal to 80% saturation in year 2040 with population increases and new home construction.

DRWA's 2022 model includes 1,564 rural residential connections (residential meter = 1.0) and 440 pasture taps (residential meter = 0.7) for a total of 2,004 total residential meters. See the KY Pipe Model Inventory in Appendix 6.7. For the pipe peak flows and total system demand see Appendix 6.8 – DRWA Summary of Peak Flows.

The total system demand equals 3,062 gpm or 4.4 MGD. This is well below the DNRC Provisional Water Marketing Permit maximum flow of 4,200 gpm or 6.0 MGD.

6.2 Design Considerations for Above Ground Storage Tanks & Pumping Stations with Power Requirements

The DEC report requested additional information regarding storage tanks, pump stations, and power for the pump stations.

6.2.1 Storage Tanks

With the 2022 model update, tank locations and pump station locations were revisited. DEQ-1, 7.0.1 requires "storage facilities sufficient to supplement source capacity to satisfy all system demands occurring on the maximum day, plus fire flow demands where fire protection is provided".[6] DRWA's rural system does not include fire protection and the communities that have a municipal tank and distribution system are responsible for their fire flow storage and meeting fire flow requirements in DEQ-1. Therefore, none of DRWA's tanks will include additional storage for municipal fire flow requirements.

Keeping the maximum number of users/geographic area served by each tank small provides uninterrupted delivery to the majority of the system in case of power outage, pipeline break, or required system maintenance. Each tank is sized to supply 2 days of storage to meet DEQ-1, 7.0.1.

The material choices for the tanks are welded elevated tanks, composite elevated tanks, on-grade concrete tanks, and buried concrete tanks.

Of the two types of elevated tanks, the welded elevated tank was chosen. These tanks are a single pedestal tank, and their interior can withstand ice formation during extreme cold in DRWA's service area without damaging the interior of the tank. The welded elevated tank height is designed to provide the minimum delivery pressure of 30 psi, required by DEQ-1, to the rural homes nearest to the tank. This requires the minimum water surface (HGL) to be 69 feet above the ground and the maximum HGL to be 100 feet.

[6] Quote from DEQ-1

The BOR completed a Value Engineering Study in 2012 and suggested the use of elevated storage tanks instead of concrete tanks. Preliminary tank drawings can be found in Appendix 6.9.

The composite elevated tanks tend to leak at the bolted seams when ice forms inside during winters. To repair the leaking seams of a bolted, composite elevated tank, a crane is used to access the exterior of the tank which is costly and time consuming. Great Plains Structures, a distributor and constructor of bolted, composite tanks will not sell them in the Rocky Mountain region due to the ice damage issue. They recommended a welded single pedestal, elevated tank. For this report, we are using their recommendation. When design of the first phase is appropriated, the tank material will be re-visited.

The proposed locations of the elevated tanks are based on system hydraulics and splits DRWA's system into 7 tank pressure zones. Each elevated tank will be filled by their own BPS except for Spring Creek Tank which supplies the Hwy 13 area. Spring Creek Tank is filled from the Horse Creek Tank. The HGL of each tank should not exceed AWWA C900 235 pressure class pipe. The tanks filling will be controlled by flow control valves and/or pressure sustaining valves. During final design of each phase, the valves and controls will be designed.

Keeping the pressure zones small prevents disruption of water delivery to the remaining users should a pipe break or a tank or BPS need to be taken offline for maintenance. Figure 6.1 shows the location of the tanks, PRVs, pump stations, and pressure zones. A larger drawing is found in Appendix 6.10.

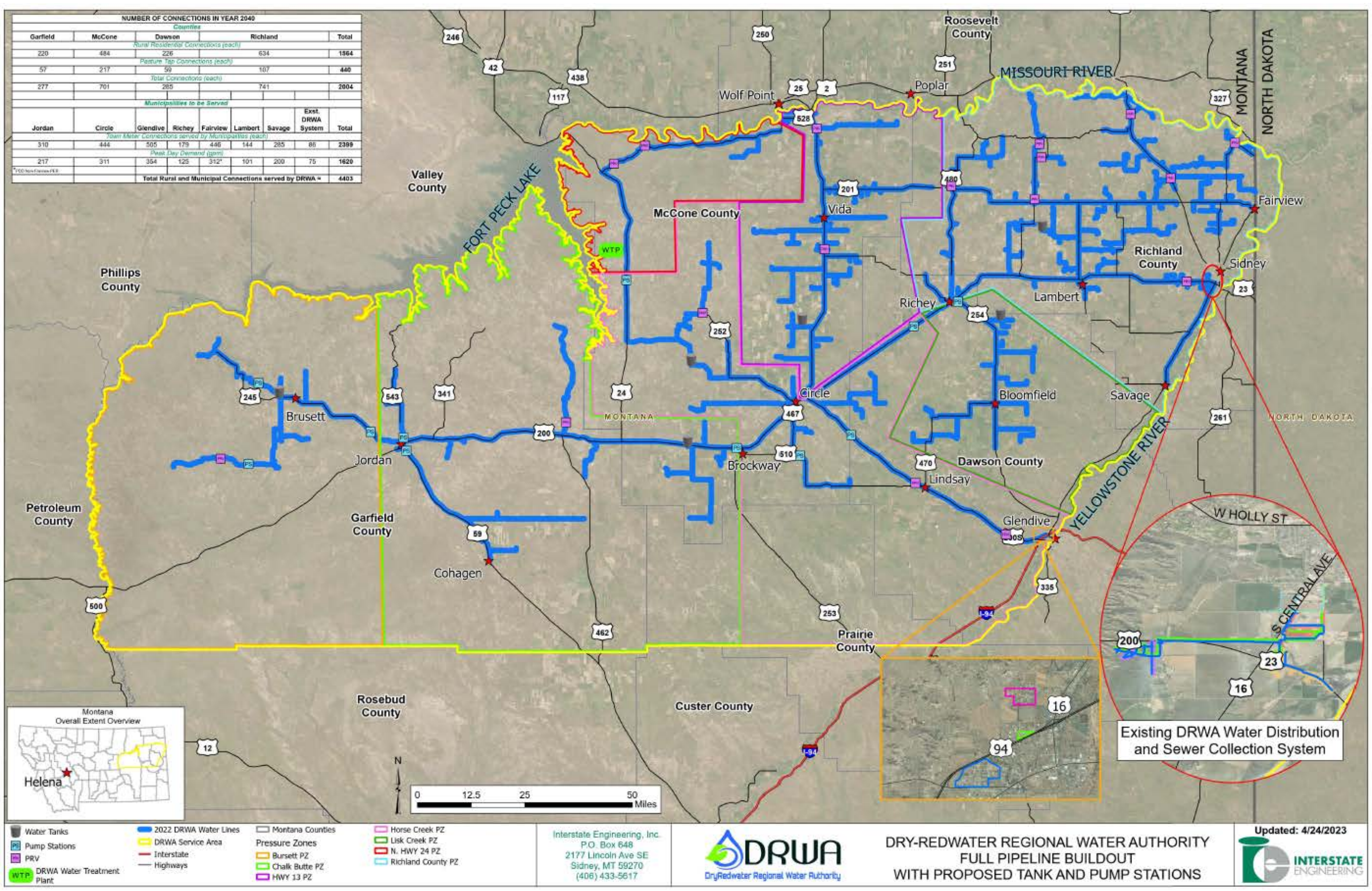


Figure 6.1 Location of Tanks & Pump Stations

Table 6.2 illustrates a breakdown of each tank and its general location within the system. It also includes the tank height, the required volume needed to service the pressure zone, the standard tank size needed to meet the demand volume, and the total cost of the tank.

Costs for each tank size were calculated using a price/gallon ratio. The ratio used was calculated using the costs obtained by Phoenix Tanks for a 150,000 gallon, 1-million gallon, and a 2-million-gallon tank. Preliminary tank design are provided in Appendix 6.8.

Example Cost Calculation for Single Pedestal Welded Tank – Chalk Butte Tank

150,000-gallon tank @ 100 ft HWL = $950,000.00 (Phoenix Tank Quote)

1,000,000-gallon tank @ 100 ft HWL = $3,500,000.00 (Phoenix Tank Quote)

($3,600,000.00 - $1,050,000.00)/(1,000,000 gal – 150,000 gal) = $3.00 per gal

(250,000 gal – 150,000 gal) x $3.00/gal = $300,000.00

$950,000.00 + $300,000.00 = $1,250,000.00

Tank Costs					
Tank	Location	Tank Height (ft)	Actual Size (gal)	Standard Size (gal)	Phoenix Tank $ (Single Pedestal Welded Steel) [1,2,3]
Richland County Tank	11 miles NW of Lambert	100	1,300,000	1,500,000	$4,400,000.00
S. Fork Lisk Creek Tank	8 miles SE of Richey	100	264,401	400,000	$1,800,000.00
Spring Creek Rd Tank	12 miles N of Circle	100	424,998	500,000	$2,100,000.00
Horse Creek Tank	17 miles NE of Circle	100	1,500,000	1,500,000	$4,400,000.00
Chalk Butte Tank	8 miles NW of Brockway	84	250,000	250,000	$1,250,000.00
Brussett Tank	1 mile W of Brusett	42	150,000	150,000	$900,000.00
					$14,850,000.00

[1] Includes all structural design and drawings, shipping, and site erection. Also includes epoxy/urethane paint w/shop applied primers, standard shallow foundations (assume 4000 psf net allowable soil bearing capacity at 8"), standard accessories per AWWA.
[2] Budget is based on good site conditions and a minimum 200'x150' flat staging area and good access to site.
[3] Does not include drilled pier or pile-supported foundations, poor site conditions (access, clearing, overhead power lines, nearby buildings, etc.), corrosion allowance, shrouding/containment or full field blasting, or hiring any union trades.

Table 6.1 Tank Cost Estimates

The breakdown of the above costs can be found in Appendix 12.3 and are included as a lump sum in the FCE found in Appendix 12.4.

6.2.2 Pump Stations

The 2012 Feasibility Report had 71 pump stations. The pump stations were revised after the 2022 model update. The number of pump stations reduced to 12 pump stations across DRWA's system including the raw water intake and the WTP HSP. Figures 6.2 and 6.3 show the locations of the pump stations downstream of the WTP and the distance to the nearest power line. For BPS power supply and costs see Section 11.3.

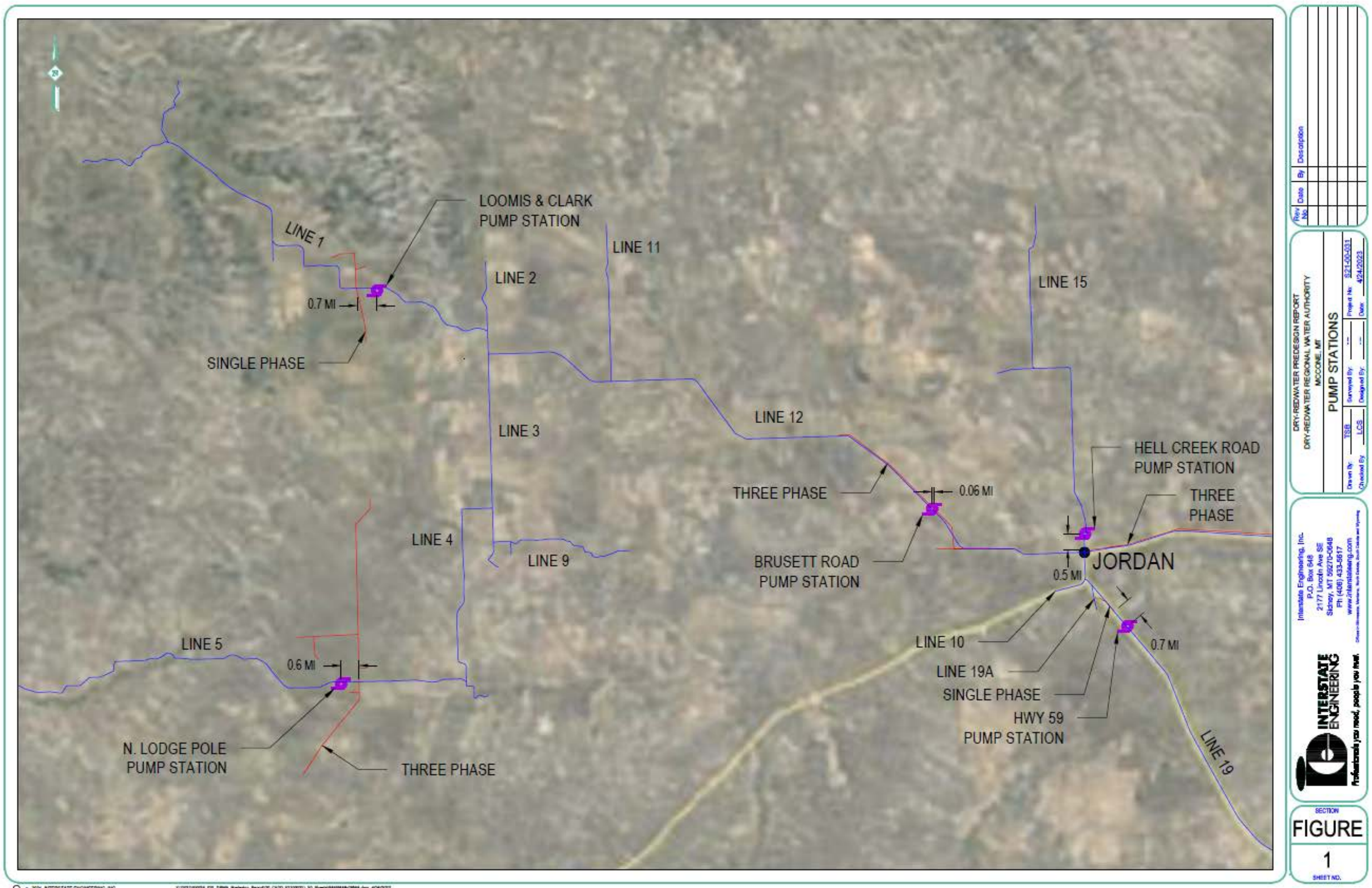


Figure 6.2 Pump Stations – West

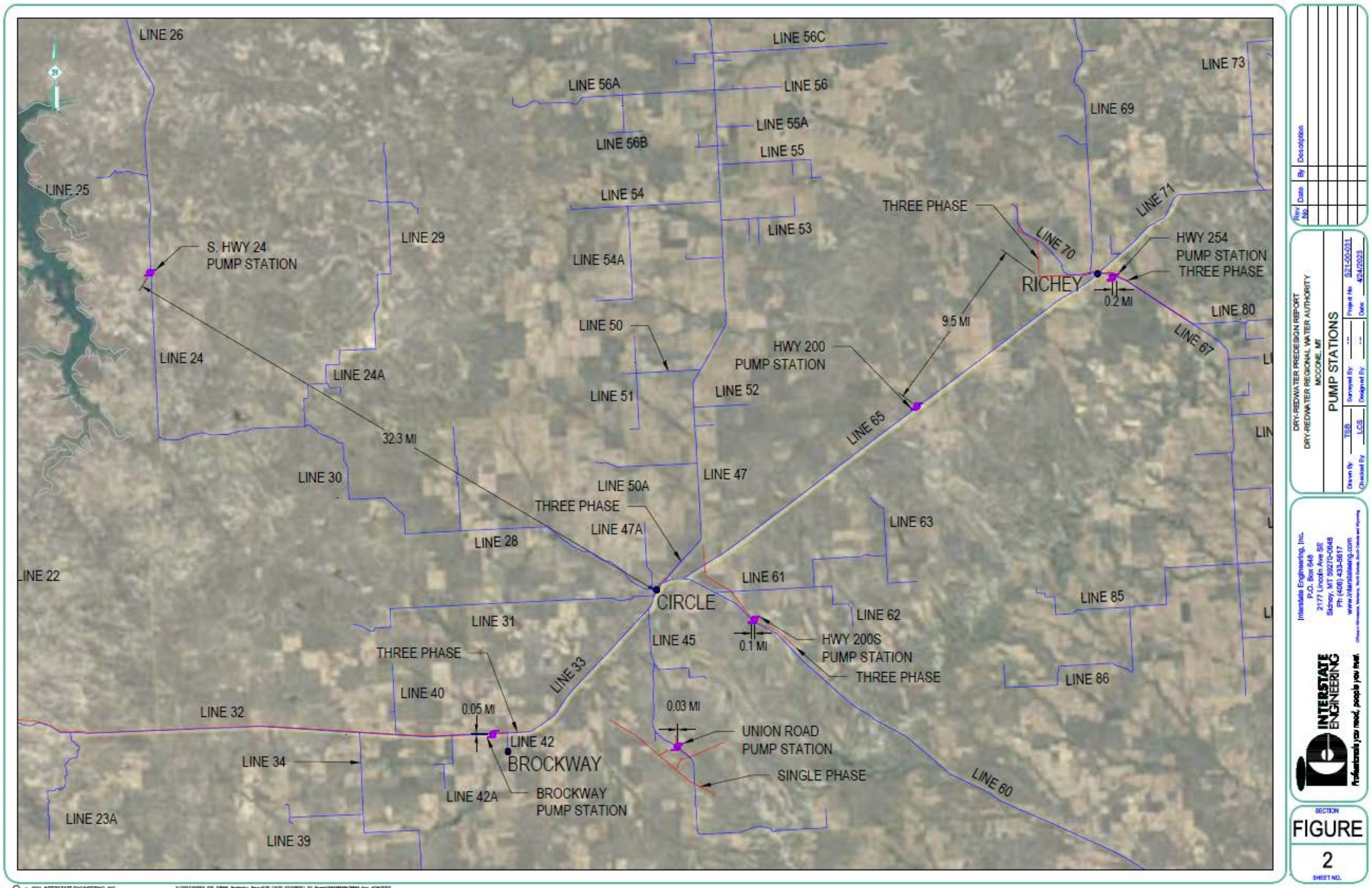


Figure 6.3 Pump Stations – Central

There are three types of BPS across this project. A distribution BPS, transmission BPS with two pumps, and a transmission BPS with three pumps. All BPS have a redundant pump per DEQ-1 requirements. The distribution BPS has a jockey pump and one pump and is for the BPS that are 10 hp and less. The transmission BPS with two pumps is for larger flows and used on transmission mains requiring 25-75 hp pumps. The transmission BPS with three pumps is for the BPS requiring over 100 hp pumps. For pumps less than 10 hp there will be soft start motors. For the larger pumps, VFD motors are used. Soft start and VFD motors are necessary to meet DEQ-1 requirements for minimizing hydraulic transients. Each BPS includes a prefabricated building, mechanical, electrical, integration controls and an on-site, permanent emergency generator. Transmission BPS include an underground reservoir. Table 6.2 shows the power requirements for each BPS.

Pump Station	Location	HP	Phase	Coordinates	Distance to Power (Miles)	Direction to Power from Pump Station	UG or OH	Pump Station Type
Loomis & Clark	Loomis & Clark Rd	2.2	Single	Lat: 47º27'28.80"N Long: -107º23'34.80"W	0.7	West	OH	Distribution
N. Lodge Pole	N. Lodge Pole Rd	0.9	Three	Lat: 47º16'26.40"N Long: -107º25'30"W	0.6	East	OH	Distribution
Brusett Rd	Brusett Rd	24	Three	Lat: 47º20'52.80"N Long: -107º00'50.40"W	Adjacent	NE	OH	Transmission (2-Pump)
Hell Creek Rd	Hwy 541/Hell Creek Rd	1.3	Three	Lat: 47º20'02.40"N Long: -106º54'32.40"W	0.5	South	OH	Distribution
Hwy 59	Hwy 59N	4.3	Single	Lat: 47º17'24"N Long: -106º52'55.20"W	0.7	NW	OH	Distribution
Brockway	Hwy 200E	37	Three	Lat: 47º18'39.59"N Long: -105º47'01.85"W	Adjacent	North	OH	Transmission (2-Pump)
S. Hwy 24	S Hwy 24	310	Three	Lat: 47º40'58.80"N Long: -106º09'18"W	32.3	SE	OH	Transmission (3-Pump)
Union Rd	Union Rd	2.5	Single	Lat: 47º17'38.40"N Long: -105º34'22.80"W	Adjacent	NE	OH	Distribution
Hwy 200S	Hwy 200S	48	Three	Lat: 47º23'24.16"N Long: -105º28'37.39"W	Adjacent	SW	OH	Transmission (2-Pump)
Hwy 200	Hwy 200	227	Three	Lat: 47º32'59.80"N Long: -105º16'37.14"W	9.5	NE	OH	Transmission (3-Pump)
Hwy 254	Hwy 254	52	Three	Lat: 47º38'31.20"N Long: -105º02'34.80"W	Adjacent	NE	OH	Transmission (2-Pump)

Table 6.2 Pump Station Electrical Table

Each type of BPS costs are shown in Table 6.3. Additional costs are found in Appendix 12.11. Preliminary pump curves and building layout examples are provided in Appendix 6.11.

Pump and Building Prices					
Transmission Pump Stations					
3-Pump Setup					
Item	Description	Quantity	Unit	Unit Price	Total
1	Mobilization	1	LS	$62,900.00	$62,900.00
2	Shipping	1	LS	$38,500.00	$38,500.00
3	Site Work	1	LS	$179,800.00	$179,800.00
4	Prefabricated 3-Pump Control Building	1	LS	$115,500.00	$115,500.00
5	Prefabricated 3-Pump Control Building Mechanical	1	LS	$385,000.00	$385,000.00
6	Prefabricated 3-Pump Control Building Electrical	1	LS	$231,000.00	$231,000.00
7	Integration Controls	1	LS	$119,500.00	$119,500.00
8	Underground Reservoir	1	LS	$303,700.00	$303,700.00
9	Testing Laboratory Service	1	LS	$18,900.00	$18,900.00
10	Emergency Generator	1	LS	$104,400.00	$104,400.00
					$1,559,200.00

2-Pump Setup					
Item	Description	Quantity	Unit	Unit Price	Total
1	Mobilization	1	LS	$62,900.00	$62,900.00
2	Shipping	1	LS	$11,600.00	$11,600.00
3	Site Work	1	LS	$119,900.00	$119,900.00
4	Prefabricated 2-Pump Control Building	1	LS	$104,000.00	$104,000.00
5	Prefabricated 2-Pump Control Building Mechanical	1	LS	$231,000.00	$231,000.00
6	Prefabricated 2-Pump Control Building Electrical	1	LS	$231,000.00	$231,000.00
7	Integration Controls	1	LS	$79,600.00	$79,600.00
8	Underground Reservoir	1	LS	$202,500.00	$202,500.00
9	Testing Laboratory Service	1	LS	$12,600.00	$12,600.00
10	Emergency Generator	1	LS	$69,600.00	$69,600.00
					$1,124,700.00
DISTRIBUTION PUMP STATION					
2-Pump Setup					
Item	Description	Quantity	Unit	Unit Price	Total
1	Mobilization	1	LS	$62,900.00	$62,900.00
2	Shipping	1	LS	$5,000.00	$5,000.00
3	Site Work	1	LS	$119,900.00	$119,900.00
4	Prefabricated 2-Pump Control Building	1	LS	$62,500.00	$62,500.00
5	Prefabricated 2-Pump Control Building Mechanical	1	LS	$87,500.00	$87,500.00
6	Prefabricated 2-Pump Control Building Electrical	1	LS	$95,000.00	$95,000.00
7	Integration Controls	1	LS	$79,600.00	$79,600.00
8	Underground Reservoir	1	LS	$202,500.00	$202,500.00
9	Testing Laboratory Service	1	LS	$12,600.00	$12,600.00
10	Emergency Generator	1	LS	$69,600.00	$69,600.00
					$797,100.00

Table 6.3 Pump Station Costs Estimates

BPS buildings are designed to meet DEQ-1 requirements. The pumps also follow DEQ-1 requirements such as automatic cutoff pressure for the suction side of not less than 20 psi. The minimum pump suction pressure is 35 psi with normal working pressure between 60 psi and 80 psi. The maximum discharge pressure will not exceed AWWA C900 CL 235 pipe pressure.

DRWA BPS buildings will be above ground and minimum of 3' above the 100-year flood elevation, with surface runoff draining away from the building. The interior floor elevation will be a minimum of 6 inches above finished grade to prevent flooding of the BPS. The interior will have floor drains and floors will be sloped to provide drainage to the floor drains. BPS will be designed in a manner that provides equipment servicing, meet OSHA requirements, and is designed in accordance with the Uniform Building Code to maintain safety. Heating, ventilation, dehumidification, and lighting will be included in BPS buildings.

6.3 Typical Drawings for Valves, Vaults, and Other Appurtenances

The DEC report requested further detail and development of typical drawings to bring the construction costs to feasibility level. The refined typical drawings and details are found in Appendix 6.12 and were used for updating the FCE including material, equipment, and labor. The FCE uses these typical sections and details and are discussed in Section 12.0.

6.4 Typical Drawings for Pipe Trenches & Highway, Road, Railway & Pipeline Crossings

The DEC report requested further development for all crossings. The typical detail drawings used to develop the costs are found in Appendix 6.12, and specifications in Appendix 6.13. Total crossing costs were developed by breaking down the individual materials for each crossing type and summing their costs.

There are 4 crossing types.

- Type 1 Highway and Railroad Crossings – Horizontal Directional Drilling or Jack and Bore, and carrier pipe must be cased. See Sheet D17 in Appendix 6.12.
- Type 2 Stream Crossings – Bored fusion welded carrier pipe. No casing pipe. See Sheet D18 in Appendix 6.12.
- Type 3 Road Crossings - Bored fusion welded, carrier pipe for crossing paved and unpaved county roads. No casing pipe. See Sheet D19 in Appendix 6.12.
- Type 4 Driveway Crossing – Open cut with compacted backfill. No casing pipe. See Sheet D2 and D19 in Appendix 6.12.

The following assumptions were made in developing crossing quantities:

1. Pipe casing lengths will be shown on the design drawings. For estimation purposes, the casing pipe is160 feet and is sized per the encasement schedule found on Sheet D20 in Appendix 6.12.
2. Jack & Bore costs include casing pipe welding, bore pit, and a receiving pit; but does not include mobilization.
3. Carrier pipe lengths continue 20 feet beyond end of casing pipe, each side.
4. Fusion prices include equipment costs but do not include travel time or mobilization costs.
5. Type 4 crossings are open cut and installed as using a typical trench detail. For estimation purposes, the trench width is 3 ft and crushed base depth is 6 inches.

Table 6.4 on the following pages provides the quantities and cost estimates for each type of crossing.

Crossing Costs*					
Type 1 Crossing (State Highway) - Horizontal Directional Drilling					
Item	Description	Unit	Quantity	Unit Price	Extended Price
1	16" HDPE 4710 DR 11	LF	160	$59.61	$9,537.60
2	Bore	LF	160	$25.19	$4,030.40
3	8" HDPE Class 200 (DR 11)	LF	200	$19.40	$3,880.00
4	Fusion	EA	6	$684.23	$4,105.38
5	Fused MJ Adapter	EA	2	228.14	$456.28
6	Mega Lug Restraint	EA	2	143.94	$287.88
7	Labor & Equipment	LF	160	$199.37	$31,899.20
					$54,196.74
Type 1 Crossing (State Highway) - Jack and Bore					
Item	Description	Unit	Quantity	Unit Price	Extended Price
1	16" Steel Casing	LF	160	$105.00	$16,800.00
2	8" PVC C900 Class 235 (DR 18)	LF	200	$19.40	$3,880.00
3	Bore	LF	160	$160.00	$25,600.00
4	Bore Pit	EA	2	$15,000.00	$30,000.00
5	Fused MJ Adapter	EA	2	$228.14	$456.28
6	Mega Lug Restraint	EA	2	$143.94	$287.88
7	Labor & Equipment	LF	160	$244.76	$39,161.60
					$116,185.76
Type 1 Crossing (Railroad) - Horizontal Directional Drilling					
Item	Description	Unit	Quantity	Unit Price	Extended Price
1	16" Steel Casing	LF	160	$105.00	$16,800.00
2	Bore	LF	160	$25.19	$4,030.40
3	8" HDPE Class 200 (DR 11)	LF	200	$19.40	$3,880.00
4	Fusion	EA	4	684.23	$2,736.92
5	Fused MJ Adapter	EA	2	$228.14	$456.28
6	Mega Lug Restraint	EA	2	$143.94	$287.88
7	Labor & Equipment	LF	160	$244.76	$39,161.60
					$67,353.08
Type 1 Crossing (Railroad) Jack and Bore					
Item	Description	Unit	Quantity	Unit Price	Extended Price
1	16" Steel Casing	LF	160	$105.00	$16,800.00
2	8" PVC C900 Class 235 (DR 18)	LF	200	$19.40	$3,880.00
3	Bore	LF	160	$160.00	$25,600.00
4	Bore Pit	EA	2	$15,000.00	$30,000.00
5	Fused MJ Adapter	EA	2	$228.14	$456.28
6	Mega Lug Restraint	EA	2	$143.94	$287.88
7	Labor & Equipment	LF	160	$244.76	$39,161.60
					$116,185.76

Type 2 Crossing (Streams)					
Item	Description	Unit	Quantity	Unit Price	Extended Price
1	Bore	LF	100	$25.19	$2,519.00
2	Fusion	EA	2	$684.23	$1,368.46
3	8" HDPE Class 200 (DR 11)	LF	100	$19.40	$1,940.00
4	Fused MJ Adapter	EA	2	$228.14	$456.28
5	Mega Lug Restraint	EA	2	$143.94	$287.88
6	Labor & Equipment	LF	100	$16.43	$1,643.00
					$8,214.62
Type 3 Crossing (Paved or Unpaved County or City Street)					
Item	Description	Unit	Quantity	Unit Price	Extended Price
1	Bore	LF	100	$25.19	$2,519.00
2	Fusion	EA	2	$684.23	$1,368.46
3	8" HDPE Class 200 (DR 11)	LF	100	$19.40	$1,940.00
4	Fused MJ Adapter	EA	2	$228.14	$456.28
5	Mega Lug Restraint	EA	2	$132.24	$264.48
6	Labor & Equipment	LF	100	$17.99	$1,799.00
					$8,347.22
Type 4 Crossing (Farm Access, Driveways, Trails)					
Item	Description	Unit	Quantity	Unit Price	Extended Price
1	8" PVC C900 Class 235 (DR 18)	LF	20	$47.35	$947.00
2	Compaction	LF	20	$15.00	$300.00
					$1,247.00
*Pipe costs have been removed from Crossing Costs on Master Cost Estimate					

Table 6.4 Crossing Types & Costs

6.5 Design Considerations for Water Treatment Plant & Processes

6.5.1 Ft. Peck Water Treatment Plant Design Considerations and Process Evaluation

The proposed Dry-Redwater Regional Water Authority (DRWA) Fort Peck Water Treatment Plant (WTP) will treat water from the Big Dry Arm/Rock Creek area of Fort Peck Reservoir. The basic design criteria for a water treatment plant are established to address water quality challenges, to comply with current and future regulations, and to reliably operate to meet water demands. This section summarizes water quality data collected to date, reviews applicable treatment technology, and provides a recommended Fort Peck WTP process and layout.

6.5.2 Source Water Sampling

Sampling of the Fort Peck raw water source occurred between July 2021 and June 2022. A location in the Rock Creek Arm near the proposed water treatment plant intake was selected and sampling efforts were completed by Interstate Engineering personnel.

INTERSTATE ENGINEERING

Locations were accessed with a motorboat during warmer weather, and on foot when the water surface was frozen. A mobile phone GPS was used as a reference tool to ensure the sampling location was consistent. The sample location is shown in Figure 6.4 below.

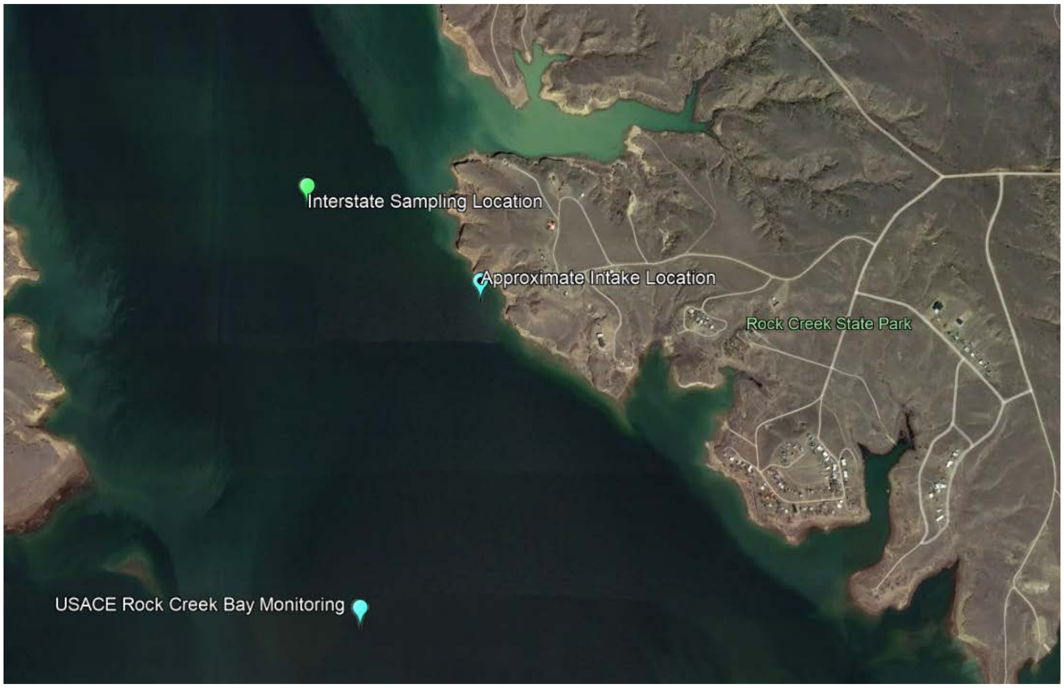


Figure 6.4 Satellite Picture of Sampling Locations and Potential Intake Location

Samples were taken at varying depths ranging from the surface to the bottom of the lake, approximately 60ft deep at this location, depending on the water surface elevation at the time of sampling. A deep-water sampling device was initially used to obtain samples at depth. The device allows water into the sample container only when its handle is pulled upward, allowing it to sample at the correct depth. From April 2022 onward, a submersible pump was operated at the desired depth to obtain samples. Indicating marks were made on the lifting cables of these devices to keep track of the depth.

Measurements such as temperature, pH, and dissolved oxygen (DO) were obtained in the field. Early sampling efforts completed with pH and DO test strips did not yield acceptable data and were omitted from consideration. A Hanna Industries HI98194 Multiparameter Meter and Probe was obtained in January 2022 and used for pH and DO sampling efforts for the remainder of the sampling period.

Most of the sample testing and analysis was completed by Energy Laboratories in Billings, MT. Samples were obtained and prepared at the sampling location in Fort Peck, and then shipped to Energy Laboratories for analysis. Samples taken in May and June of 2022 were delivered by Interstate directly to Energy Laboratories. For testing that Energy Laboratories was unable to provide, such as algae identification, and *cryptosporidium* analysis, this work was completed by EMSL Analytical of Cinnaminson, NJ.

Between July 2021, and April 2022, seven trips occurred to obtain samples from Fort Peck. Parameters analyzed during these trips included the following, each tested at varying depths: Physical properties, hardness, nutrients, total organic carbon (TOC), dissolved metals, and total metals. During the sampling trip in April 2022, inclement weather cut sampling activities short, and no field measurements were obtained.

Two sampling trips were completed in May and June of 2022. For these trips, the range of sampling was broadened to include the following in addition to the parameters previously listed: Odor precursors, microbes, algae and algal biproducts, dissolved organic carbon (DOC), ions, radionuclides, oil and grease, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), per and polyfluoroalkyl substances (PFAS). These parameters were also analyzed at varying depths as previously noted.

A partial summary of key sampling results are listed in Table 6.5, full sampling results are included in Appendix 6.14.

Summary of Sample Analysis			
Parameter	Average	Minimum	Maximum
pH, SU	8.5	8.4	8.7
Total dissolved solids, mg/L	437	431	443
Specific conductance, µS/cm	690	679	709
Turbidity, NTU	1.5	0.5	2.6
Alkalinity, mg/L	168	168	169
Hardness, mg/L	247	229	276
Calcium, mg/L	56	52	62
Iron(1), mg/L	0.04	ND	0.09
Magnesium, mg/L	26	24	29
Copper, µg/L	ND	ND	ND
Zinc, µg/L	ND	ND	ND
Total organic carbon, mg/L	2.9	2.4	4.0
Dissolved organic carbon, mg/L	3.0	2.8	3.3
Total coliform, MPN/100mL	326	1	649
Fecal coliform, MPN/100mL	<1	<1	<1
Giardia(2), cysts/mL	0	0	0
Cryptosporidium(2), oocysts/L	0	0	0
VOCs, µg/L	ND	ND	ND
SOCs, µg/L	ND	ND	ND
PFAS, µg/L	ND	ND	ND

1 Only one sample from 42 had iron above detection limit

2 Microorganisms (*Cryptosporidium* and *Giardia*) were not detected in samples taken however hold time and temperatures of samples were outside of specifications prior to analysis.

Key:
µg/L = micrograms per liter
mg/L = milligrams per liter
MPN/100mL = most probably number per 100 milliliters
ND = not detected
NTU = nephelometric turbidity unit
µS/cm = micro Siemens per centimeter

Table 6.5 Summary of Sample Analysis

6.5.3 Finished Water Goal Development

The treated water quality goals for the Fort Peck WTP are based on an assessment of regulatory requirements (both existing and future), maximum contaminant level (MCLs), required treatment technologies (TT), secondary standards, required pathogen log removals, and aesthetic water quality goals. Pathogen log removal is based on taking and converting the logarithm of 1 – minus the percent removal (as a fraction) to a positive number. For example, 99.9 percent removal is equal to a 3-log removal [-log(1-0.999)].

6.5.3.1 Regulatory Framework

Drinking water quality is regulated by the United States Environmental Protection Agency (EPA) and the Montana Department of Environmental Quality (MDEQ) through a number of current regulations. The Safe Drinking Water Act (SDWA) of 1974 gave EPA the authority to set standards for contaminants in drinking water supplies. It empowered the EPA to set limits (maximum contaminant levels or MCLs) on inorganic and organic chemicals, microorganisms, disinfectants, disinfection byproducts, and radionuclides in water sources that can adversely affect the health of the end users of a water distribution system. Examples of inorganic chemicals are lead and mercury, and microorganisms are *Cryptosporidium* and *Giardia*. These contaminants and their concentration limits are included in the National Primary Drinking Water Regulations (NPDWR). The National Secondary Drinking Water Regulations (NSDWR) are limits the EPA recommends on contaminants that do not affect the end user's health however do affect other aspects of finished water quality. These other aspects include taste, color, and smell of the water. Over the past 42 years, several new and modified regulations have been promulgated by EPA and additional regulations or modifications to current regulations are currently under development.

The State of Montana is required to adopt State regulations that meet or exceed the Federal regulations. MDEQ has primacy for the SDWA which means it has the authority to implement and enforce the Primary SDWA Regulations.

The quality of the water provided by the Fort Peck WTP must meet all existing and proposed State and Federal regulatory requirements. The full-scale water treatment, storage and distribution facilities must allow the system operators to comply with all applicable regulations under the anticipated range of source water quality and operational conditions. Therefore, both the existing and anticipated future regulations must be considered during evaluation and design of the water treatment facility.

Table 6.6 below provides a summary of the provisions of each regulation that may influence the design of the Fort Peck WTP.

REGULATION	PROVISIONS
Revised Total Coliform Rule (RTCR)	1. Requires monthly sampling for total coliforms at designated sampling locations in the distribution system. Samples must be absent of total coliforms in 95 percent of all samples in the month or the system is in violation. Positive samples must be verified by testing for E. Coli, which must be absent. 2. The plant must be designed to fully disinfect ambient fecal matter coliforms, so it does not enter the distribution system, resulting in RTCR violations.
Surface Water Treatment Rule (SWTR)	1. Treatment must achieve 3.0-log (99.9%) or more removal/inactivation for Giardia lamblia. 2. Treatment must achieve a 4.0-log (99.99%) or more removal/inactivation for viruses. 3. Turbidity monitoring continuously or by grab samples every four hours. 4. Establishes chemical disinfection credit based upon the C x T value (disinfection residual concentration "C" multiplied by the disinfection contact time "T").

Lead and Copper Rule (LCR)	1. Requires periodic monitoring of designated locations in the distribution system for concentrations of copper and lead. 2. Action levels for lead and copper is exceeded if the concentration in more than 10 percent of samples collected is greater than 0.015 mg/L and 1.3 mg/L, respectively. 3. Systems exceeding action levels are required to implement treatment to prevent corrosion, lead service line replacement, public education, and additional monitoring.
Interim Enhances Surface Water Treatment Rule (IESWTR)	1. Reduced turbidity requirements to the following: combined filtered water turbidity less than or equal to 0.3 NTU in at least 95% of monthly samples and combined filtered water turbidity never to exceed 1 NTU.
Stage One Disinfectants / Disinfection Byproduct Rule (DBPR)	1. Set total organic carbon (TOC) removal requirement percentages dependent upon the source water alkalinity and TOC concentration. 2. Established DBP MCLs as follows: TTHM - 80 µg/L; HAA - 60 µg/L; bromate – 10 µg/L; and chlorite - 1.0 mg/L. 3. Required monitoring in the distribution system to verify compliance with the DBP MCLs. 4. Establishes MRDLs for chlorine and chloramines.
Radionuclides Rule	1. Established MCL for uranium of 30 µg/L and retains MCLs for gross alpha particles, beta/proton emitters, and radium 226/228. 2. Initially requires four quarterly samples at entry points to distribution system to determine compliance with rule and to set continued monitoring schedule. 3. Management techniques or treatment will be necessary if uranium MCL is exceeded.
Arsenic Rule	1. Lowered the total arsenic MCL to 10 µg/L in drinking water. 2. Arsenic MCL compliance is calculated as running annual average of quarterly sampling at each distribution system point of entry.
Filter Backwash Recycling Rule	1. Designates that all recycled streams in the WTP are returned to the front of the plant such that the recycled water is treated through all plant processes. 2. Recycled streams can be no more than ten percent of the total plant raw water flowrate.
Filter Term 1 ESWTR (LT1ESWTR)	1. Establishes MCLG for Cryptosporidium at zero. 2. Filtered systems must provide 2.0 log (99%) Cryptosporidium removal. 3. Establishes combined filtered water turbidity standards of < 0.3 NTU in 95% of samples for conventional filters, alternative technologies performance established by the State. 4. Requires systems to develop a disinfection profile and benchmark.
Long Term 2 ESWTR (LT2ESWTR)	1. Requires systems to collect and analyze 24 monthly samples of surface water sources for Cryptosporidium and turbidity. 2. Monitoring results dictate if treatment of Cryptosporidium based upon the running annual average concentration from the collected samples. The average concentration indicates which “Bin” the source water is classified. 3. Treatment requires 2.0 or more log-removal of Cryptosporidium depending on the Bin and the treatment technology. 4. Established a toolbox of processes that can be used to meet the additional removal requirements.
Stage Two Disinfectants / Disinfection Byproduct Rule	1. Revises compliance based upon a locational running annual average (LRAA) at the highest concentration areas in the distribution system.

Table 6.6 Summary of Drinking Water Regulations with Impact on the Fort Peck WTP

Treated water quality goals must meet all applicable federal, state, and local drinking water regulations. Some of the primary treatment goals include meeting the requirements of the Clean Water Act (CWA), SDWA, Surface Water Treatment Rule (SWTR) including the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), Stage 1 and Stage 2 Disinfection Byproduct Rules, and the Lead and Copper Rule. Additionally, the water should not contain objectionable levels of taste or odor causing compounds.

The regulatory provisions presented in Table 6.7 were evaluated by the Project Team and translated into specific criteria and a set of overall water treatment/water quality goals to address treatment concerns for the Fort Peck WTP. The criteria and goals established for full-scale operation are summarized in Table 6.8.

6.5.3.2 Inorganic Chemicals/Contaminants - NPDWR

The inorganic chemical concentrations, or levels, can be influenced by man-made sources upstream of the water intake as well as natural sources the water encounters along its path to the intake. Most inorganic contaminants are dissolved[7] in the water and the removal process varies from contaminant to contaminant. Some of the processes are as simple as settling, while others can involve energy intensive filtration or changing the conditions of the water to force the contaminant to precipitate. From the source water sampling results, no inorganic chemicals were detected above the actionable levels set by the NPDWR.

Contaminant/Parameter	Treated Water Goal	MCL or TT	Secondary Standard
Arsenic, mg/L	< 0.008	0.010	
Fluoride, mg/L	< 2.0	4.0	2.0
Nitrate as N, mg/L	< 8.0	10	
Nitrite as N, mg/L	< 0.8	1	
Gross Alpha, (pCi/L	< 10	15	
Uranium, µg/L	< 10	30	
Other Inorganics	< MCL	Per Standard	
Total Trihalomethanes (TTHM), µg/L as LRAA	< 64	80	
Haloacetic Acids (HAA), µg/L as LRAA	< 48	60	
Turbidity, NTU	< 0.2	TT	
Aluminum, mg/L	< 0.05		0.05 – 0.2
Chloride, mg/L	< 100		250
Color, color units	< 5		15
Copper, mg/L	< 0.8		1.0
Iron, mg/L	< 0.3		0.3
Manganese, mg/L	< 0.02		0.05
Odor, TON	< 3		3
pH	7.5 – 8.3		6.5 – 8.5
Sulfate, mg/L	< 100		250
Total Dissolved Solids	< 300		500
Zinc mg/L	< 5		5
Cryptosporidium	2 log removal/inactivation	TT	
Giardia lambila	3 log removal/inactivation	TT	
Viruses	4 log removal/inactivation	TT	

Table 6.7 Fort Peck WTP Treated Water Goal Summary

6.5.3.3 Microorganisms - NPDWR

The regulations for water sources in relation to microorganisms are split between ground water and surface waters. As applicable to Fort Peck surface waters are subject to the Surface Water Treatment Rule (SWTR), Interim Enhanced Surface Water Treatment Rule (IESWTR), Filter Backwash Recycling Rule (FBRR), Long

[7] A dissolved solid is defined by it passing through a 2-micron (µm) filter.

Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR or LT1 Rule), and Long Term 2 Enhance Surface Water Rule (LT2ESWTR or LT2 Rule).[8]

The SWTR introduced rules for removal of *giardia* and viruses while the subsequent LT1 and LT2 rules, introduced regulations for the removal of *Cryptosporidium*. These regulations were put in place because measuring relevant microorganisms can take days to complete and may not allow for a timely correction to the treatment process should the need arise.

The LT2 rule places a water source into a "bin" classification based on *cryptosporidium* analysis results from source water samples taken over a 24-month period, as further defined in Table 6.10 below. The bin classification determines the extent of the filtration required since *cryptosporidium* is resistant to some disinfection techniques, such as chlorination.

For systems that are:	Mean *Cryptosporidium* *Concentration*[9]	Bin Classification
… required to monitor for *Cryptosporidium*	< 0.075 oocysts/L	Bin 1
	From 0.075 to < 1.0 oocysts/L	Bin 2
	From 1.0 to < 3.0 oocysts/L	Bin 3
	≥ 3.0 oocysts/L	Bin 4

Table 6.8 From EPA LT2 Rule Factsheet

The initial sampling for microorganisms did not show the presence of giardia or cryptosporidium. However, sampling was limited, and one data point is not statistically significant enough to make design decisions. A monthly sampling program would need to be developed for 24 months to verify the proper Bin classification of the Fort Peck Reservoir water, or DRWA must commit to a filtration treatment process with at least 5.5 log removal and deactivation of *Cryptosporidium*.

6.5.3.4 Hardness

Hardness in water describes the total amount of calcium and magnesium ions present within. Excessive hardness can lead to deposits of mineral scale within fixtures and increases the amount of soap or detergent required to generate a lather. There are currently no hardness limitations set forth by the EPA through the Primary or Secondary Standards of the Safe Drinking Water Act. Sampling efforts completed at Fort Peck provided baseline information on the hardness of the raw water, which averaged 246 mg/L as $CaCO_3$ through all samples. This water would be categorized as "Hard" by the American Water Works Association (AWWA), exceeding the "Moderately Hard" range of 75-150 mg/L as $CaCO_3$, but shy of the "Very Hard" range in excess of 300 mg/L as $CaCO_3$.

The municipalities within the proposed service area of the DRWA water system are generally producing soft water in the range of 6-39 mg/L as $CaCO_3$, a result of the Reverse Osmosis filtration processes utilized by the various systems. Fairview was the exception, with a reported hardness of 238 mg/L as $CaCO_3$.

Two softening processes were considered to determine the feasibility of softening the Fort Peck raw water to better match the soft water that some of the service area constituents are familiar with.

[8] https://www.epa.gov/dwreginfo/surface-water-treatment-rules

[9] Samples must be analyzed by an approved laboratory and use EPA method 1622 or 1623.

A common approach to reducing the hardness of water in a water treatment plant setting is to use a chemical softening process. This is typically configured to use a chemical addition of lime or quicklime, with a specialized clarifier basin. The amount of hardness that can be treated by lime is limited to the available carbonate and bicarbonate in the source water. Following the softening process, carbon dioxide is bubbled into the water to extinguish any remaining lime and lower the pH closer to neutral. Based on the composition of the Fort Peck raw water, using only lime softening the hardness could safely be reduced to 150 mg/L as $CaCO_3$. This would just classify the water on the high end of the "Moderately Hard" range. Using this process for softening would increase the amount of chemicals used for water treatment, and increase the hazards associated with the treatment process. Lime and other softening chemicals are caustic and require specialized handling and storage considerations. Carbon dioxide poses an asphyxiation risk and comes with its own storage and handling requirements as well. The sludge generated by this softening process is also caustic and would require specialized storage and disposal.

Another approach to water softening at this scale is to use reverse osmosis (RO) membrane filtration to remove hardness constituents from the water. The pores within the RO membrane are too small for the particles that make up hardness to pass through and allow for only water molecules to pass. This process requires exceptionally clean water to implement efficiently, and for the proposed Fort Peck water plant, would need to be located after the primary treatment process. To remove the hardness from the water completely, all water would need to be treated by the RO system. The total hardness of the plant finished water can be reduced proportionally by treating a fraction of the flow through the RO system.

For example, to reduce the hardness by half, only half of the water would need to be treated by the RO system, and it would then be blended back into the primary treatment path. In addition to the specialized RO membranes required for this process, this process requires more electricity due to high pressure requirements, resulting in additional costs, and requires storage and disposal of the brine stream. This stream is typically 20-25% of the total water processed by the RO system.

Softening the Fort Peck source water is possible, however doing so would add considerable cost and complexity to the overall treatment process. Pursuing a chemical softening process would only see a marginal reduction in hardness without a significant increase in softening chemical addition, while adding substantial operational hazards. Implementing an RO membrane system to treat for hardness would incur a significant increase in overall equipment cost, power consumption, and maintenance requirements. Both softening alternatives result in increased process waste in the form of the hardness being removed from the water and would require storage space and periodic disposal. Based on the additional cost and treatment complexity softening of the Fort Peck source water was not included as a finished water goal.

6.5.4 Water Treatment Process Overview and Analysis

DRWA's objective is to provide safe, clean, water to its constituents with a low-cost plant that is dependable and easily operated with minimal staff given the extensive and sparsely populated service area. Based on the initial sampling results, the Fort Peck water source provides good quality water that lends itself to straightforward treatment and should help DRWA meet their objectives.

The typical water treatment process train for surface water treatment includes three basic unit operations: pretreatment, filtration, and disinfection. In addition to the basic unit operations, other treatment units or chemicals are often included to optimize water treatment and achieve better treated water quality. These treatment units can include grit removal, oxidation chemicals, powdered activated carbon (PAC) and corrosion inhibitors. For some waters advanced treatment such as granular activated carbon (GAC) and nanofiltration or reverse osmosis (NF/RO) are included in the process. The initial sample results taken by Interstate Engineering and the US Army Corps of Engineers results from 2006 do not indicate a need for an intensive and complicated treatment process. No significant inorganic chemical levels were found; therefore, the treatment process should consist of pretreatment for the selected type of filtration, filtration units, primary disinfection for *giardia* and viruses, and residual disinfection for the distribution system, with appropriate solids handling.

Given the water samples taken have shown the inorganic chemical contaminants are under the maximum contaminant level set forth by the NPDWR, the primary objective of the water treatment plant is to ensure the microorganism removal and inactivation is achieved to satisfy the LT2 Rule.

The expected end usage of the treated water will be a mixture of residential and livestock watering. Projected buildout peak day demand for the proposed Dry Redwater Regional Water system is approximately 3065 gpm, or 4.4 mgd.

Disposing of generated waste can be expensive in terms of capital cost and added complexity to the plant process. If excess solids are generated, they need an additional process step to be dewatered prior to disposal. Seasonal temperatures also need to be taken into consideration if drying can only happen during a certain period of the year. Given the remote location of the water treatment plant, the design filtrate recovery of the treatment process should be greater than 99.5%.

6.5.4.1 Pretreatment Alternatives

In the DEQ Circular 1, 2022 ed., part 3.1.3 Minimum Treatment for Surface Water states that “filtration preceded by appropriate pretreatment must be provided for all surface waters.”

One of the main purposes of pretreatment is to remove excess, easily settleable raw water turbidity prior to loading the filtration process with the suspended matter in the raw water. The sampling results from the proposed Fort Peck Reservoir source have indicated a low turbidity (less than 3 NTU) water source.

Another primary consideration for the pretreatment process is natural organic matter (NOM) content in the source water, which can react with disinfection chemicals to create disinfection byproducts (DBPs). The two main categories of DBPs are the Haloacetic Acids group (HAA5) and Total Trihalomethanes (TTHM). DBPs have been shown to negatively affect human health and are regulated by the EPA under the Disinfection Byproducts Rule (DBPR).

Without a pilot study or existing plant reference, measuring DBPs is not possible, however precursor indicators have been established. Measuring total organic carbon (TOC) and dissolved organic carbon[10] (DOC) along with the UV_{254} absorbance[11] can help determine the formation potential of DBPs. This is done by calculating the specific ultraviolet absorbance (SUVA), which is shown below. A high SUVA,

[10] Sampled is filtered with a 0.45μm filter prior to TOC measurement.

[11] Absorbance of the raw water sample is calculated with a spectrophotometer at 254nm of UV light.

greater than 6 L/mg·m, indicates an increased likelihood of forming DBPs while less than 2 L/mg·m is considered low. From the samples taken, the SUVA was 1.9 L/mg·m, signifying the low likelihood of forming significant quantities of DBPs.

$$SUVA\left(\frac{L}{mg.m}\right) = \frac{UV_{254}\,(cm^{-1})}{DOC\left(\frac{mg}{L}\right)} \times 100\left(\frac{cm}{m}\right)$$

$$\frac{0.057\ (cm^{-1}\ average)}{3.0\ \left(\frac{mg}{L}\ average\right)} \times 100\left(\frac{cm}{m}\right) = 1.9\left(\frac{L}{mg\cdot m}\right)$$

Even though the risk of forming DBPs is low based on the sampled water quality, the treatment for DBPs still needs to be considered in the design of the water treatment system. Membrane filtration by itself does not remove a significant portion of NOM due to the small particle sizes, however the addition of a filter aid can change the removal efficiency. The filter aid changes the particle charges and allows the membrane to remove the NOM via adsorption versus particle size exclusion.

Conventional filtration control of DBPs is regulated under 40 CFR 141.135 which requires the use of enhanced coagulation or enhanced softening prior to filtration. These techniques are not required if an alternative compliance can be met. A few of the alternative compliance methods are as follows:

- If the SUVA in the raw water or treated water falls under 2.0L/(mg·m):
  - This is required to be calculated quarterly as a running annual average or on a monthly basis.
  - Given the raw water is close to the 2.0L/(mg·m) limit and no pilot plant study is in place yet, this alternative compliance method may not be applicable.
- If the raw TOC is less than 4.0mg/L with an alkalinity of more than 60mg/L, and the measured TTHM is less than 40μg/L and HAA5 is less than 30μg/L:
  - These are calculated quarterly on a running annual average.
  - High water alkalinity can prevent the significant removal of TOC via coagulation.
  - Samples taken show significantly higher alkalinity at 168mg/L, and TOC consistently less than 4.0mg/L.
  - Need pilot plant study to DBP creation however given the SUVA is close to 2.0mg/L, this alternative compliance method may be more applicable.

With the relatively good water quality based on the sampling information, and the relatively low risk of DBP formation, the selected pretreatment technology should be limited in complexity.

6.5.4.1.1Conventional Sedimentation

Conventional sedimentation involves chemical addition, rapid mixing, coagulation, flocculation, and sedimentation. This process has been demonstrated to be capable of removing turbidity, color, TOC, Dissolved Organic Carbon (DOC), viruses, bacteria, and protozoans such as *Giardia* and

Cryptosporidium. This pretreatment alternative can cope with source water turbidity up to 1,000 NTU or higher and is a reliable pretreatment alternative for both membrane and conventional filters.

6.5.4.1.2 Coagulation and Flocculation for Low Turbidity Waters

If the raw water source has low turbidity (less than 5 NTU) such as found in lakes, reservoirs or rivers flowing out of lakes/reservoirs, pretreatment consisting of coagulation followed by flocculation may provide sufficient pretreatment prior to filtration. This approach is often called direct filtration. Since sedimentation basins are not required, costs are lower for direct filtration plants than for conventional plants.

6.5.4.1.3 Dissolved Air Flotation

Dissolved air flotation (DAF) is based on the principle that the naturally occurring and coagulated particles can be made to float with the help of dissolved air bubbles. The flocculation time used in DAF plants is typically less than those used by conventional coagulation sedimentation plants. Advantages of DAF include:

- Small tanks compared with those for sedimentation
- Possibly lower coagulation and flocculent aid dosages, can operate without polymer addition
- Provide better removal of low-density particles and algae

DAF is a suitable pretreatment for both media filter and membrane filters for the proposed Fort Peck WTP. A general schematic for a DAF system is shown in Figure 6.5.

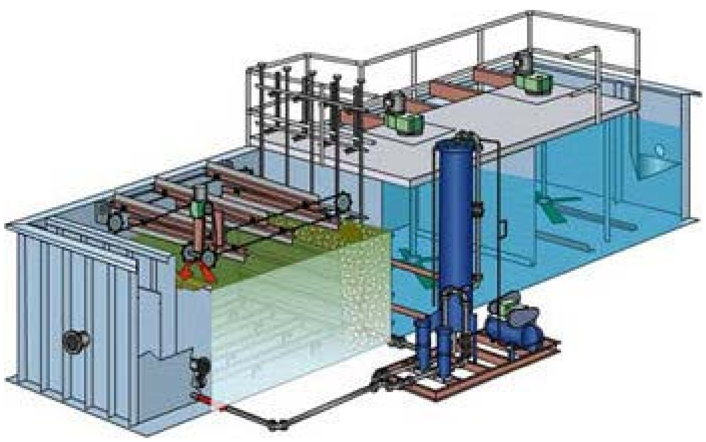


Figure 6.5 Schematic of DAF System

6.5.4.1.4 Sludge Blanket Clarifiers

Sludge blanket clarification, or solids contact clarification, involves coagulation within a mass of previously formed solids. Coagulation chemicals are added in a rapid mixing chamber and the water and resulting particles then percolate upward through a sludge blanket. The contact between the newly flocculated particles and the existing mass in the sludge blanket aids in the removal of particles from the water because newly formed particles readily absorb onto existing particles. During stable operation, the sludge blanket clarifier can generally produce lower turbidity water compared with the conventional sedimentation basin. One disadvantage of the sludge blanket clarifiers is the blanket stability can be disrupted during flow changes, abrupt water quality changes, or temperature changes, resulting in sludge carryover to the filters. Sludge blanket clarification is a viable pretreatment for both media and membrane filtration.

6.5.4.1.5 Ballasted Clarification

Ballasted clarification is a high-rate clarification system (e.g., Actiflo by Kruger), which includes separate chemical addition, followed by rapid mixing, flocculation, and sedimentation compartments (with plate or tube settlers) within a single unit. The process utilizes Microsand to enhance flocculation and settling. Coagulated particles adhere to the Microsand and are removed in the sedimentation compartment. The settled solids/Microsand is pumped to a hydrocyclone where the Microsand is separated and returned to or reused in the flocculation compartment. The solids/sludge is discharged to the solids handling process.

The advantages of ballasted processes are the reduced coagulation and flocculation times and the higher rise rate compared to conventional settling. The ballasted flocculation process has been successful even under extreme conditions such as low temperature, high color, and very high or very low turbidities. Ballasted clarification is expected to perform well as the pretreatment alternative for media filters. Ballasted clarification has also been used ahead of membrane filters, however, testing at many facilities indicates that polymer carryover can occur causing rapid fouling of the membranes. Ballasted clarification would not be the best application for the proposed Fort Peck WTP if membranes are selected for filtration. A general schematic for a Ballasted Clarification system is shown in Figure 6.6.

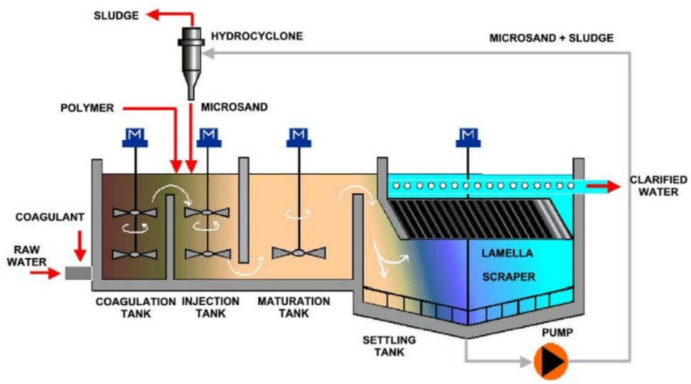


Figure 6.6 Schematic of Actiflo Ballasted Clarification System
(Image Courtesy of Veolia Water Technologies)

6.5.4.1.6 Plate and Tube Settlers

Plate and tube settlers are very similar in nature, to simplify only plate settlers will be further referred to in this section. Plate settlers perform the same function as conventional sedimentation basins and can be installed in the same location in the process train.

Flocculated water enters the plate settler at the bottom of the plates and flows through the inlet channel to each plate. Water enters the settling area between the inclined plates through openings on both sides of the plates and flows upward between the plates to the outlet area. Settled solids slide down the inclined surface and drop into the basin below.

Plate settlers allow for overall basin loadings from 2 to 4 gpm/ft^2, several times that for conventional basins, thus offering considerable savings in space and cost over conventional sedimentation. Plate settlers are expected to perform well as the pretreatment for both media filters and membrane filters proposed for the Fort Peck WTP. An example of a plate settler installation is shown in Figure 6.7.

Figure 6.7 Plate Settlers Installed in Sedimentation Basin (Kennewick, WA)

6.5.4.1.7 Presedimentation Basins with Provisions for Chemical Addition

An additional pretreatment alternative evaluated for the proposed Fort Peck WTP is pre-sedimentation basins followed by rapid mix to filtration, a similar concept to the direct filtration alternative discussed previously. Based on the year-round low source water turbidity readings, ranging from 0.5 to 2.6 NTU, and the lack of DBP precursor indicators, many of the pretreatment processes discussed do not add substantial benefit to the treatment process for the associated costs, provided the filtration method can handle direct filtration. As the turbidity of the influent water decreases, the percentage of solids removal by coagulant and flocculation also decreases, leading to diminishing returns for treatment. Coagulation and flocculation performance depends on particles interacting with each other and as the particle counts decrease (lower turbidity), particle interaction becomes more difficult due to a lower particle density.

Pre-sedimentation basins in addition to allowing some settlement for turbidity removal as well as a place for coagulation chemical addition upstream of the basins in the event it is deemed necessary, also provide the benefit of onsite raw water storage. In the event there are issues with the intake facility, or the water quality of the source water, the pre-sedimentation basins can provide water to the treatment plant while the issue is resolved.

Aeration of the basins should be provided to help control algae and provide a means of mixing to keep the water quality consistent throughout. Algae can start to form in low oxygen environments and can cause fouling issues for treatment equipment downstream and release toxins if stressed.

Pre-sedimentation Basins with potential chemical addition are expected to perform well as the pretreatment for membrane filters, however it is not recommended for media filtration, as media filtration typically requires flocculated water to perform well.

6.5.4.1.7.1 Rapid Mix

Rapid mix is used to provide the mixing energy needed to properly disperse coagulants, or filtering aids, prior to the settling or filtering process. Proper application of a coagulant starts the process of floc formation through charge neutralization, allowing particles that once repelled each other to clump together. The bonds formed that hold the particles together are not strong enough to maintain the flocs when mixed excessively, thus the need for properly designed mixing. Several options exist for rapid mixing, a mechanically mixed chamber or the injection of a small stream of high velocity water into the supply pipeline (flash mix) are the two most common types. For any chemical addition rapid mixing ensures a uniformly dispersed chemical throughout the water stream. Rapid mixing will be included in the pretreatment train for either media filtration or membrane filtration for the proposed Fort Peck WTP.

6.5.4.1.7.2 Preferred Pretreatment Alternative

For Conventional (Media) Filtration, coagulation addition with rapid mixing and flocculation followed by plate settlers is the preferred pretreatment method for this application. The rapid mix basin will ensure proper dispersion of the coagulant, and as noted previously flocculation is necessary to increase particle size and thereby increase performance of media filters which is especially necessary based on the low influent turbidity. Plate settlers were selected over traditional sedimentation basins to reduce the footprint of the settling basins. Due to the cold weather in eastern Montana, these basins will need to be enclosed, by reducing the footprint there is an associated reduction in building and facilities required, resulting in overall cost savings. The plate settlement basins also provide the location for solids to be collected and removed from the treatment train.

For Membrane Filtration, Pre-sedimentation Basins with provisions for coagulant addition at the inlet followed by rapid mixing is the preferred pretreatment method for this application. The low raw water turbidity coupled with the lack of DPB precursor indicators points to direct filtration being a successful treatment strategy.

6.5.4.2 Filtration Alternatives

Filtration is the primary means of removing suspended particles, including microorganisms, from the water and performance is measured by turbidity in nephelometric turbidity units (NTU). The EPA requires filtered water to be under 0.3 NTUs 95% of the time and never over 1.0 NTU for conventional and membrane filtration processes. Filtration provides a barrier against the transmission of waterborne diseases, and filtration and disinfection together provide an effective barrier against pathogens. Filtration can assist significantly by reducing the load on the disinfection process and increasing disinfection efficiency. Filtration can be divided into two basic types: Conventional or Media filtration and Membrane filtration. Both filtration techniques have numerous installations for drinking water treatment with conventional being more popular due to age of the technology. However, the use of membrane filtration systems has increased in recent years due to increased regulations on pathogen removal and issues around DBPs. Each type of filtration will be briefly discussed in the following sections.

6.5.4.2.1 Conventional (Media) Filtration

Media filtration can include slow sand filtration (0.05 to 0.1 gpm/ft^2), rapid sand filtration (1 to 2 gpm/ft^2), high-rate granular media filtration (up to 10 gpm/ft^2 or even higher), Diatomaceous Earth (DE) filtration, and those used in pressure filters such as green sand filtration. High-rate granular media filtration is the most commonly used media filtration in modern surface water treatment plants and will be the basis of this evaluation. Media configuration in the high-rate granular media can be:

- Conventional sand
- Dual-media (coal over sand)
- Mixed media (coal over sand over garnet)
- Deep bed (coarse sand or coal, unstratified, 48 to 72 inches)

A typical dual-media filter section is shown in Figure 6.8.

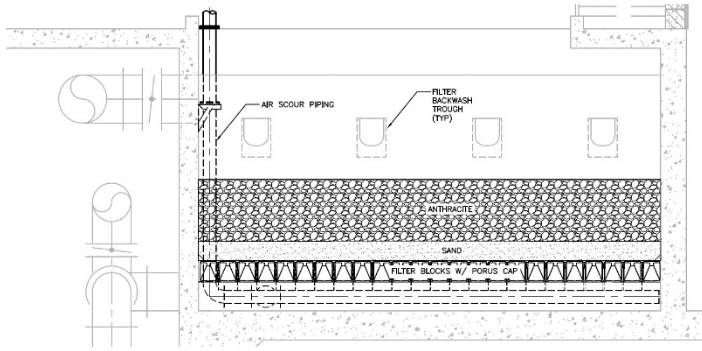


Figure 6.8 Dual-Media Filter Example

Granular activated carbon (GAC) has also been used frequently in replacement for coal or as a cap, a layer of GAC on top of the filter media, to improve filtration and organic removal.

Effective operation of a media filtration system requires effective pretreatment of the source water.

The nature, as well as the quantity of suspended material in the pretreated water can greatly influence filter performance. The most commonly used filtration pretreatment process is coagulation/flocculation and sedimentation. Unflocculated water can be difficult to filter regardless of the type of medium used.

With proper pretreatment, media filters typically can operate from 12 to 96 hours before either reaching the head loss limit or experiencing a turbidity breakthrough leading to poor effluent water quality. A filter backwash is required when either of the above conditions occur. Media filters are typically backwashed with finished water at 15 to 20 gpm/sf with the bed expansion between 15 and 30 percent. Backwash cycles are generally 10 to 20 minutes in duration. Air scours are generally used during backwash to enhance the cleaning of the filter media. At the end of a backwash cycle, some particles remain trapped within the filter bed. When a filter is returned to service after backwashing, these particles are carried into the filter effluent, causing elevated turbidities and particle counts during the initial filtration period. A "filter-to-waste" step is generally required before a filter is put back into normal filtration after a backwash. The filtered water collected during this period is recycled to an upstream location in the process stream or delivered to a separate treatment process.

Under Montana DEQ Surface Water Regulations, media filtration (dual-media) filters provide 2.5-log removal of *giardia,* and 2-log removal of viruses and *cryptosporidium*. This still leaves an additional 0.5-log removal needed for giardia and 2-log removal for viruses. Typically, this is done through disinfection and is discussed in further detail later. Media filtration satisfies the requirements for Bin 1 of the LT2 Rule for *cryptosporidium*.

If the LT2 Rule classification falls into Bin 2, additional treatment techniques are required. They are found in the "Microbial Toolbox" issued by the EPA as part of the LT2 Rule. One example is: if both the combined filter effluent (CFE) turbidity and individual filter effluent (IFE) turbidity are under 0.15NTU (a 50% reduction from the NPDWR turbidity requirement) in 95% of samples each month, 1-log total of additional *cryptosporidium* removal credit is granted.

Should the bin classification fall into Bin 3 or 4, an additional treatment technique is necessary, incurring additional capital costs. Table 6.3 in the MDEQ Surface Water Regulations Summary describes the log-removal credits for each technique.

Removal of solids in a media filtration system also needs to be accounted for in the design of the plant. Backwash water from the filters must be recycled back to the head of the plant which does not allow the solids trapped by the filters to be removed without an additional process step. Sludge removal via the pretreatment process is the only way to remove solids from the system. Sludge generated is removed while the operation is online, and the mixture generated typically has 1% or less solids, requiring a larger area to store and dispose of the sludge.

6.5.4.2.2 Membrane Filtration

There are four types of pressure membrane systems that are typically used in water treatment. These are Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF) and Reverse Osmosis (RO). Microfiltration is a low-pressure membrane process with the largest pore size membranes. Microfiltration can easily remove *Giardia lamblia* cysts and *Cryptosporidium* oocysts as well as other microorganisms, colloids, and high-molecular weight compounds. Ultrafiltration is another low-pressure membrane system that operates at a slightly higher pressure and has smaller pore size than MF. Since the membrane pore size is smaller, it can remove what MF can remove plus viruses. Nanofiltration operates at a much higher pressure than either MF or UF, but less than RO. NF is capable of removing hardness, pathogens, viruses, some dissolved organics, and organic color. RO is the membrane system with the smallest membrane pores and operates at the highest pressure. It is capable of removing most organic compounds and ions, all bacteria, viruses, microorganisms, and radionuclides. However, NF and RO are typically not used in surface water treatment due to relatively high cost, except in cases of brackish water supplies. For this project, MF and UF are the membrane systems that can replace conventional surface water treatment systems at a comparable cost. An example of a modular membrane unit is detailed in Figure 6.9 on the next page.

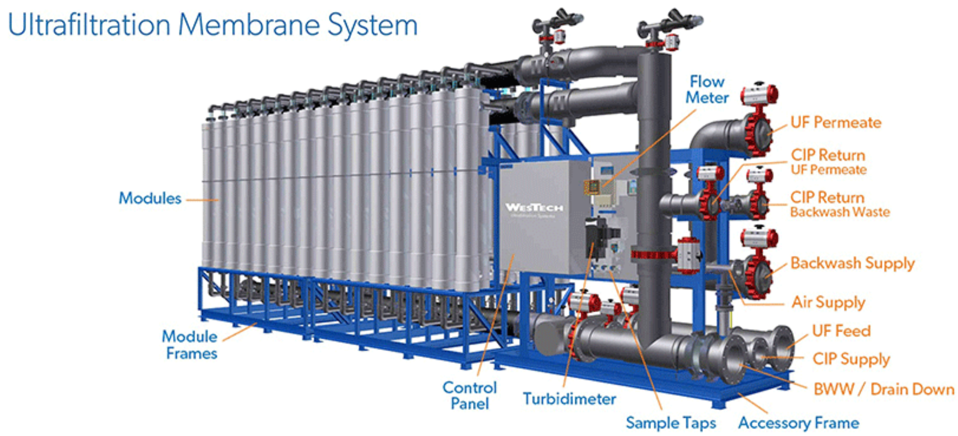


Figure 6.9 Example of UF Assembly (Image Courtesy of WesTech)

Microfiltration and ultrafiltration are hollow-fiber membrane systems that remove contaminants by physical straining (sieving). The membranes remove particulates by physical straining from the water the particles greater than the nominal pore size of the membrane. The UF membranes pore size (0.01 micron) is about one order of magnitude less than the MF pore size (0.1 micron). These membrane systems can be pressure-driven or vacuum-driven membrane processes that operate at low (5 to 50 psi) pressures and flux rates of 15 to 75 gallons/ft^2/day (gfd). Chemical conditioning of the raw-water feed is usually not required except where enhanced organics or pathogen removal is desired.

While the MF and UF systems are pressure driven, there are two basic configurations: modules mounted in pressure vessels operating under positive pressure and modules submerged in an open basin that operate under vacuum.

For the positive pressure system, the water is pumped through the membranes. For the vacuum system, the membrane is submerged in a metal or concrete tank and the water is pulled through the membrane by a pump. The submerged systems operate at a lower transmembrane pressure than do pressure systems.

Most membranes used in municipal water treatment are prepared from synthetic organic polymers. These membranes include those supplied by USFilter/Memcor, Zenon, Pall, Kock, and Norit. Inorganic membranes are available, such as the NGK ceramic membranes supplied by Kruger. Although the ceramic membrane is more expensive than the other MF and UF membranes, it does offer the following advantages:

- High flux rates (greater than 100 gfd)
- Direct filtration of high turbidity water
- Long membrane life
- High water recovery
- Minimized Clean-in-Place (CIP) requirements.

CIP involves soaking the membranes in caustic and acid solutions to remove accumulated contaminants not removed by the normal backwash process.

The general operation of the membrane types discussed is basically the same. Particulates, microorganisms, and colloidals are filtered from the water by the membrane. As more and more material is removed from the water, the operating pressure increases, so periodically the system is backwashed to remove the filtrate and return it back to original operating conditions. In addition to the normal backwashing, membranes need to be periodically cleaned chemically to remove any scale or particulate matter that is not removed with normal backwash. Some systems use a daily maintenance wash in which sodium hypochlorite is used. In addition to the maintenance wash, a CIP is used about every month to remove the accumulated organic and inorganic scales. Normally citric acid, caustic and a surfactant are used to soak the membranes during the CIP operation.

"For the purposes of compliance with the LT2ESWTR, membrane filtration is defined as a pressure- or vacuum-driven separation process in which particulate matter larger than 1 μm is rejected by an engineered barrier primarily through a size exclusion mechanism and which has a measurable removal efficiency of a target organism that can be verified through the application of a direct integrity test (40 CFR 141.2)." [12]

For surface water treatment, membrane filtration falls under the "Alternative Filtration Techniques" and microorganism removal credits are granted based on challenge testing. Some states do give initial design credits for membrane systems however Montana does not. For reference, California provides log credits based on previous challenge tests done by manufacturer and model of membrane systems (See CA SWTR AFT Membrane Filtration Summary Tables). According to their results, all UF membranes achieved 4-log removal of *cryptosporidium* and *giardia* with virus removal varying.

According to the EPA LT2ESWTR: Toolbox Guidance Manual, "a membrane filtration processes could potentially meet the Bin 4 *Cryptosporidium* treatment requirements."

Membrane systems can utilize a smaller membrane system to polish the backwash from the primary membrane filters. When this system is backwashed, the generated mixture is sent to the established disposal method. Due to the remote location of the proposed WTP, waste lagoons should be built so the water from the backwash mixture can be evaporated.

6.5.4.2.3 Preferred Filtration Alternative

Both conventional filtration and membrane filtration can be used at the proposed Fort Peck WTP. The advantages and disadvantages of membrane filtration compared with conventional media filtration are summarized in this section.

6.5.4.2.3.1 Advantages

The advantages of the membrane process are:

- Membranes provide a positive barrier for the removal of all microbials and most pathogens, which increases the flexibility of the system to meet future regulations.
- The overall footprint for the facility is smaller than conventional surface water treatment processes.

[12] EPA Membrane Filtration Guidance Manual

- The overall treatment process modular and easy to expand by adding cartridges or skids.
- With the automation of the process and the entire plant, the operational personnel requirement is lower.
- Less pretreatment is required, only presedimentation basins, versus the coagulation/flocculation and sedimentation process.
- Less chemical is required, no flocculant and less or no coagulant.
- The operation of the facility is flexible to accommodate changing raw water quality.

The advantages of the Conventional treatment process are:

- It is a proven process with many years of experience.
- Will not generate CIP waste stream

6.5.4.2.4 Disadvantages

The disadvantages of the membrane process are:

- Membranes are proprietary thus replacement parts are likely sole source. Would need to consider a negotiated guaranteed price for replacement parts.
- Membrane treatment systems traditionally require approximately 2.5 percent more power consumption compared to conventional filtration.

The disadvantages of Conventional treatment are:

- Conventional filtration relies on chemical destabilization of particles for pathogen removal and is not as reliable as membrane treatment.
- Greater chemical usage and annual operating costs.

In evaluating Conventional (Media) Filtration versus Membrane Filtration for the Fort Peck WTP, the main consideration for selecting a filtration method is compliance with LT2ESWTR. Without significant data of the *cryptosporidium* concentration in the Fort Peck water source, selecting the most robust filtration method is key to DRWA achieving their treatment goals. Another point to consider is after the first round of sampling, another sample set must be recorded in six years according to the LT2 Rule. If the concentration of *cryptosporidium* changes significantly, the bin classification can also change.

Conventional filtration by itself is only adequate up to a Bin 2 classification, and even in Bin 2, more stringent operational goals or additional treatment enhancements are required. If Fort Peck were to fall into Bin 3 or 4, additional capital would be required for additional treatment techniques, UV disinfection or similar, on top of conventional filtration. Including UV disinfection with conventional filtration would increase the power consumption of that alternative to be on par with the power consumption of membrane filtration.

Membrane filtration provides the most flexibility in the removal efficiency of *Cryptosporidium*. Challenge testing is required before the removal credits are granted in Montana however references from other states show removal credits for Bin 2 are easily obtained. If the LT2 Rule testing comes back with a Bin 3 or 4 classification, certain control techniques can be implemented in tandem with membrane filtration that would not require significant additional capital investment.

Based on the simplified pretreatment requirements, the smaller facility footprint, and ability to more easily meet current and future regulatory requirements and water quality goals, membrane filtration was selected as the preferred filtration treatment alternative.

6.5.5 Disinfection

Disinfection is the primary means of controlling microorganisms in the source water that are not removed by the filtration process and can cause harm to the end users in significant quantities. In water treatment plants, the disinfection process is normally achieved one of three ways; addition of halogenation chemistry (chlorine), UV and ozone. The downside of UV and ozone is there are no residual disinfection capabilities for the distribution system and therefore are generally not used in rural water systems as a primary means of disinfection, and are therefore not included herein for further consideration.

6.5.5.1 Chlorine

Chlorine has many attractive features that contribute to its wide use in the industry. Chlorine effectively inactivates a wide range of pathogens commonly found in water, it leaves a residual in water that is easily measured, it is economical, and it has an extensive track record of successful use for improving water treatment operations. Many utilities use chlorine because it helps to prevent algal growth, enhances taste and odor control, oxidizes iron, manganese and sulfides, enhances color removal, helps to maintain water quality in the distribution system, and helps to maintain treatment plant infrastructure (particularly filter media). Chlorine is the preferred method of disinfection by the Montana Department of Environmental Quality.

Disadvantages of using chlorine include the formation of halogenated disinfection byproducts (THMs and HAA5s, which are regulated, and many others that are not regulated) and taste and odors due to chlorine overdose. Chlorine does not inactivate Cryptosporidium within typical doses and contact times available in water treatment plants. Safety requirements associated with chlorine can require special technologies and management plans.

Chlorine for use in drinking water is available as a gas, liquid or solid. All three forms of chlorine are fed into the drinking water process stream as a solution, with the concentration of that solution varying between applications. Hypochlorous acid (HOCl) and hypochlorite ion (OCl^-) are the active chemical forms of chlorine that disinfect. The chemical reactions that occur for each form of chlorine have some impact on treatment because they affect pH, but the disinfection strength is the same for all forms at the same free chlorine concentration.

The typical sources of chlorine are chlorine gas and sodium hypochlorite (NaCOl / bleach). Solid hypochlorite is also an option that is available and could be useful for initial phases of the project. AWWA surveyed several water providers[13] in 2017 and the types of free chlorine used are listed below in Figure 6.10.

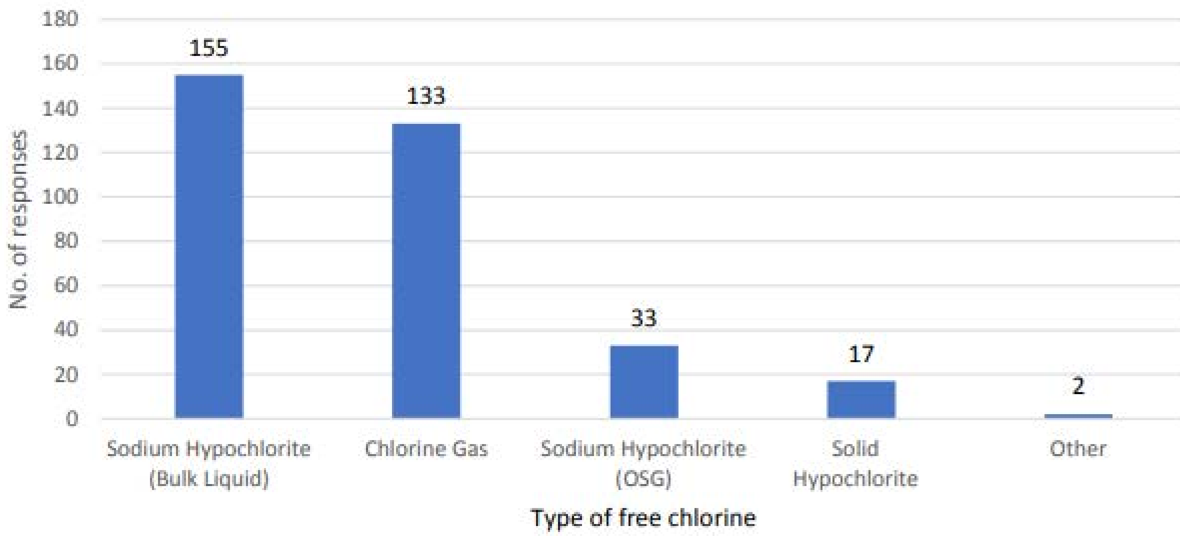


Figure 6.10 Sources of Free Chlorine, AWWA 2017

6.5.5.2 Gaseous Chlorine

Chemically, chlorine gas hydrolyzes rapidly in water to form HOCl. The following equation describes the hydrolysis reaction:

$$Cl_2(g) + 2H_2O \rightarrow 2HOCl + 2H^+$$

Note that the addition of chlorine gas to water reduces the pH of the water due to the production of hydrogen ion.

Hypochlorous acid is a weak acid (pKa of about 7.5) which means it does not dissociate completely at typical pH levels in water.

$$HOCl \leftrightarrow H^+ + OCl^-$$

[13] AWWA 2017 Water Utility Disinfection Survey Report

Between a pH of 6.5 and 8.5 this dissociation is incomplete and both HOCl and OCl^- species are present to some extent. At pH 7.5 and 20°C, the two species will be present at about a 50:50 ratio. Below a pH of 6.5, no dissociation of HOCl occurs, while above a pH of 8.5, complete dissociation to OCl^- occurs. The relative fractions of the two species as a function of pH are shown in Figure 6.11. As the germicidal effect of HOCl is much higher than that of OCl^-, chlorination at a lower pH is preferred and the disinfection credit tables in the Surface Water Treatment Rule reflect this difference.

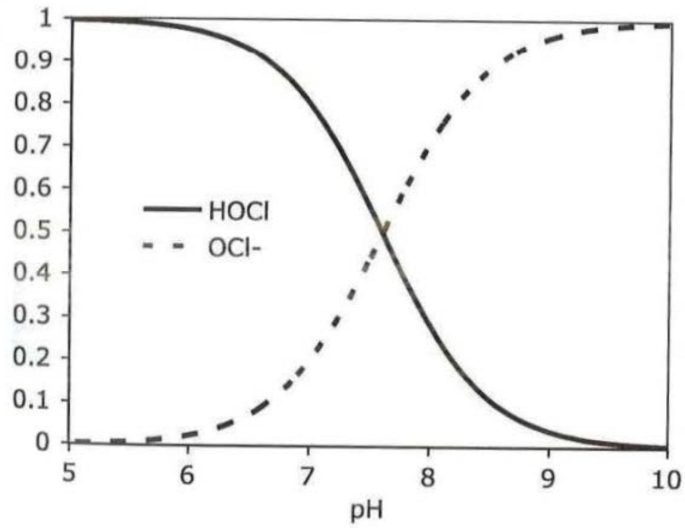


*Figure 6.11 Effect of pH on Relative Amount of Hypochlorous Acid and Hypochlorite Ion at 20*C (Ref: Edzwald)*

6.5.5.3 Feed System

Chlorine gas is typically evaporated from liquid to gaseous chlorine prior to metering. Once the compressed liquid chlorine is evaporated, chlorine gas is fed under vacuum until dissolved in water. Either an ejector or a vacuum induction mixer can be used to create the required vacuum.

DEQ requires a positive displacement gas feed system to be provided. Due to the essential role of disinfection, complete redundancy of the largest feed unit must be provided. Additional items required include:

- Gas cylinder scales
- Available space for 30-days' worth of storage
- Proper ventilation of the feed system and HVAC in the storage room
- NIOSH and OSHA approved personal protective equipment (PPE) and emergency shower/eye wash (ESEW) stations
- A bottle of ammonium hydroxide, 56 percent ammonia solution, must be available for chlorine leak detection. Where ton containers are used, a leak repair kit approved by the Chlorine Institute must be provided, or if pressurized chlorine gas is present, continuous chlorine leak detection equipment is required and must be equipped with both an audible alarm and a warning light.
- The feed system must be located in an area to prevent chlorine gas feed lines from exiting beyond the chlorinator room

The location of the chlorine gas feed and storage room has many specific requirements required by DEQ. These requirements include the proper location of the storage area so it may be properly secured and easily inspected from outside the storage area.

Public safety must be addressed by locating the storage facility on the prevailing downwind side of the building away from entrances, windows, and other ventilation. If the DEQ requirements cannot be met, the utility must apply for a variance.

6.5.5.4 Pros and Cons of Gaseous Chlorine

Safety issues surrounding gas chlorine arise from the fact that the gas is poisonous. Fire codes typically regulate the storage and use of all forms of chlorine. In the case of chlorine gas, automated shut-off valves are required by the International Fire Code (IFC) 2009. Facilities that store more than 2,500 pounds of chlorine are required to meet Process Safety Management standards under Occupational Safety and Health Administration (OSHA) requirements and the Risk Management Program Rule, administered by EPA under the Clean Water Act. In previous standards the State reserved the right to review the need for neutralization on a case-by-case basis.

Aside from the risk of spills, another risk in using gas chlorine is that the product may become less readily available if the federal regulations put enough pressure on the chlorine industry or chemical distribution companies decide not to handle chlorine gas anymore. The latter was the case for one Billings Montana distribution company that now needs to get containers trucked from Denver to distribute.

On the positive side, gas chlorine is typically the least expensive form of chlorine.

6.5.5.5 Sodium Hypochlorite – Bulk or On-site Generated

Sodium hypochlorite is produced when chlorine gas is dissolved in a sodium hydroxide solution. Commercially produced sodium hypochlorite solution typically contains 12.5 percent available chlorine. One gallon of 12.5 percent sodium hypochlorite solution contains the equivalent of one pound of chlorine.

Dilute sodium hypochlorite solutions can be generated electrochemically on-site from salt brine solution. On-site generated sodium hypochlorite is typically produced at 0.8 percent strength and contains 0.07 lb of equivalent chlorine per gallon of solution. To generate each pound of chlorine in solution, 3.5 lb of salt and 2.5 kW-hr of electricity are required.

The reaction between sodium hypochlorite and water produces hypochlorous acid, similar to chlorine gas hydrolysis. However, unlike chlorine hydrolysis, the addition of sodium hypochlorite to water yields a hydroxyl ion that will increase the pH of the water.

$$NaOCl + H_2O \rightarrow HOCl + Na^+ + OH^-$$

Sodium hypochlorite degrades over time with solution stability dependent on the hypochlorite concentration, the storage temperature, and the length of storage time. The degradation of sodium hypochlorite is catalyzed by the impurities of the solution and exposure to sunlight. Sodium hypochlorite decomposition weakens the solution, which affects the feed rate and dosage over time. Sodium hypochlorite is a corrosive chemical, so the system design must take this into consideration. Higher concentrations of hypochlorite solutions are unstable, so the storage tanks must be vented properly. Dilute hypochlorite solutions produced by on-site generation systems are more stable than the bulk 12.5 percent solution.

6.5.5.6 Bulk Sodium Hypochlorite Feed System

Bulk sodium hypochlorite is typically stored on site in bulk storage tanks in the delivered strength (12.5 percent solution) and then diluted into secondary tanks for storage. Dilution tends to reduce problems associated with off-gassing of hypochlorite solutions and reduces the building requirements in terms of classification. With a 12.5 percent solution the storage area would need to be sprinkled and the ventilation increased. But the choice of whether to dilute on delivery must also include considerations for tank sizing and available space to store adequate amounts of solution. Diluted to a 6 percent solution, the approximate average usage at 4 MGD would equate to 200 gal/day. DEQ recommends 30 days of storage for bulk sodium hypochlorite and a day tank with a volume of storage no larger than 30 hours. Storage beyond 28 days of a solution above 6% is not recommended since high strength sodium hypochlorite decays with time.

6.5.5.7 On-Site Generation Sodium Hypochlorite Feed System

In on-site generation, brine solution (NaCl) is used as the chloride source. Salt is dissolved with softened water to form a concentrated brine solution. This solution is then diluted and passed through the generation cell where electrolysis takes place as represented by the following formula:

$$NaCl + H_20 + 2e^- = H_2 + NaOCl + NaCl$$

The final product contains approximately 8,000 ppm (0.8 percent) sodium hypochlorite. The system is self-regulating, so cell output and electrical efficiency are maximized. The hydrogen gas produced during electrolysis is safely and conveniently vented to avoid any local area build-ups. With an on-site generation system, only the required quantities of hypochlorite solution are produced. Approximately two days of solution storage volume (based on design maximum day usage) are provided in a typical system design. The hypochlorite generation system includes a water softener and cleaning system for periodic electrolytic cell cleaning. A general schematic of an onsite hypochlorite generation system is shown in Figure 6.12.

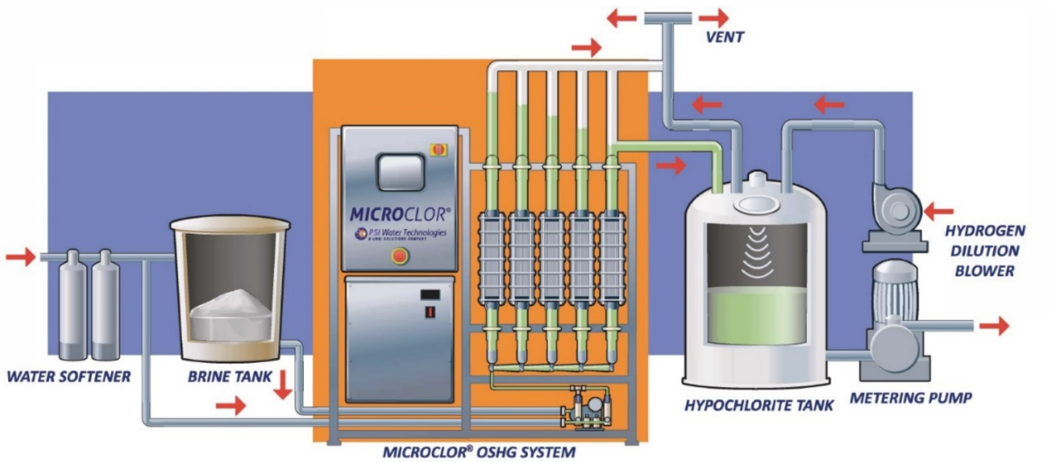


Figure 6.12 Onsite Hypochlorite Generator System Schematic (Graphic Courtesy of PSI Water Technologies)

To generate dilute sodium hypochlorite solution, two 100-lb/day hypochlorite generators are required. One 5-ton (1,000-gal 30% NaCl) FRP salt brine storage tank would provide 30 days storage of salt at the average monthly flow. In addition, one and a half days of storage of 0.8 percent sodium hypochlorite solution is provided in two 1,200-gallon FRP tanks. Dilute hypochlorite feed piping can be PVC.

Provisions are included at the solution storage tanks to accept commercial grade sodium hypochlorite as an alternative source of hypochlorite solution in the event that the generators are out of service. A dilution assembly should be provided at the storage tanks to convert commercial grade hypochlorite 12.5% concentration to the design feed concentration of 0.8 percent.

6.5.5.8 Pros and Cons of Sodium Hypochlorite

Hypochlorite use is known to produce chlorate, perchlorate and bromate. Bromate is currently limited to 10 μg/L in drinking water, while perchlorate and chlorate are not currently regulated, and future regulatory levels are unknown. Recent research results (Stanford, B.D., et al, JAWWA, June 2011) have demonstrated that typical sodium hypochlorite systems contribute very small amounts of perchlorate and bromate to finished water, but that chlorate levels can be significant.

Not all hypochlorite systems will create a chlorate issue, but it is a factor to consider comparing gas chlorine to sodium hypochlorite. Dilute solutions are less likely to produce perchlorate and chlorate, so the practice of diluting 12.5 percent sodium hypochlorite to a 6 percent solution on delivery, can reduce the formation of these degradation products. Storage at a lower temperature reduces the rate of perchlorate formation – for every 5°C reduction in storage temperature the formation of perchlorate is reduced by a factor of 2. Concentrated solutions of hypochlorite stored at high pH (11 to 13) slow decomposition and the formation of chlorate but could have an adverse effect on treated water pH.

Since on-site generated solutions are often at a pH of 9-10, they should be used as soon as possible and not be stored more than one or two days. Extended storage times should be avoided for all types of hypochlorite solutions because hypochlorite (bleach) will naturally decompose to produce oxygen, chlorate, and perchlorate. Fresh solutions contain a higher concentration of hypochlorite, thus reducing the amount of solution required to meet a target chlorine residual and reducing the contaminant concentration in the finished water. On-site generation systems should use high purity salt to minimize the amount of bromide in the brine, and thus the amount of bromate formed

6.5.5.9 Calcium Hypochlorite

Calcium hypochlorite is produced commercially as a solid and is formed from the precipitate that results from dissolving chlorine gas in a solution of calcium oxide (lime) and sodium hydroxide. Granular calcium hypochlorite typically contains 65 percent available chlorine. This means that 1.5 pounds of calcium hypochlorite contains the equivalent of one pound of chlorine. The reaction between calcium hypochlorite and water produces hypochlorous acid, similar to the other forms of chlorine, as shown in the following reaction:

$$Ca(OCl)_2 + 2H_20 = 2HOCl + Ca^{++} + 2OH^{-}$$

Similar to sodium hypochlorite, calcium hypochlorite reacts in water to yield hydroxyl ions that will increase the pH of the water.

Calcium hypochlorite is most often fed by way of a tablet feeder, in which solid tablets are dissolved in a tank fed by a sidestream of water to create a calcium hypochlorite solution.

The solid chemical must be stored in a cool, dry place because it reacts with moisture and can lose strength over time. Under normal storage conditions, calcium hypochlorite loses 3 to 5 percent of its available chlorine in a year, so it is essential to avoid using chemical that has been in storage for long periods of time. Although they do degrade, it should be noted that the tablets are more stable than liquid hypochlorite. Depending on the quality of the dilution water, calcium carbonate precipitate may form in a calcium hypochlorite solution; therefore, an antiscaling chemical may be needed.

Typically, tablet feeders are used for smaller treatment plants, as the maximum production of existing feeders is approximately 35 lb/hr of chlorine. These feed rates would fit with the proposed Fort Peck WTP. An example calcium hypochlorite feed system is shown in Figure 6.13.

Figure 6.13 Calcium Hypochlorite Feed System

6.5.5.10 Chloramines

6.5.5.11 Formation of Chloramines

The formation of chloramines in water depends on two sets of chemical reactions, one when chlorine is dissolved in water and the second when ammonia is added. Whether chlorine gas, sodium hypochlorite or calcium hypochlorite is dissolved in water, HOCl is formed, resulting in both HOCl and OCl^- being present in the water in proportions dependent on pH.

When ammonia is added to water that contains free chlorine, regardless of the speciation of chlorine, chemical reactions take place which form one or more species of chloramine.

The formation of different forms of chloramine is highly dependent on pH and the chlorine to ammonia-nitrogen dose ratio expressed as weight: mg/L chlorine to mg/L ammonia measured as nitrogen (Cl_2:NH_3-N), and to a lesser degree on temperature and contact time.

$$HOCl + NH_3 \rightarrow NH_2Cl + H_2O \qquad \text{monochloramine}$$

$$NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O \qquad \text{dichloramine}$$

$$NHCl_2 + HOCl \rightarrow NCl_3 + H_2O \qquad \text{nitrogen trichloride (or trichloramine)}$$

Theoretically, chloramines form and remain semi-stable when even small amounts of ammonia are present along with free chlorine. The total chlorine residual will largely be in the form of monochloramine with trace dichloramine present at near neutral pH. Dichloramine forms in increasing concentrations as pH values decrease below about 8. Nitrogen trichloride is typically not present in significant quantities unless pH values are less than 4. Under typical chloramination treatment conditions, a Cl_2:NH_3-N range of 3:1 to 5:1 result in monochloramine being the dominant species formed.

Temperature influences both reaction rates and nitrification potential. At 25°C, the reaction to form monochloramine takes only seconds; however, at 0°C this same reaction takes about 5 minutes. Nitrification tends to occur at water temperature in excess of 18 to 20°C, but it has been reported at temperatures as low as 10 to 13°C.

Using chloramines for disinfection requires an understanding of the theoretical breakpoint curve to be able to control the Cl_2:NH_3-N ratio in the range where disinfection is optimal. The breakpoint curve is a graphic representation of chemical relationships between total chlorine concentration, total ammonia concentration and the Cl_2:NH_3-N ratio. A detailed discussion of the theoretical breakpoint curve can be found in Appendix 6.15.

6.5.5.12 Ammonia Feed System

Ammonia can be supplied as liquid anhydrous ammonia, as aqua ammonia, or a solid form ammonium sulfate. Anhydrous ammonia is a gas but can be easily liquefied, so it is usually stored and shipped in pressurized cylinders similar to chlorine gas. Anhydrous ammonia is typically fed through ammoniators to form a solution that is pumped to the treatment process, similar to gaseous chlorine feed. This type of system has the same safety issues as a gas chlorine system so recent installations generally do not use anhydrous ammonia.

Aqua ammonia is very soluble in water and is therefore commercially available in solution strengths between 20 and 30 percent aqua ammonia. It is usually dissolved in deionized or softened water and stored in low-pressure tanks. The vapor pressure of 30 percent aqua ammonia is greater than 1 atmosphere (atm), requiring storage in a pressurized tank. A 20 percent aqua ammonia solution has a vapor pressure less than 1 atm, so low- pressure storage is acceptable, and most applications use this concentration. Steel and fiberglass tanks are both used in water treatment. Typical installations include a bulk storage tank, a day tank and metering pumps. The ammonia storage and feed facilities must be kept separate from hypochlorite facilities in order to comply with regulatory requirements.

Ammonium sulfate is a salt available in 50-lb sacks and similar to calcium hypochlorite is also fed via a tablet feeder.

The solid ammonium sulfate salt is dissolved in a tank fed by a sidestream of water to create a solution and then dosed into the process stream. The benefits of ammonium sulfate for remote locations are the material itself is not considered hazardous and is extremely stable. No extra precautions are necessary for shipping or storage, and it has an almost indefinite shelf life if stored under the proper conditions.

Disinfectant control in chloraminated systems can be accomplished using a compound control loop to feed chlorine according to flow rate, allowing adjustments to compensate for changes in chlorine demand to ensure a consistent chlorine residual at the point of ammonia addition. Ammonia can then be added at a rate proportioned by flow at the ammonia feed location, or a second compound control loop may be used to control ammonia feed.

6.5.5.13 Pros and Cons of Chloramines

Chloramines have some advantages over free chlorine as a residual disinfectant. Chloramines have a lower odor threshold than free chlorine, so they can be fed at a higher concentration without consumer complaint. They are more effective in controlling growth on pipe surfaces and are generally more stable, and therefore longer lasting in the distribution system. Chloramines greatly reduce the formation of disinfection byproducts (DBPs), thus reducing DBPs at the extent of the distribution system.

Chloramines are subject to destruction by biological nitrification, particularly in warm water and when excess ammonia is used (thus requiring close control of chlorine to ammonia ratios). A steep learning curve exists for operations staff that has never managed chloramine formation before. If excess nitrogen exists in the distribution system, nitrification can be aggravated, moving from minor to major nitrification episodes. When nitrification occurs, residuals are often reduced to near zero. Recent evidence has shown that use of chloramines can result in the formation of low levels of nitrosodimethylamine (NDMA), one of a group of chemicals referred to as nitrosamines, which are known to be cancer-causing agents.

NDMA and other nitrosamines are currently under consideration by EPA for regulation at levels that are not yet defined. Some of the conditions that instigate NDMA formation, such as a high chlorine-to-ammonia ratio, are the same things that discourage nitrification.

Disinfection contact time credit is normally obtained using free chlorine prior to ammonia addition because the CT requirements for inactivation of *giardia* and viruses with chloramine are very high (>5x higher) and not realistically reached within the contact time available in most plants.

6.5.5.14 Preferred Disinfection Alternative

Chlorine disinfection is recommended for the control of microorganisms and obtaining required disinfection contact time. Due to the projected size of the DRWA distribution system, chloramine is recommended for residual disinfectant, based on stability and the reduction of the formation of DBPs.

Based on the overall stability of the chemical, storage requirements, and ease of handling, calcium hypochlorite was selected as the preferred chlorine disinfection alternative.

Calcium hypochlorite provides an easier means of shipping to the remote WTP site, it will last longer stored onsite, and will require less tankage, equipment and facilities to use. The proposed tablet feeder provides a relatively simple means of chemical make down and dosage.

Similarly, ammonium sulfate was selected as the preferred chloramine (ammonia) residual disinfectant. It provides overall chemical stability, ease of handling and simplified make down and dosage systems compared to liquid or gaseous ammonia. It also provides an easier means of shipping to the remote WTP site.

6.5.6 Alternatives for Ancillary Treatment

In addition to the three basic treatment categories discussed above: pretreatment, filtration, and disinfection; other ancillary treatment units and/or chemicals may be needed to achieve the treatment goals such as chemical addition for coagulation, filter aid, or pH adjustment and control. The ancillary treatment units and chemicals appropriate to membrane filtration are incorporated into the two treatment alternative discussed in the following section.

6.5.7 Proposed Membrane Filtration Treatment Process

Based on the source water sampling results, the stated DRWA water quality goals, and reviewing the various treatment technologies previously discussed the Membrane Filtration treatment alternative is recommended as the preferred treatment alternative for the Fort Peck WTP. Additional details, proposed WTP and site layouts and an opinion or probable construction costs associated with the Membrane Filtration Treatment Plant are further discussed herein. Preliminary major equipment information associated with the proposed Fort Peck WTP including budgetary cost data is included in Appendix 6.16.

6.5.8 Membrane Filtration Alternative

A process flow diagram outlining the proposed Membrane Filtration Alternative is included in Figure 6.14. A summary of the design conditions associated with the proposed Fort Peck WTP are included in Table 6.9.

6.5.8.1Presedimentation Basins

Two approximately 4.0 acre each pre-sedimentation basins are proposed. The basins will provide approximately 56 million gallons of raw water storage onsite at the WTP, equal to approximately 12 days' worth of storage at full WTP capacity. The basin sizing was selected more to provide system resiliency in the event of an issue with the raw water intake or pumps than for process related reasons. Typical pre-sedimentation basin sizing is a minimum three-hour detention time. Based on the remote nature of the site it is assumed that response time to the intake, problem diagnosis, and sourcing replacement parts or materials could take on the order of magnitude of days to weeks to resolve. Maintaining enough raw water onsite at the WTP to account for intake issues was determined to be a priority. Although not observed during the raw water sampling period the pre-sedimentation basins would also provide raw water in the event the water quality deteriorates in Fort Peck for a short period of time. Common events that cause poor water quality are storm or excess spring runoff.

Currently the pre-sedimentation basins are estimated to be of earthen construction with a membrane liner, with construction costs estimated at $6.7 million dollars. In the event the project budget cannot support the full basin cost, the sizing could be adjusted to reduce overall cost, and the onsite storage volume.

Provisions will be provided to bypass the pre-sedimentation basins and send raw water directly to the Rapid Mix basin of the WTP. Due to the low source water turbidity no automatic means of sludge removal was considered, it is assumed that in the event of excessive solids buildup within the basins, one could be taken offline, and sludge removed manually. Additional design considerations for the pre-sedimentation basin facilities include a provisional coagulation dosage point, to aid in natural organic matter control, and a provisional chlorine dosage point at the inlet to the basins. Aeration equipment is also planned to aid in mixing and reduce the potential for algae formation. Under normal operation conditions water will flow by gravity from the pre-sedimentation basins to the Rapid Mix chambers, however a small pump station will also be provided, to allow for the full volume of the basins to be utilized in the event the need arises. A site plan of the proposed WTP campus layout is included in Figure 6.15.

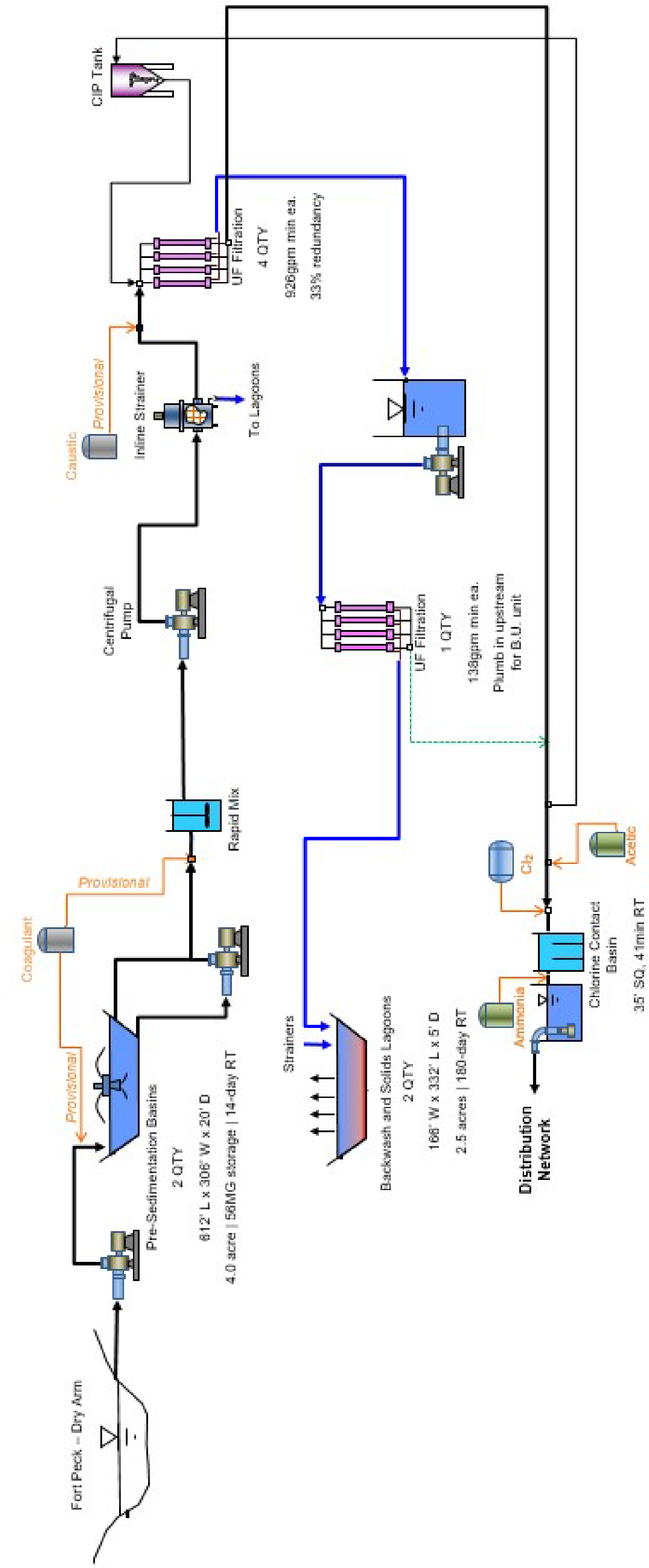


Figure 6.14 Proposed Membrane Filtration Process Flow Diagram

PROPOSED FORT PECK WTP – DESIGN PARAMETER SUMMARY	
Item	Value
WTP Design Flow	4.4 MGD
Pre-Sedimentation Basins (2):	
Storage (Total)	12 Days, 56.0 MG
Depth	20 ft
Area	4.0 acres each
Low Lift Pump Station:	
Number of Pumps	2 (1 working, 1 standby)
Pump Capacity	4.5 MGD
Rapid Mix (2):	
Inline Mixer (per basin)	15 HP
Mixing Intensity (G Value)	>700 second^{-1}
Detention Time	Min. 30 seconds per Basin
Dimensions	6.9 ft square x 8.7 ft deep
Filtration Membrane Train (4 Total, 3 Working, 1 Standby) Per Train:	
Design Temperature	1.0°C
Feed Pumps	4 (3 working, 1 standby)
Pump Horsepower	50 HP
Pre-Filter, Self Cleaning (3)	200μm
Modules per Train	51
Average Net Filtrate	3060 GPM
Water Recovery	95.8%
Backwash Interval	30 minutes
Recovery Membrane Train:	
Feed Tank	6,000 gal
Pump	1 working
Pre-Filter, Self Cleaning	200μm
Modules per Train	12
Average Net Filtrate	120 GPM
Water Recovery	90.5%
Backwash Interval	17 minutes
Membrane System:	
Overall System Recovery	99.6%
CIP Frequency (Estimated)	30 days
Chlorine Maintenance Wash Interval (Estimated)	36 hours
Backwash/Rinse Waste	18,500 gpd (Includes Strainer Allowance)
Backwash and Solids Lagoons (2):	
Storage	180 days, 4.0 MG
Water Depth	5 ft
Land Area	1.4 acres each

Chlorine Contact Basins (2):	
Giardia Log Removal	0.5
pH, Temperature, Cl_2	≤ 9.0, 0.5°C, 2 mg/L
Baffled, serpatine type, Baffle Factor	0.7
CT (Required)	83 min · mg/L
CT (Provided at Max Flow per Basin)	85 min · mg/L
Solid Hypochlorite / day	150 lb
Volume	187,000 gal
Dimensions	50 ft square x 10 ft deep
Finished Water Pumping:	
Number of Pumps	2 (1 working, 1 standby)
Pump Capacity	3350 gpm
Pump Horsepower	500 HP
Finished Water:	
Water pH Target	8.2
Solid Ammonium Sulfate / day	100 lb
Wet Well Retention Time	37 minutes

Table 6.9 Proposed Fort Peck WTP Process Design Summary

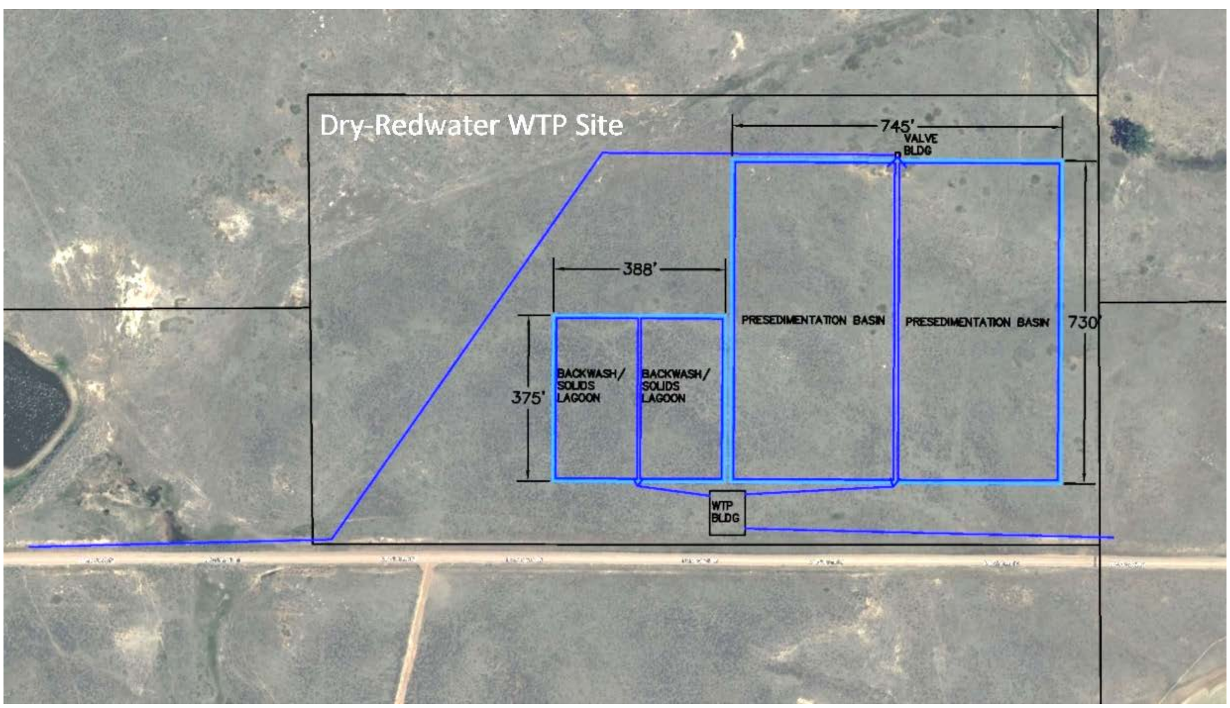


Figure 6.15 Proposed Fort Peck WTP Site Layout

6.5.8.2 Rapid Mix

Two rapid mix basins are planned, located in the lower level of the proposed WTP, conceptual location shown in Figure 6.16, and in the proposed Fort Peck WTP Basin Level floor plan shown in Figure 6.16. Each basin will be sized to provide a detention time of approximately 30 seconds with a mixing gradient value greater than 700. Basins will be configured to operate in parallel or in series, allowing one basin to operate at low plant flows, and the basins to be operated in series at high plant flows to achieve adequate mixing. A provisional coagulant dosage location will be provided upstream of the rapid mix basins. To facilitate proper mixing over a wider range of flows the rapid mixers will be provided with variable frequency drives to adjust the speed based on the incoming plant flow.

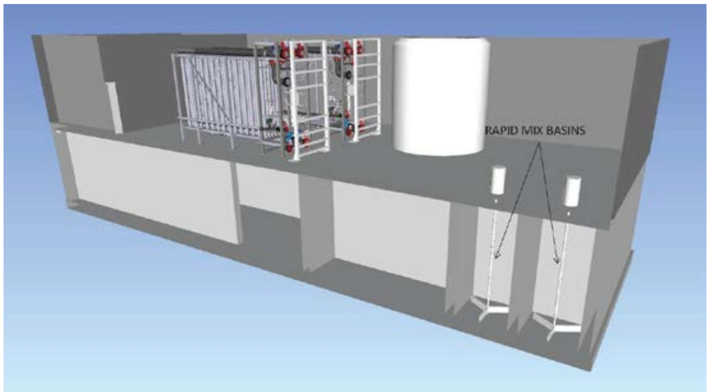


Figure 6.16 Conceptual Rapid Mix Basin Location

6.5.8.3 Membrane Feed Basin

After the Rapid Mix Basins flow travels to the Membrane Feed Basin. The intent of this structure is to provide storage volume upstream of the membrane filters to adjust for flow variations both on the WTP influent flow and membrane feed flow. The basin will also provide a relatively constant suction head for the membrane feed pumps. The proposed Membrane Feed Basin is shown in the Fort Peck WTP Basin Level floor plan in Figure 6.17.

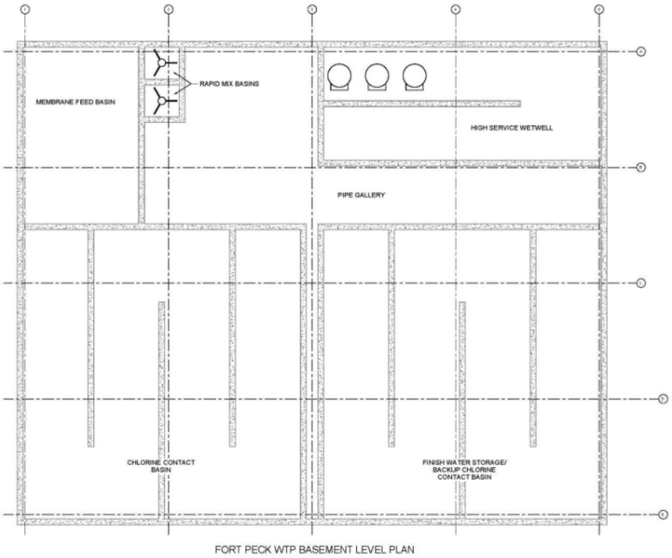


Figure 6.17 Proposed Fort Peck WTP Basin Level Floor Plan

6.5.8.4 Membrane Filtration Skids

Provisions are included for four Membrane Filtration skids, three duty skids and one standby unit. Each skid will have a minimum average net filtration capacity of 1030 gpm. A smaller Residuals Membrane skid with a minimum average net filtration capacity of 120 gpm minimum will also be provided. Conceptual Layout of the Membrane Filtration skids is shown in Figure 6.18 and on the Fort Peck WTP Ground Level floor plan Figure 6.19.

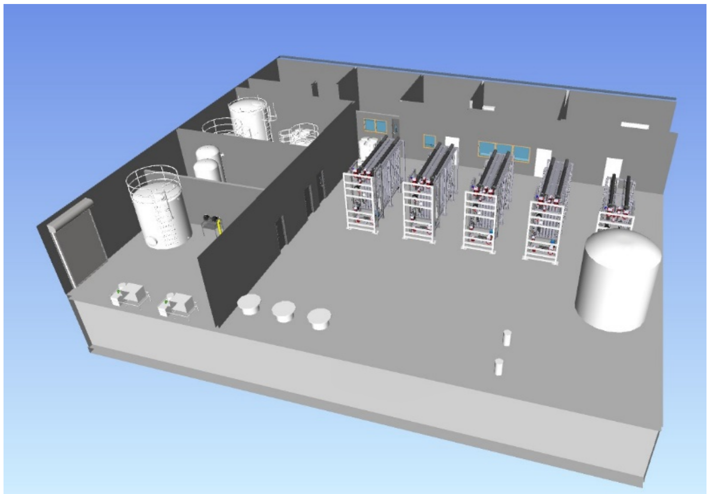


Figure 6.18 Conceptual membrane Skid Layout

Membrane feed pumps controlled by variable frequency drives will pump from the membrane feed basin through strainers and to the membrane modules. The fine-mesh strainers are required to protect the membranes from excess foulants and damage from larger particles. Mesh sizes will be based on recommendations from the membrane manufacturer. Newer strainers are designed to be self-cleaning to reduce the need for operator maintenance and the waste stream is sent to the backwash and solids lagoons. Each membrane skid will be equipped with a flow meter, a laser turbidimeter, and quick connections for a mobile particle counter. Membrane permeates (filtered water) will be injected with calcium hypochlorite prior to discharge to the chlorine contact basin.

Membrane filters will be backwashed at intervals from 20 to 60 minutes. Backwash water will be supplied from the clearwell or from the membrane feed pumps depending on the membrane manufacturers system. Backwash waste will be collected in a Backwash Tank. Backwash waste will be treated with an additional dedicated membrane skid called the Residuals Membrane skid to reduce the amount of wastewater generated by the membrane filters. Filtrate from the Residuals Membrane skid will discharge to the contact basin for disinfection and distribution as treated water. Piping will be configured with the flexibility to return backwash recovery filtrate to the rapid mix basins if needed. Backwash waste from the Residuals Membrane Skid will discharge to the backwash and solids lagoons for disposal.

All membrane units require compressed air to actuate valves on the membrane racks, and some manufacturers use additional air for scouring the feed side of the membrane during reverse flow with filtered water. It is anticipated that air compressors, dryers and receiver tanks will need to be included with the membrane filtration system.

The membranes will need to be cleaned occasionally to reduce the pressure loss across the membrane (transmembrane pressure or TMP). The type of cleaning chemical used will depend on the membrane units supplied. Cleaning is expected to be required approximately every 3 months. Waste from the cleaning system may contain acid, base, or chlorine. Cleaning waste will be discharged to the neutralization tank. pH will be monitored, and acid or base will be added while the tank is being mixed to neutralize the waste stream. Once neutralized, the waste will be pumped to the backwash and solids lagoons for disposal.

Chemical storage and feed facilities at the WTP will include calcium hypochlorite for disinfection and membrane cleaning and acetic acid for corrosion control, membrane cleaning and waste neutralization. Citric acid will also be delivered to the site in tote containers for membrane cleaning and waste neutralization. Depending on the membrane equipment manufacture, additional chemicals (such as detergents) could be needed on site for chemical cleaning. Dedicated clean-in-place tanks in addition to the other chemical feed systems will be provided for membrane cleaning. Potential layout of the chemical feed facilities is shown in the Fort Peck WTP Ground Level floor plan in Figure 6.19.

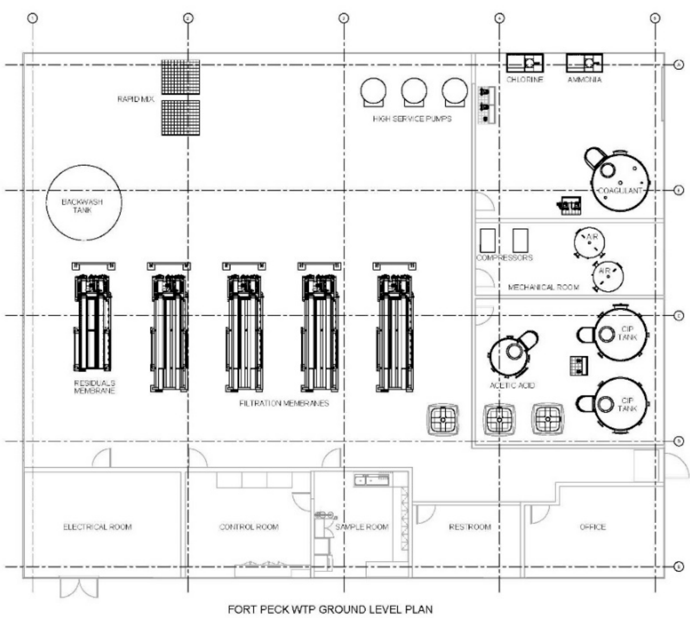


Figure 6.19 Proposed Fort Peck WTP Ground Level Floor Plan

6.5.8.5 pH Adjustment

Provisions are included for Acetic Acid dosage to the membrane skid discharge for pH adjustment as necessary. Acetic acid will be stored onsite in a bulk chemical tank and dosage controlled with a chemical metering pump.

6.5.8.6 Chlorine Disinfection

A tablet feed system for Calcium Hypochlorite will be provided for chlorine disinfection. As previously discussed, the base material is stable for long periods of time and more can be stored without the need for additional accidental release controls, making the required 30-Day supply of chemical easy to accomplish. Handling of the raw material is safer and there are lower risks from accidental exposure. The proposed feed system will have a rated capacity of 6.25 lb/hr, and the units typically have a wide turndown ratio, helping with change in flows from the change in seasons and ability to grow as the plant capacity increases. Plant water supply from the finished water distribution system will be utilized for chemical make down in the feeder. Metering pumps will control the flow to the requisite dosage points.

6.5.8.7 Chlorine Contact Basin

While the membrane filtration process has been shown to have 4-log removal amount for *giardia* (3-log required), a minimum of 0.5-log removal by free chlorine in the contact basin will be provided for a worst-case scenario, low temperatures with high flows at a pH of ≤ 9.0. The Chlorine Contact Basin is located in the basement level of the proposed Fort Peck WTP. Currently two identically sized basins are envisioned and will be piped such that either basin can function as the required Chlorine Contact Basin while the other basin would function as additional finished water storage. In the event future disinfection contact time is required, the basins could be operated in series to double the currently planned CT time. Figure 6.20 details the proposed Chlorine Contact Basin configuration.

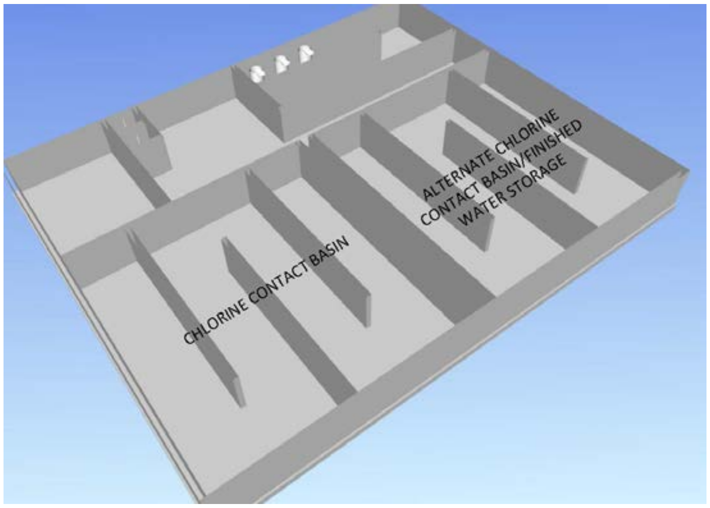


Figure 6.20 Proposed Fort Peck WTP Chlorine Contact Basin Configuration

6.5.8.8 Chloramine Residual Disinfection

After the chlorine contact basin, ammonia will be metered into the water to form chloramines for the long-term disinfection of finished water. Ammonium sulfate was selected for the ammonia source due to several benefits for small and remote systems. It comes in solid form and has a similar feed system to solid hypochlorite. No special storage requirements are needed for the solid. Solid ammonium sulfate is also very stable when properly stored and the shelf life is extremely long.

6.5.8.9 High Service Pumping

Finished water pumping will be from a finished water wet well, isolated from the raw water and chlorine contact basin per MT DEQ Circular 1. Pumping and storage of the finished water will be designed to keep upstream flows steady on the filter process and minimize excess storage to prevent water quality degradation. Pumps will be sized to full WTP buildout at 4.5 mgd and 400 FT TDH. It is anticipated based on system phasing that initially pumps will be smaller and additional pump configurations provided to meet developing system demands.

6.5.8.10 Residuals Handling

Two approximately 1.4 acre each Backwash and Solids Lagoons are provided. The lagoons will provide approximately 4.0 million gallons of residuals storage onsite at the WTP, equal to approximately 180 days' worth of anticipated generation. The intent is to provide adequate storage volume to store residuals for 6 months, the anticipated timeframe where temperatures are low enough to not provide adequate evaporation.

6.5.8.11 Facility Considerations

Excluding the Pre-sedimentation Basins and Backwash and Solids Lagoons all remaining process elements and chemical storage and feed equipment is housed in a single building. In addition, building space is provided for various support facilities, a Control Room, a small Sample Room for routine water quality analysis, Office, Restroom, Electrical and Mechanical Rooms. The main process elements, membrane skids, chemical feed equipment, and support facilities are planned to be at ground level, and the basement of the facility will house storage and treatment basins as previously described. The basement will be constructed of cast-in-place concrete, and the building is currently planned as a pre-engineered metal building, 80 ft. x 100 ft. in dimension. General preliminary floor plans for the upper and lower levels of the facility were previously detailed in Figures 6.19 and 6.20. Additional conceptual renderings of the proposed Fort Peck WTP are detailed in Figures 6.21-6.24.

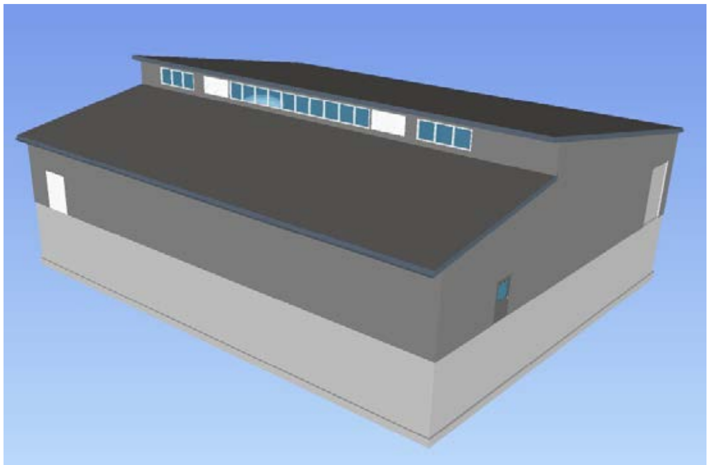


Figure 6.21 Conceptual Fort Peck WTP Exterior

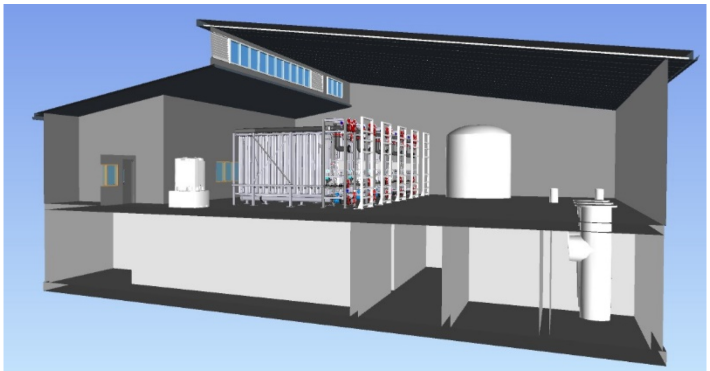


Figure 6.22 Conceptual Fort Peck WTP Section View

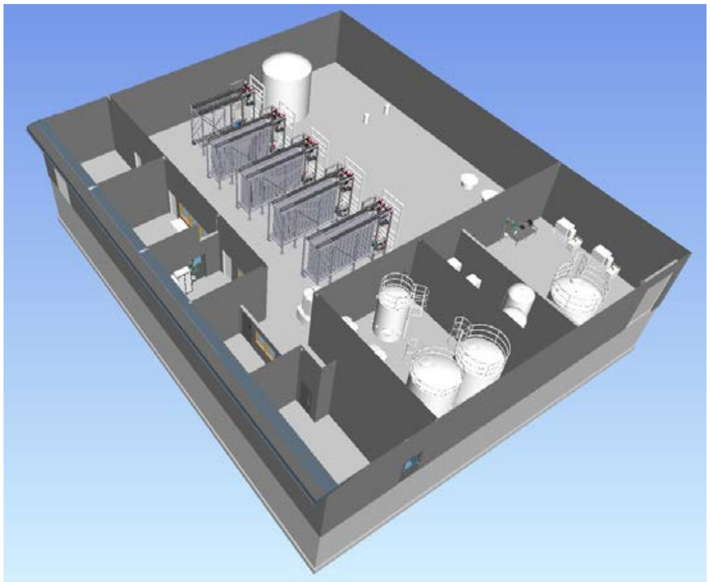


Figure 6.23 Conceptual Fort Peck WTP Interior

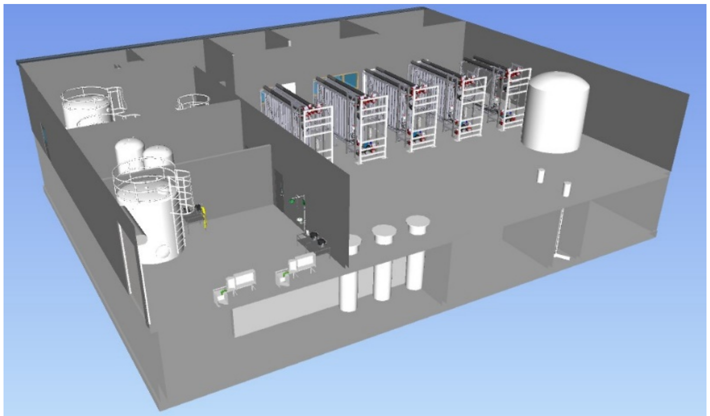


Figure 6.24 Conceptual Fort Peck WTP Alternate Section View

6.5.8.12 Water Quality Monitoring and Sampling

For LT2 Rule Bin Classification, 24 monthly samples need to be collected for turbidity, *Cryptosporidium* and *E. Coli*. The sampling program needs to be registered with the EPA and once the sampling is complete, the Bin Classification will need to be applied for by the water distributor.

During normal operation, influent online monitoring can include, but is not limited to, turbidity, pH, and temperature. Certain water samples for microorganisms, organic and inorganic chemicals may need to be sent to an outside lab for analysis. Tests on these samples can include Total Coliform Bacteria, arsenic, lead, selenium, and copper.

Monitoring of the filtration process should include turbidity of each filter, a combined filter turbidity and pressure decline across the filter. For the chlorine contact basin, free chlorine, temperature, and pH should be monitored online to ensure the proper CT for disinfection is being achieved.

Final effluent turbidity, total chlorine, and monochloramine should be monitored real-time and online options are available for each parameter. Grab samples for microorganisms, organic and inorganic chemicals, and DBPs should be collected per EPA regulations and a consumer confidence report will need to be issued for the constituents.

6.5.8.13 Opinion of Probable Construction Costs

A preliminary estimate of probable construction costs for the preferred Membrane Filtration treatment alternative are presented in Table 6.10. The preliminary estimate is based on general design criteria, significant known equipment cost estimates where available, and estimated quantities. No site-specific geotechnical data has been reviewed, earthwork costs included herein represent assumed conditions and do not consider adverse or challenging conditions or site soils that could be present. These are planning level costs and represent an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate. A Class 4 estimate is the standard of care for estimating construction costs during the feasibility and pre-design stage of a project. The accuracy of a Class 4 estimate in accordance with AACE guidelines is expected to be between 0.8 and 1.4 times the actual cost of the project. An estimated percentage for Contractor's overhead and project is included in the individual estimate line items. This estimate identifies construction costs only and does not include contingencies (design or construction related) or other ancillary project costs including engineering or other associated administrative costs, reference chapter 12 for estimated total project costs. This estimate does not represent extreme market fluctuations due to events which cannot be predicted.

DRWA Fort Peck WTP - Preliminary Cost Estimate				
Description	Qty	Unit	Unit Price	Total Price
Concrete - Division 3				
Cast-In-Place Concrete - Foundation/CT Basin/Wetwell	1000	CY	$1,875	$1,875,000
Metals - Division 5				
Pre-engineering Steel Building	8,000	SF	$125	$1,000,000
Misc. Metals/Supports/Grating Allowance	1	LS	$62,500	$62,500
Wood, Plastics, Composites - Division 6				
Carpentry- Room Partitions, Finish Work Lab/Office	1	LS	$187,500	$187,500
Openings - Division 8				
Doors & Frames - Single Door	11	EA	$5,000	$55,000
Doors & Frames - Double Door	2	EA	$7,500	$15,000
CT Basin/Clearwell Pump Hatch	2	EA	$6,250	$12,500
Overhead Exterior Door	2	EA	$12,500	$25,000
Window Allowance	1	LS	$62,500	$62,500
Finishes - Division 9				
Painting and Protective Coatings	1	LS	$125,000	$125,000
Plumbing Division 22				
Plumbing Allowance	1	LS	$62,500	$62,500
HVAC Division 23				
HVAC/Ventilation Allowance	1	LS	$437,500	$437,500

Description	Qty	Unit	Unit Price	Total Price
Electrical - Division 26				
Admin & Basic Requirements	1	LS	$31,250	$31,250
Wire, Cable, Grounding, Raceway, Boxes	1	LS	$187,500	$187,500
Transformer, Switchboard, Panelboard, Safety Switches	1	LS	$125,000	$125,000
Motor Control Center	1	LS	$81,250	$81,250
High Service Pump VFDs - 500 HP	2	EA	$93,750	$93,750
Building/Site Interior and Exterior Lighting	1	LS	$62,500	$62,500
Earthwork - Division 31				
Access Road & Parking - Gravel Surfacing	1	LS	$12,500	$12,500
Backwash Basins Excavation	26,000	CY	$9.70	$252,200
Backwash Basins Liner	180,000	SQFT	$2.80	$504,00
Pre-sedimentation Basins Excavation	280,000	CY	$9.70	$2,716,000
Pre-sedimentation Basins Liner	800,000	SQFT	$2.80	$2,240,000
Excavation for Building (0-20 feet)	4,000	CY	$9.70	$38,800
Exterior Improvements - Division 32				
Site Grading/Seeding	1	LS	$25,000	$25,000
Security Chain-link Fence	5280	LF	$50	$264,000
Security Chain-link Gate	2	EA	$3,125	$6,250
Utilities - Division 33				
Site Piping	1	LS	$75,000	$75,000
Holding Tank Allowance	1	LS	$18,750	$18,750
Process Interconnections - Division 40				
Flow Meter, Magnetic, 16-in	4	EA	$12,500	$50,000
SCADA- Antenna, Cable, Conduit	1	LS	$93,750	$93,750
Plant Controls & Instrumentation - PLC, PC, System Panels, Level/Pressure Instruments, Etc.	1	LS	$406,250	$406,250
Small Diameter Piping	350	EA	$20	$7,000
Fittings - Small Diameter Piping	1	EA	$2,125	$2,125
Medium Diameter Piping	180	EA	$315	$56,700
Fittings - Medium Diameter Piping	1	EA	$50,000	$50,000
Large Diameter Piping	220	EA	$245	$53,900
Fittings - Large Diameter Piping	1	EA	$137,500	$137,500
Turbidimeter, constant operation	3	EA	$8,000	$24,000
High Service Pumps - 3350 GPM/400 TDH	2	EA	$156,250	$312,500
Water Quality Sampling Equipment Allowance	1	LS	$93,750	$93,750

Description	Qty	Unit	Unit Price	Total Price
Process Liquid Handling, Purification, Equipment - Division 43				
Coag/Polymer Feed System -Dosing Pumps, Mixer, Tank/Tote	1	LS	$18,750	$18,750
Chlorine Feed System - Solid Hypochlorite Source	1	LS	$67,500	$67,500
Ammonia Feed System - Solid Ammonium Sulfate Source	1	LS	$118,750	$118,750
Package Compressed Air System - Included in UF System	0	LS	$ -	$-
Acetic Acid Feed System - Dosing Pumps, Mixer, Tank/Tote	1	LS	$18,750	$18,750
Water/Wastewater Preliminary Treatment Equipment - Division 46				
Lab Testing Equipment	1	LS	$56,250	$56,250
PreSed Basin Mixing	4	EA	$75,000	$300,000
Ultrafiltration Skid - Includes Feed, Backwash, CIP, Compressed Air, Piping/Valves	4	EA	$982,800	$3,145,000
Polish Ultrafiltration Skid - Includes Feed, Backwash, CIP, Compressed Air, Piping/Valves	1	EA	$988,200	$988,200
Backwash, Feed, CIP Tanks	4	EA	$10,000	$40,000
Subtotal				$17,574,400
Mobilization and Bonds (%)			6%	$1,054,500
Total Field Costs				$18,628,900

Table 6.10 Opinion of Probable Construction Cost Fort Peck WTP

6.6 Design Considerations for Fort Peck Reservoir Intake

6.6.1 Fort Peck Reservoir Intake Design Considerations and Alternative Evaluation

The purpose of this conceptual evaluation is to provide a planning-level comparison of potential intake alternatives to supply the proposed central Fort Peck Water Treatment Plant (WTP) for the Dry-Redwater Regional Water Authority (DRWA). Based on previous studies performed related to the DRWA system and the concept of a centralized Fort Peck WTP, the proposed intake was selected to be sited in the Big Dry Arm/Rock Creek area of Fort Peck Reservoir, see Figure 6.25 below.

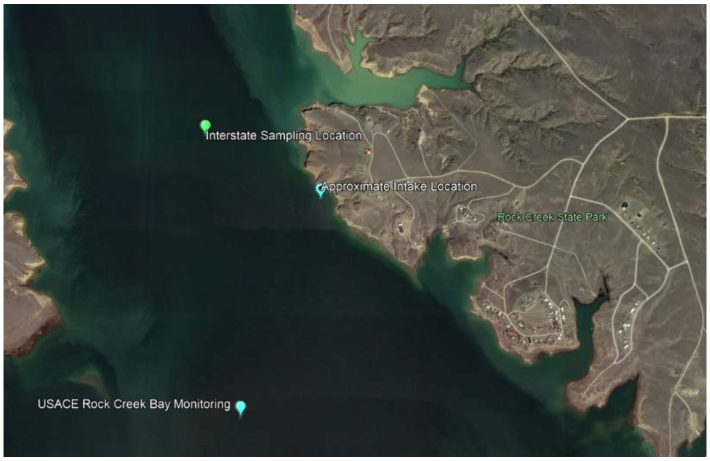


Figure 6.25 Satellite Picture of Potential Intake Location

The basic function of the intake/raw water delivery system is to withdraw water from the Fort Peck Reservoir and pump it to the new Fort Peck WTP via a raw water pipeline connecting the facilities. Water will flow by gravity from the river intake screen structure to the pumps which will provide sufficient pressure to overcome the elevation and friction losses within the raw water pipeline. Design criteria for the intake are established to address the following key areas:

- Adequate capacity throughout the operating level range of the Reservoir
- Velocity limitations specific to intake screen
- Intake location to minimize hazards due to debris and navigation
- Protection from problems due to ice
- Water quality
- Reliability

This section provides a review of raw water intake structure and screening alternatives relative to the proposed intake conditions and provides a recommended Fort Peck raw water intake and pump station configuration.

6.6.2 Fort Peck Reservoir Reliability

Fort Peck Reservoir was formed in the 1930's by the construction of Fort Peck Dam on the Missouri River. The Reservoir is approximately 134 miles long and has a maximum depth of 220 feet when full. Water level within the Reservoir is controlled by the U.S. Army Corps of Engineers (USACE) operations at the Fort Peck Dam. During normal operations USACE releases water from the Reservoir to generate power and balance reservoir levels for other uses. During periods of high runoff operations shift to reducing flood risks.

The full pool water level of Fort Peck Reservoir is 2234 feet above sea level and the winter pool elevation is 2197 feet, which reflects the low recorded water level of the reservoir. Any proposed intake structure must be capable of maintaining operations over the noted approximately 40-foot water surface fluctuation.

Figure 6.26 on the next page details water depths at full pool elevation for the area of the proposed intake. The intake draw-off location and elevation(s) must be located in an area with a depth greater than 40 feet of water depth to accommodate the variation from full to winter pool elevation.

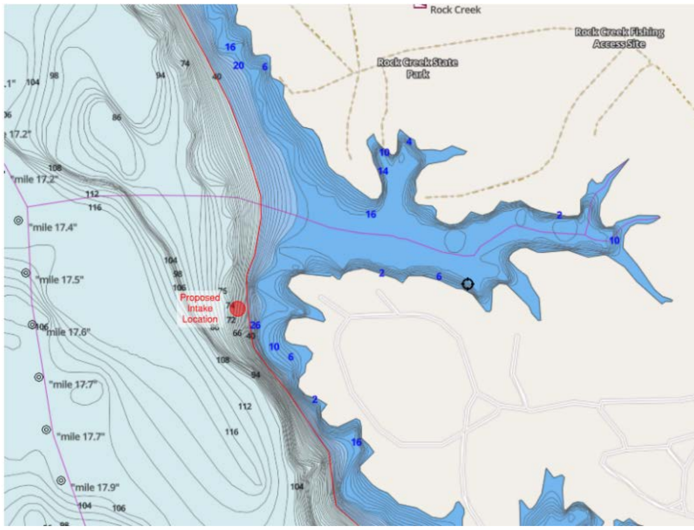


Figure 6.26 Fort Peck Reservoir Water Depths at Full Pool Elevation

Sampling of the Fort Peck raw water source occurred between July 2021 and June 2022, at a location in the Rock Creek Arm near the proposed water treatment plant intake. The sampling location is shown in Figure 6.25. An in-depth discussion related to the sampling efforts and results is included in Section 6.5.2 of this report, however related specifically to the proposed intake design, water quality samples were taken at varying depth, ranging from the surface to the lake bottom to evaluate the water quality throughout the entire water column.

One issue sometimes found with water sources from lakes or reservoirs is that the water quality can be significantly different at varying depths. Most detriments to water quality as depth changes are related to the temperature and oxygen content of the water.

Cold water has a higher dissolved oxygen capacity then warm water and as the capacity changes, certain inorganic chemicals can be released from the surrounding soils and rocks, mainly iron and manganese. While not part of the Primary Drinking Water Standards, iron and manganese are included in the Secondary Drinking Water Standards because of their aesthetic effects on the water. Iron and manganese removal requires additional capital and operating expenses at a WTP. Intake structures located in the water body are typically designed to allow the system operators to draw from different depths to select the most optimal water quality. In general, the raw water sampling results indicated the Fort Peck Reservoir is a good water source for the proposed DRWA Fort Peck WTP. Specifically related to the intake design, the sampling results also indicated very little fluctuation of raw water quality with respect to water depth. This element simplifies the overall intake design as multiple draw off elevations tailored to specific water quality at different depths and time of year is not required. Full sampling results are included in Appendix 6.14 for reference.

6.6.3 Intake Structure Alternatives

There are a multitude of raw water intake options available. Two general categories of intakes are direct source and indirect source. Direct source intakes draw directly for the water source i.e., a hard piped connection to the Reservoir, while indirect source utilizes ground water movement through the soil in the vicinity of the water source to supply the intake. Ranney Well Collectors and infiltration galleries are examples of indirect intakes, an example of a Ranney Well is shown in Figure 6.27.

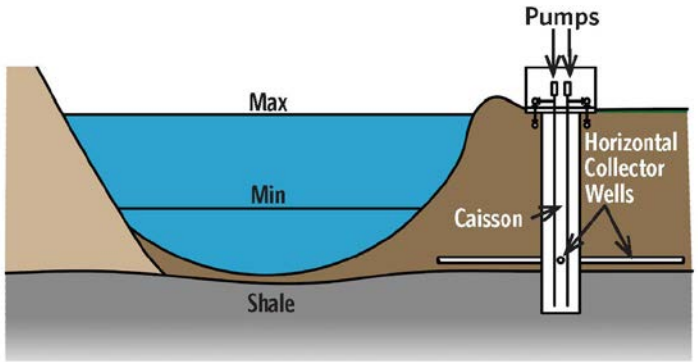


Figure 6.27 Ranney Well Collector Example

Indirect intakes provide the advantage of screening and filtering raw water naturally through the ground which typically improves water quality. Essentially a pre-filter. An efficient indirect intake requires permeable sand/gravel deposits to achieve high infiltration capacity from the source without plugging. Although detailed geotechnical data has not been obtained for the proposed intake location, silt deposits common in lakes and reservoirs, combined with the known existence of clay soils throughout the area of the proposed intake site indicate that an indirect stye intake is not likely feasible. Groundwater movement through the silt and site clays would be limited, requiring a large infiltration/collection area to obtain the necessary capacity. Additionally, the good water quality of Fort Peck doesn't really need to be pre-filtered.

The higher cost indirect intake style is not warranted and likely won't work well, and as such are removed from further consideration.

Further intake alternative evaluation focuses on direct source intake alternatives.

6.6.3.1 In-Lake Structure intake

The general concept of the in-lake structure intake is the screening elements and pumps reside in a structure within the waterbody. This structure could either be a caisson type structure set out from the bank and connected with a bridge for access similar to Figure 6.28 or located on the bank of the waterbody with one side providing direct access to the source water, see Figure 6.29.

Figure 6.28 Example of a Caisson Type Water Intake in a Body of Water

Figure 6.29 Example of a Bank Style Intake

The main benefit of this type of intake structure is that it can be designed to support a variety of screen types, from flat panel, cylindrical, and cone styles. The structure can also be designed so that it provides protection for the fine screens from debris damage. Additionally, this type of structure also lends itself to providing multiple intake draw-off elevations, however as previously noted the water sampling associated with Fort Peck determined this was not necessary.

To facilitate year-round operations, the intake must be located below the winter low pool elevation of 2197. To accommodate this criterion, a bank style intake would result in an approximate 100-foot-deep excavation at the reservoir bank of the selected intake site due to existing ground elevation. Aside from issues with the depth, the excavation would also have to extend out into the reservoir as the bank slopes into the water. Excavating that much material and construction of the associated structure is cost prohibitive.

A caisson-style structure set out from the bank and connected via bridge would be more cost-effective than a bank style in this situation, structural requirements would be relatively similar, however no mass excavation is required. Construction of the main structure could be done offsite and barged and craned into place, however anchoring of the structure is not as simple as one located on land. The raw water pipe from the intake structure to shore would also be exposed during the winter and would need to be heat traced and insulated to prevent freezing. Flowing water inside the piping also helps prevent freezing issues, however the winter water needs to the DRWA system are expected to be half of what they are in the summer. Since on/off operations could lead to more issues during the winter, a VFD would be necessary for the pumps, increasing capital costs.

Permitting requirements for building a new structure in the reservoir are expected to be more complex than a land-built structure. The amount of land required for this option is minimal since the equipment and appurtenances are in the tower structure. Shore access should be straight forward via the adjacent state park.

6.6.3.2 Onshore Intake Well

The onshore style intake is similar to the caisson-style in-lake intake; however, the caisson or wet well is constructed on land, and connected to the waterbody with a pipeline. See Figure 6.30 below for a general layout of the onshore intake well style of intake.

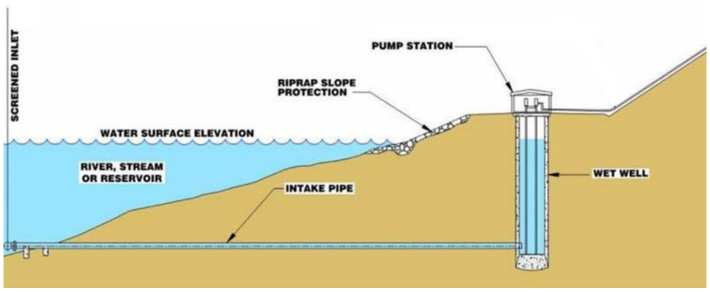


Figure 6.30 Onshore Intake Structure Illustration,
Image courtesy of Montana DNRC Eastern MT Water Supply Intake Resiliency Analysis Report.

An onshore intake simplifies certain aspects of the similar structure built inside the lake. However, it does come with its own set of complexities. The structure still needs to reach below the winter pool level of 2197 feet, the shore elevation at the proposed intake site is roughly 2300 feet, so the resultant wet well structure would be over 100 feet deep.

Construction of the wet well structure is typically completed in a phased approach. Sections of the well caisson are built on site. The initial section is termed a "cutting foot" and after completion, it is set in the final location of the wet well. An example of the cutting foot is shown in Figure 6.31.

Figure 6.31 Cutting Foot Construction

Once the cutting foot is set in place, a crane with a clam shell excavation attachment is used to remove earth from inside the caisson. As the earth is removed, the cutting foot steadily sinks by gravity. Once the cutting foot reaches a depth around two feet from the surface, the first standard section of the caisson is lifted into place on top of the cutting foot and sealed to it. The excavation then continues, and more sections are added until the final required depth is reached. Figure 6.32 shows the excavation of a caisson. Once the structure is in place, the bottom of the wet well is then sealed with reinforced concrete.

Figure 6.32 Excavation of the Wet Well

The intake pipe lateral(s) are then installed with a hydraulic jacking tool that is used to push the pipe from the wet well into the water body. A barge and divers are used to install a screen on the lateral ends to prevent the infiltration of aquatic life. If multiple laterals are installed, valves or gates can be installed on the laterals to isolate them individually for routine maintenance or to draw water from different depths.

Vertical turbine or submersible pumps are installed in the wet well to pump water up and into the pipeline to the WTP.

Accessing the intake pumps and appurtenances for operations and maintenance is easier on land then the in-lake structure, and pipes do not have to be exposed to the elements, reducing the freezing concerns. More land area would be required compared with the in-lake option, however most of the land surrounding the proposed intake area is a state park and managed by Fish and Wildlife. Coordination with Fish and Wildlife is expected to be straightforward and present minimal issues.

This option would provide less disturbance within the Fort Peck Reservoir waterbody, as such the permitting process is expected to be less complex than the in-lake structure option.

6.6.3.3 Sloped Tube intake

The general concept behind the sloped tube style intake is to minimize excavation and structures. Intake pipes or casings are installed via direction drilling, and the intake pumps reside within the pipes. An example of a sloped tube intake is shown in Figure 6.33.

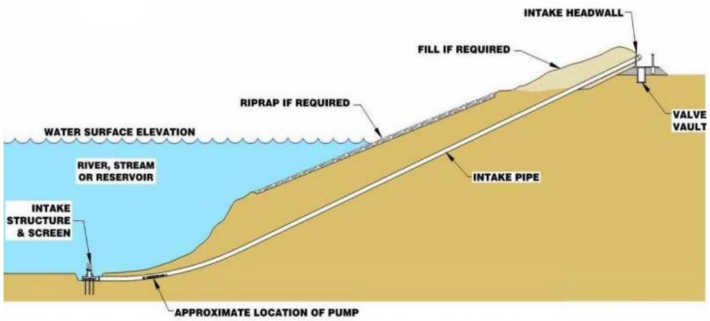


Figure 6.33 Sloped Tube Intake Example
Image courtesy of Montana DNRC Eastern MT Water Supply Intake Resiliency Analysis Report.

A sloped tube style intake requires a small amount of excavation work and has minimal disruption to the surrounding environment, as most of the casing pipe installation takes place via directional drilling. Typically, construction equipment is staged on the shore and on a barge in the lake. Silt screens are placed in the water around the area of the construction barge to prevent help protect the reservoir water from construction materials. A directional drilling rig on shore is utilized to install the casing pipe. Initially, a small drill string is pushed into the lake along the path of the casing pipe. Special preparation is made to make sure the drilling mud will not harm the reservoir water once the string "daylights" or enters the water from underground. Divers locate the string, and it is floated onto the barge. Once on the barge, a large bit is installed, and the casing pipe is attached behind the bit, see Figure 6.34 for an example.

Figure 6.34 Attaching the Drill Bit on a Barge

A larger bore is drilled when the drill string is pulled back to the ground surface and the casing pipe is set in its final location. Grout or cement is typically used to fix the casing pipe in place. A screen is installed in the water on the end of the casing pipe to prevent the suction of aquatic life and debris into the intake.

Submersible pumps set within the individual intake casing pipes are connected to the discharge piping and the assembly is lowered to an elevation below the low pool level. Figure 6.35 shows a pump installation.

Figure 6.35 Pump, Piping and Accessories being Lowered into Place.

There are several options to address the discharge piping from the individual pumps/casing pipes. The pump discharge pipes can simply penetrate the casing where it daylights and be combined into a header pipe before being routed to the WTP. In the colder climate of the proposed intake location this is not advisable without provisions for pipe freezing. The lines could be insulated, and heat tape installed, or a building could be constructed to house the exposed discharge pipe. The latter option would address the freezing concern, however, could result in limitations for maintenance on the pumps. To maintain the pumps, they need to be pulled from the casing, an operation that requires significant open space to perform, as such an enclosed structure over the pumps would make this difficult. An at grade vault could also be constructed to house the casing head and discharge pipes, this structure would need to be climate conditioned, and configured to allow access to the casing to pull the pumps for maintenance.

Pitless well adapters (typical for groundwater well pumps) have also been used successfully in sloped-tube style intakes, eliminating costly structures and heating requirements. The pitless adapter allows all the raw water piping to be installed below the frost line, while still providing surface access to the casing pipe for pulling the pumps for maintenance. See Figure 6.36 for a visual representation on the next page.

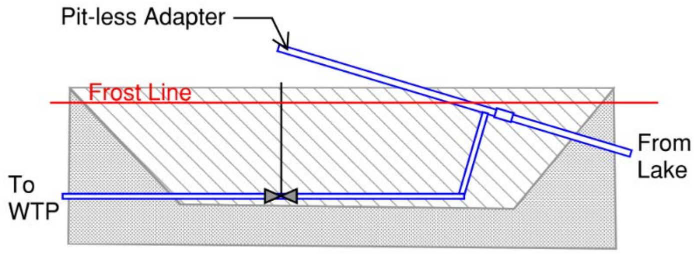


Figure 6.36 Finished Surface of Wellhead Illustration

The adapter is installed on the end of the discharge piping, it anchors the piping assembly in place and seals the discharge piping around the casing discharge port. The discharge connections and valves are buried, with valve boxes and extension stems installed on the valves to allow them to be operated from the surface.

An example of a pitless adapter unit is shown in Figure 6.37. Although vertical applications are more common, the adapters have been installed successfully in an angular configuration as well.

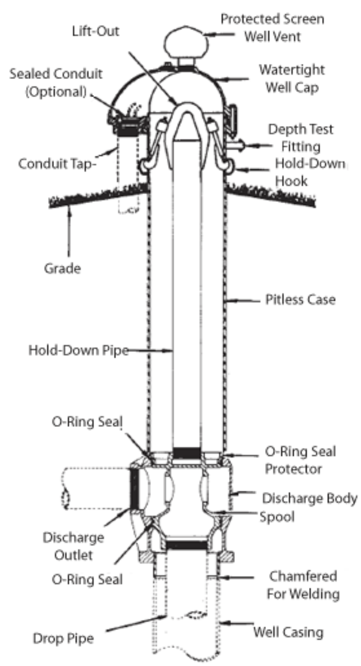


Figure 6.37 Pit-less Adapter
(Image courtesy of Baker Monitor Water Systems)

Similar to the onshore intake well option, accessing the intake pumps and appurtenances for operations and maintenance will be easier on land then an in-lake structure, and pipes do not have to be exposed to the elements, reducing the freezing concerns. More land area would be required compared with the in-lake option, however most of the land surrounding the proposed intake area is a state park and managed by Fish and Wildlife. Coordination with Fish and Wildlife is expected to be straightforward and present minimal issues.

This option would provide less disturbance within the Fort Peck Reservoir waterbody, as such the permitting process is expected to be less complex than the in-lake structure option.

6.6.4 Screen Alternatives

The purpose of providing a screen on the intake of the raw water system is to allow water to pass through the screen while debris and aquatic life remain in the water. The main operational issue associated with a screening system is keeping the system open and clear to allow for the unobstructed flow of water into the system. These obstructions can range from debris and sedimentation found within the Reservoir, to ice during colder months, and aquatic life including potential invasive species such as Zebra Mussels. Several configurations and options of screens are available, those alternatives are further discussed herein.

For the purpose of this evaluation fine screen systems with a screen slot size of 1.75 mm and a screen slot velocity of 0.5 ft/s were considered. While Montana doesn’t have criteria for opening size and velocity, but these numbers are typical of screens in the northwest.

Screens generally fall into a combination of fixed or removable and passive or mechanical cleaning. Fixed screens are hard mounted to their location and not capable of being removed for inspection or service, removable screens generally are track mounted and provided with a lifting mechanism to allow them to be raised above the water surface for maintenance, inspection and cleaning. Passive screens are stationary, with no moving parts, while mechanical screens rely on a brush or other element to physically clean the screen surface. Passive and mechanical screen systems can be provided with alternate means of cleaning. Backflush piping systems are common which reverse the flow of water and push collected debris off the screen. Air burst systems can also be fit to these screen systems, a burst of compressed air can be delivered to the screen to remove debris from the screen surface.

6.6.4.1 Drum Screen

A drum screen can be provided in either passive or mechanical and fixed or removable configurations. This style of screen functions best in lakes or reservoirs where the intake does not reside in a linear flow path. In a fixed application, the drum screen bolts directly to a flange installed on the intake pipe or casing and would be applicable to the sloped tube and onshore intake styles. An example of a fixed drum screen is shown in Figure 6.38.

Figure 6.38 Example of a Drum Screen
(Image Courtesy of Hendrick Screen Company)

The mechanically cleaned configuration of the drum screen utilizes a fixed external brush and a hydraulic motor attached to the inside of the screen that rotates the screen cylinder over the brush, cleaning the screen. This configuration can be supplied in either a fixed configuration, or on a retrieval track allowing it to be removed from the water for maintenance. The removable configuration is more appropriate for the in-lake intake structure. An example of a removable drum screen is shown in Figure 6.39.

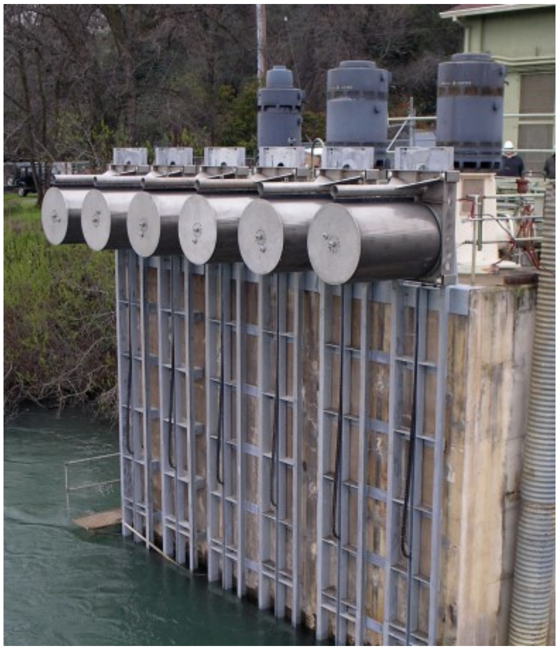


Figure 6.39 Example of a Removable Drum Screen
(Image Courtesy of Intake Screens, Inc.)

6.6.4.2 Cylindrical Screen

A cylindrical screen can be provided in multiple variations, either passive or mechanically cleaned and either fixed or removable. They are similar in concept to the drum screen, although mounted in a tee configuration from the connection flange. An example of a passive cylinder screen is shown in Figure 6.40.

Figure 6.40 Example of a Passive Cylinder Screen
(Image Courtesy of Johnson Screens)

Cylindrical screens provide efficient filtering and smooth flow dynamics, a high open area while maintaining low entrance velocities and pressure drop across the screen.

Passive cylinder screens are configured to bolt directly to a flange installed on the intake pipe, a configuration applicable to the sloped tube and onshore intake styles.

Similar to the drum screen, the mechanically cleaned configuration of the cylindrical screen utilizes a fixed external brush and a hydraulic motor attached to the inside of the screen that rotates the screen cylinder over the brush, cleaning the screen, the cylindrical screens also come equipped with a fixed internal brush on the screen structure to provide additional cleaning. Typically, due to the additional equipment, brushes and associated maintenance requirements, the mechanical cleaning option on the cylindrical screens are only supplied in a removable configuration, more appropriate for the in-lake intake structure. As example of a removable cylindrical screen is shown in Figure 6.41.

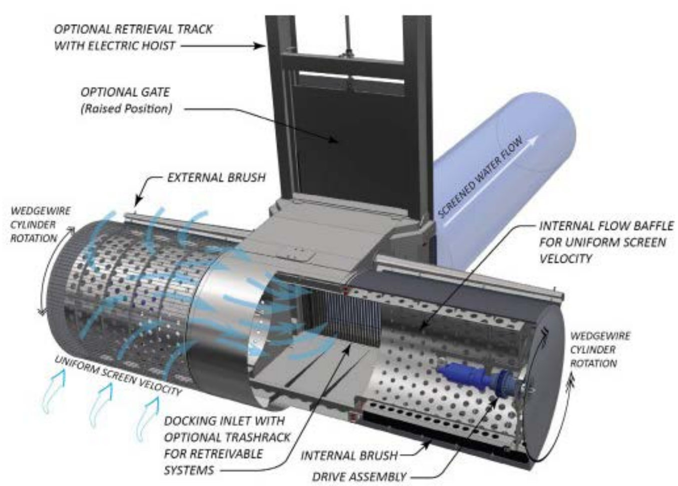


Figure 6.41 Example of a Removable Cylindrical Screen
(Image Courtesy of Intake Screens Inc.)

6.6.4.3 Cone Screen

Cone screens are typically only provided in a mechanical and fixed configuration. This style of screen was initially designed for shallow water applications, as the screen can function when partially submerged, with the largest screen area at the lowest part of the screen, however they can also be utilized in deep fully submerged applications. External brushes rotate over the fixed cone screen to provide a mechanical clean. The cone base would need to mount to a custom base to allow connections to the intake pipes associated with the sloped tube and onshore style intakes, or the cone screens could be mounted to the floor of the in-lake style intake. An example of a cone screen is shown in Figure 6.42 on the following page.

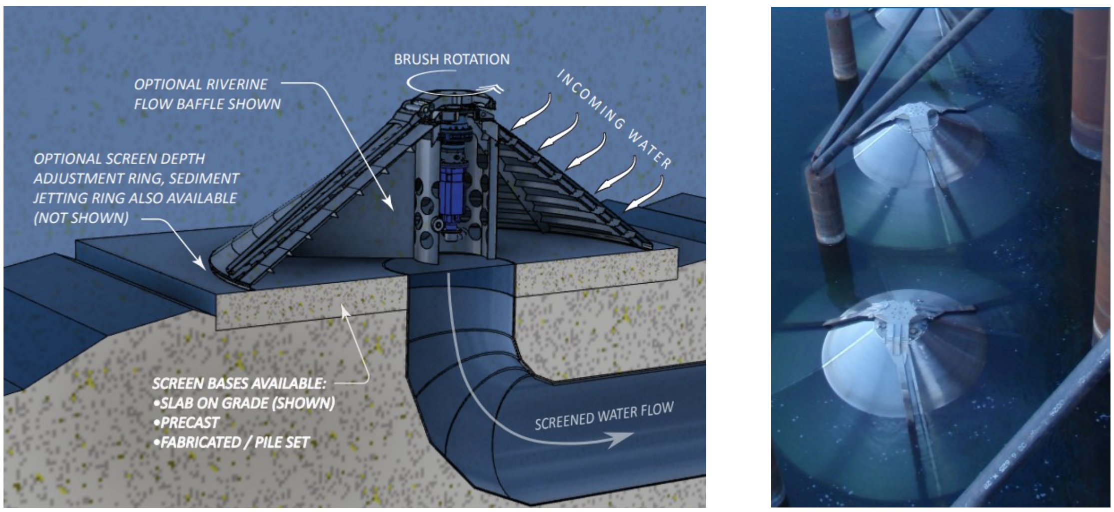


Figure 6.42 Example of a Cone Screen (Image Courtesy of Intake Screens Inc.)

6.6.4.4 Flat Panel Screen

Flat panel screens are typically only available in a passive and fixed configuration. The screen is installed within an opening in the designated structure. For this application the flat panel screen would only be applicable with the in-lake style intake. An example of a flat panel screen is shown in Figure 6.43.

Figure 6.43 Example of a Flat Panel Screen
(Image Courtesy of Elgin Separation Solutions)

6.6.4.5 Additional Screening Considerations

6.6.4.5.1 Invasive Mussel Mitigation

At this time the eastern Montana reach of the Missouri River and Fort Peck Reservoir has not experienced the establishment of invasive mussels, however, there have been specimens detected in lower reaches of the Missouri, and in 2016 Montana detected invasive mussel larvae in Tiber Reservoir and a suspect detection in Canyon Ferry Lake. The Missouri River and Fort Peck Reservoir have a medium to high risk of the future establishment of these mussels. Currently the Columbia River Basin is the only basin that has not been invaded by the invasive mussels.

Water systems can be impacted in many ways by this aquatic nuisance causing the potential for large financial impacts to DRWA to manage. These impacts include:

- Algae growth changes or decay of dead mussels leading to high levels of taste and odor compounds
- Loss of hydraulic capacity of screens, trash racks, pipelines, and pumps
- Increased metallic pipeline corrosion

The MT Fish & Wildlife watercraft inspection is the last line of defense that is currently standing between the Upper Missouri River and Fort Peck Reservoir and a pending mussel invasion. Once the mussels inhabit a river or reservoir ecosystem there are several control methods that have shown to provide varying levels of controls measures. These options are detailed in Table 6.11.

Control Method	Prevention Mechanism	Effective Dosing Range	Advantages	Disadvantages	Applicability to Fort Peck Intake
Riverbank Infiltration System	Riverbank Infiltration Gallery or Collector Well	NA	Filtration media prevents the mussels from access to intake system	Requires the construction of an infiltration intake system	Infiltration intake system has been ruled out based unknown and assumed site soils conditions
Antifouling Alloy or coatings	Antifouling or foul release coatings	Coatings have been shown to last in a range of 3-10 year	Reduces growth on screens and allows screens to be cleaned relatively easily	Periodic cleaning is required. Surfaces are not resilient to cleaning methods.	Surface water screening will benefit from these coatings.
Mechanical Cleaning	Scraping, pigging, pressure jet cleaning	Seasonal cleaning dependent on growth within river ecosystem	Capacity of screening structure can be improved to initial design amount	Continually maintained will be required, reactive method. Continued cleaning may compromise and accelerate the integrity of screen structure.	Minimum control method option to maintain capacity. Fixed vs. removable screens will allow for varying levels of cleaning depending on screening type.

Continued on Next Page

Control Method	Prevention Mechanism	Effective Dosing Range	Advantages	Disadvantages	Applicability to Fort Peck Intake
Chemical Oxidants	Will cause mussel mortality and deter attachment	0.2 to 10 mg/L, dependent on oxidant utilized	Effective at deterring attachment	Potential for increased DBP formation, high chemical costs, potential for impact to treatment processes	Challenging to dose on deep submerged intake alternatives
Electrified Screen-Pulsed or impressed	Electric field stun settling mussels for a period reducing settlement and causing veliger mortality	Min. 12 V per ms	Does not utilized chemicals therefore does not create DBPs,	Does not completely stop attachment and mechanical cleaning would still be periodically required, not widely proven	Few vendors but option on surface water screens, electrical field would heat water around screen potentially helping prevent screen frazil ice issues
Copper Ion Generation & Injection	Copper and Aluminum ions are injected into water to inhibit mussel settlement	Estimated at 5-10 ppb	Minimal treatment impacts	Additional copper and aluminum added to raw water may impact treatment process	Challenging to dose on deep submerged intake alternatives

Table 6.11 Invasive Mussel Mitigation Options

Ultimately the recommended mussel mitigation strategy is dependent on a final intake type determined.

6.6.4.5.2 Frazil Ice

Frazil ice is a collection of loose, randomly oriented ice crystals, typically millimeters and smaller in size and in varying shapes. These crystals form during supercooling events in waterbodies, when the water temperature drops below 0 degrees Celsius. Two requirements are necessary to trigger a super cooling event, turbulent water, and a period of intense heat transfer from the water surface. Turbulence, although more common in rivers and streams with active current, can also be found in lakes and reservoirs due to winds. Winds blowing across the open surface generate turbulence that creates a mixed upper layer with uniform temperatures that can trigger a supercooling event. The period of intense heat transfer only occurs when the water surface is open, and not covered with floating ice. The heat transfer, driven by frigid air temps and combinations of wind, low humidity, and clear skies, is also aided at night, when there is no solar radiation.

Unlike solid ice, frazil ice doesn't float. The small crystal size gives them an ineffective buoyancy, which allows the crystals to be carried below the water surface to the submerged intake screen. Once they start to adhere to the screen they quickly begin to increase in number, where the accumulation can bridge between adjacent screen bars, and in some instances extrudes into the space between the screen bars due to hydrostatic pressure, which blinds off the screen, reducing the intake capacity. An image of frazil ice buildup on a submerged screen is shown in Figure 6.44.

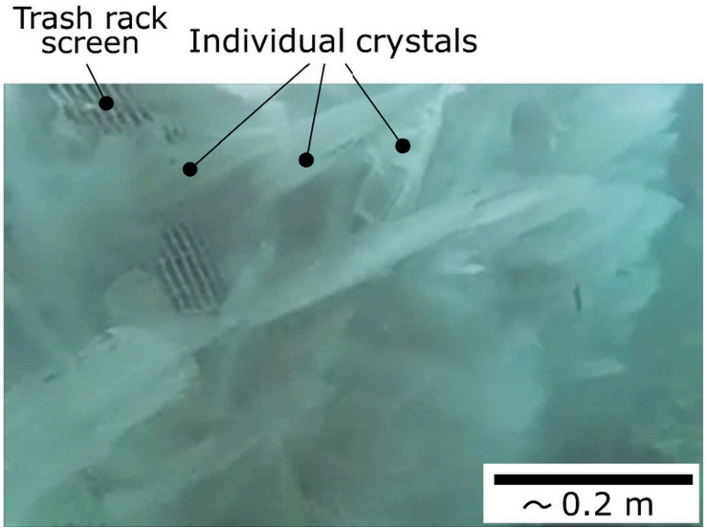


Figure 6.44 Frazil Ice on Submerged Intake Screen

Numerous strategies exist to combat the formation of frazil ice on intake screens ranging from operational strategies to additional heating or other equipment. Several of these strategies are further discussed below.

- Only operate intakes during the day. This strategy hinges on the supercooling events occurring more frequently at night when there is no solar radiation. By not operating the intake, currents formed by the usual intake of water are not occurring, which limits the potential currents will bring the frazil ice crystals to the screen. This strategy can be successful if the system contains adequate raw and finished water storage to facilitate operations.
- Increase backflushing frequency during supercooling events. By monitoring the atmospheric conditions and predicting the supercooling events, standard backflushing operations used to remove debris from the screen can be utilized to help dislodge crystals that have formed, prior to them blinding the screen.
- Increase air burst operations during supercooling events. Similar to the above, if the system is equipped with an airburst system for debris removal and cleaning it can be activated during a supercooling event to help dislodge frazil ice.
- Increase mechanical cleaning operations during super cooling events. If the intake screen is equipped with mechanical (brush) screens, by operating the system continuously during a supercooling event the brushes will dislodge frazil ice to keep the intake screen operational.
- Heating either the intake screen or surrounding water. Electrical resistance heaters installed on the screen have shown to be successful in raising the temperature of the screen metal, reducing the ability of frazil ice to adhere, however there are potential safety concerns and power cable routing challenges. A heated water flush line can be provided to the screen to heat the area surrounding it to limit frazil ice formation. Flush water only needs to be heated to slightly above freezing, however the volumes necessary typically result in very large water heating systems to make this alternative effective.

The recommended frazil ice mitigation strategy will be dependent on a final intake type determined.

6.6.5 Proposed Fort Peck Intake System

This section evaluates the various structure, screening, and ancillary considerations associated with the proposed Fort Peck Reservoir Intake and provides a summary and opinion of probable cost associated with the preferred alternative. The intake structure represents the largest cost associated with the intake system. It also dictates screening type and ancillary considerations after the preferred structure is identified.

Three options were considered for the intake structure on Fort Peck Reservoir, an in-lake structure, an onshore intake well, and a sloped tube intake, diagrams of the three alternatives are shown in Figure 6.45.

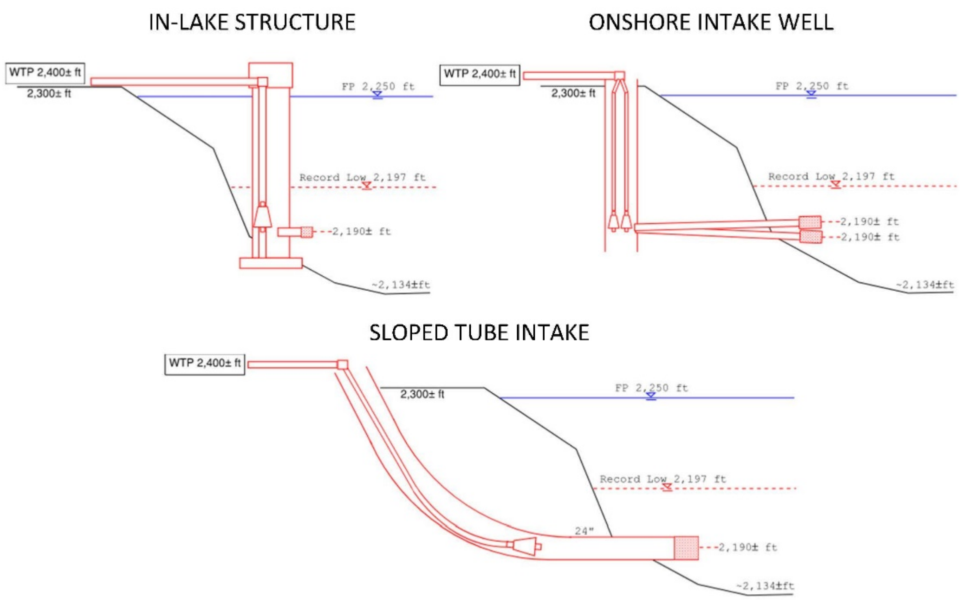


Figure 6.45 Intake Structure Alternatives

The options were compared to each other in several different categories including:

- Constructability – Ease of construction
- Cost – Assumed capital cost
- Permitting – Amount/degree of permitting required
- Accessibility – Considers the accessibility of the screen and raw water pumps
- Land Requirements – Amount of land required for the proposed structure
- Screening Alternatives – Available screen options and ancillary items available with the proposed intake structure.

Table 6.12 below summarizes the evaluation of the three intake structure alternatives. In each category the alternative was evaluated as the highest (best) option or the lowest (worst) option in the respective category, relative to the other intake structure alternatives.

INTAKE STRUCTURE ALTERNATIVE RANKING, 1 HIGHEST TO 3 LOWEST						
Alternative	Constructability	Cost	Permitting	Accessibility	Land Requirements	Screening Alternatives
In-Lake	3	3	3	2	1	1
Onshore	2	2	2	1	3	2
Sloped Tube	1	1	1	1	2	2

Table 6.12 Intake Structure Alternative Ranking Summary

As detailed in the ranking summary, the sloped tube style intake structure provides the most benefit compared to the other alternatives and was selected as the preferred intake structure. Note, no site-specific geotechnical data has been reviewed or considered associated with the recommended sloped tube style intake, this evaluation assumes site soils are conducive to the required directional drilling associated with the sloped tube intake. Prior to finalizing the intake type and location a comprehensive geotechnical evaluation is recommended.

The complexity of the sloped tube intake is expected to be minimal with a directional drilling rig doing most of the work from the shore and limited excavation with less in-lake construction requirements than the other options. Cost of the installed well casing is significantly less than a major structure construction either on-land or in-lake. With the only disturbance to the reservoir being limited to the penetration into the water and no major excavation requirements, the permitting of the sloped tube style intake should be straightforward. Accessing the pumping equipment on land will make maintenance easier and not require exposure of the piping to the elements (by using the pitless adapter option). While the land area requirement is expected to be higher than the in-lake alternative, no large excavation requirements should limit the disturbance to the area. Also, given the land surrounding the proposed intake area is owned by the State of Montana, coordinating with the relevant agency (Fish, Wildlife and Parks) for the final location is anticipated to be straightforward.

The main negative of the sloped tube style intake is it limits the associated screen options to fixed screens. Additionally, preliminary layout puts the intake screen approximately 900 lineal feet from the location where the casing pipe would daylight to the ground surface, and with the reservoir at full pool elevation the screen would be submerged approximately 60 feet. Based on this considerable distance, power to the intake screens would be challenging, and the deep submergence with the screen being fixed provides additional maintenance complexity to any moving parts or service items associated with the screen, for these reasons passive style intake screens are the preferred alternative.

There is little variation between the passive style drum or cylinder screens, it is recommended both alternatives be considered for future installation, potentially including both options in project bid documents. The discharge piping of the raw water pumps will be configured to provide backflushing from the header to each screen, to aid in debris removal. An air burst system is also recommended, to provide additional debris removal capacity and to potentially aid in frazil ice prevention. If the full cost of the air burst system is not feasible at this time, at a minimum the piping should be installed, to allow for the system to be implemented at a later date as conditions or available funding dictates. It is also recommended that the screens be constructed of copper nickel alloy, the anti-fouling alloy noted in the invasive mussel mitigation section to prevent mussel fouling, as other mitigation options associated with mussels in the deep fixed submerged style intakes are limited, with mechanical cleaning already having been noted as cost prohibitive.

A summary of the proposed Fort Peck Reservoir Intake design considerations is provided in Table 6.13.

PROPOSED FORT PECK RESERVOIR INTAKE – DESIGN PARAMETER SUMMARY	
Item	Value
Intake Design Flow	4.8 MGD
Sloped Tube Intake (2)	
Number of Screens	2 (1 working, 1 standby)
Screen Capacity (Each)	4.8 MGD
Screen Type	Passive, Fixed Drum or Cylinder
Screen Cleaning	Backflush and Air Burst
Screen Slot Velocity	0.5 ft/s
Screen Slot Size	1.75 mm
Sloped Tube Casing Size	24-inch
Number of Raw Water Pumps	2 (1 working, 1 standby)
Pump Design Conditions	350 HP, 3350 GPM, 300 TDH

Table 6.13 Proposed Fort Peck Intake Process Design Summary

Preliminary major equipment information associated with the proposed Fort Peck Reservoir intake including budgetary cost data is included in Appendix 6.16.

6.6.6 Opinion of probable Construction Costs

A preliminary estimate of probable construction costs for the preferred sloped tube style intake alternative are presented in Table 6.14. The preliminary estimate is based on general design criteria, significant known equipment costs estimates where available, and estimated quantities. As noted previously no site-specific geotechnical data has been reviewed, directional drilling costs included herein represent assumed conditions and do not consider adverse or challenging drilling conditions or site soils that could be present. These are planning level costs and represent an Association for the Advancement of Cost Engineering (AACE) Class 4 estimate. A Class 4 estimate is the standard of care for estimating construction costs during the feasibility and pre-design stage of a project. The accuracy of a Class 4 estimate in accordance with AACE guidelines is expected to be between 0.8 and 1.4 times the actual cost of the project. An estimated percentage for Contractor's overhead and profit is included in the individual estimate line items. This estimate identifies construction costs only and does not include contingencies (design or construction related) or other ancillary project costs including engineering or other associated administrative costs, reference chapter 12 for estimated total project costs. This estimate does not represent extreme market fluctuations due to events which cannot be predicted.

DRWA Fort Peck Intake - Preliminary Cost Estimate				
Description	Qty	Unit	Unit Price	Total Price
Concrete - Division 3				
Foundation / Slab	64	CY	$1,250	$80,000
Metals - Division 5				
Pitless Units	2	EA	$100,000	$200,000
Prefabricated Building – Electrical/Control Bldg..	440	SF	$188	$82,720
Wood, Plastics, Composites - Division 6				
Interior Carpentry/Finish Work	1	LS	$12,500	$12,500
Openings - Division 8				
Doors & Frames - Single Door	1	EA	$5,000	$5,000
Doors & Frames - Double Door	1	EA	$7,500	$7,500
Window Allowance	1	LS	$6,250	$6,250
Finishes - Division 9				
Painting and Protective Coatings	1	LS	$6,250	$6,250
HVAC Division 23				
HVAC/Ventilation Allowance	1	LS	$31,250	$31,250
Electrical - Division 26				
Admin & Basic Requirements	1	LS	$12,500	$12,500
Wire, Cable, Grounding, Raceway, Boxes	1	LS	$43,750	$43,750
MCC, Transformer, Switchboard, Panelboard, Safety Switches	1	LS	$93,750	$93,750
Building/Site Interior and Exterior Lighting	1	LS	$12,500	$12,500
Earthwork - Division 31				
MPDES Permit – Dewatering	1	LS	$12,500	$12,500
MPDES Permit – Stormwater	1	LS	$12,500	$12,500
USACE NWP Permit – In Lake Construction	1	LS	$18,750	$18,750
Floodplain Permit	1	LS	$12,500	$12,500
Access Road & Parking – Gravel Surface	1	LS	$25,000	$25,000
Pitless Unit Excavation/Install (2-20'x20'x10')	1	LS	$37,500	$37,500
Exterior Improvements - Division 32				
Site Grading/Seeding	1	LS	$12,500	$12,500
Security Chain-link Fence	300	LF	$50	$15,000
Security Chain-link Gate	1	EA	$3,125	$3,125
Utilities - Division 33				
Intake Casing – 24" HDD	1800	LF	$595	$1,071,000
Process Interconnections - Division 40				
Site Piping – Pitless Manifold, Piping, Valves	1	LS	$125,000	$125,000
Pump Discharge Pipe In Casing Pipe	1200	LF	$65	$78,000
Flow Meter	1	EA	$25,000	$25,000
Pump Control Panel – PLC, Programming, Startup	1	LS	$62,500	$62,500
SCADA – Telemetry Panel, Antenna, Cable,	1	LS	$56,250	$56,250

Process Liquid Handling, Purification, Equipment - Division 43				
Submersible Pump/Motor/Cable	2	EA	$1,000,000	$2,000,000
Airburst System	1	EA	$103,125	$103,125
Water/Wastewater Preliminary Treatment Equipment - Division 46				
Wedge Wire Screen – 4.8 MGD	2	EA	$25,000	$50,000
Screen Installation – Diver Work	2	EA	$62,500	$125,000
Subtotal				**$4,439,200**
Mobilization and Bonds			6%	$266,400
Total Field Costs				**$4,705,600**

Table 6.14 Opinion of Probable Construction Cost Fort Peck Intake (Total and Subtotal values rounded to nearest hundred)

6.7 Design Considerations for Water Age and Chlorine Residuals

The Fort Peck Water Treatment Plant will use chloramines for disinfection since they tend to remain active for longer periods and at greater distances from the plant than free chlorine.

Chloramines are disinfectants used to treat drinking water. Chloramines are most commonly formed when ammonia is added to chlorine to treat drinking water and they provide longer-lasting disinfection as the water moves through pipes to consumers. This type of disinfection is known as secondary disinfection.

EPA requires water utilities to meet strict health standards when using chloramines to treat water. The regulations are based on the average concentration of chloramines found in a water system over time. Table 6.15 shows water quality problems that are caused or worsened by increased detention time in the distribution system.

Summary of Water Quality Problems Associated with Water Age		
Chemical Issues	Biological Issues	Physical Issues
*Disinfection by-product Formation	*Disinfection by-product Biodegradation	Temperature Increases
Disinfection Decay	*Nitrification	Sediment Deposition
*Corrosion Control Effectiveness	*Microbial regrowth/recovery/shielding	Color
Taste and Odor	Taste and Odor	
*Denotes water quality problem with direct potential public health impact.		

Table 6.15 Summary of Water Quality Problems

Any one of these issues may create disinfection byproducts. The drinking water standard per EPA for chloramines is maximum of 4 ppm measured as an annual average. The Stage 2 Disinfection Byproducts Rule (DBPR) is intended to reduce potential cancer and reproductive and developmental health risks from disinfection byproducts, which form when disinfectants are used to control microbial pathogens. This rule tightens compliance monitoring requirements for Trihalomethanes (TTHM) and Haloacetic acids (HAA5).

Per Circular DEQ 1, chloramine concentrations should be maintained higher than chlorine to avoid nitrifying bacterial activity. A range of 1-2 mg/L, measured as combined chlorine, on entry to the distributions system and greater than 1 mg/L at the system's extremities is recommended. Higher water temperatures cause a higher chlorine demand; however, Fort Peck Reservoir water temperatures were consistent over the one-year of water sampling and testing. The temperatures for water test at elevation 2167 was in the low 30s to high 50s and the temperature for water test at elevation 2197 was in the low 30s to a high of 73. The WTP plant intake will be above the low water elevation of 2167 and less than

2197 to minimize severe water temperature fluctuations. Table 6.16 below shows the temperature for various depths from July 2021 to July 2022. See Section 6.5 for further discussion on disinfection.

DRWA Fort Peck Temperatures					
Sample Date	Surface Water Elevation	Sample Depth	Sample Elev.	Time	Temp
23-Jun-22	2222	0	2222	8:43	61.39
23-Jun-22	2222	7	2215	8:45	60.92
23-Jun-22	2222	17	2205	8:45	59.64
23-Jun-22	2222	27	2195	8:51	58.9
24-May-22	2222	0	2222	10:03	51.48
24-May-22	2222	7	2215	10:09	50.97
24-May-22	2222	17	2205	10:11	49.99
24-May-22	2222	27	2195	10:13	48.3
28-Feb-22	2222	0	2222	11:33	32.33
28-Feb-22	2222	5	2217	11:34	34.91
28-Feb-22	2222	15	2207	11:35	34.82
28-Feb-22	2222	25	2197	11:37	34.79
25-Jan-22	2224	0.5	2223.5	12:56	31.72
25-Jan-22	2224	7	2217	12:59	33.026
25-Jan-22	2224	17	2207	13:00	33.098
25-Jan-22	2224	27	2197	12:53	33.098
26-Oct-21	2227	0	2227	10:06	56.3
26-Oct-21	2227	10	2217	10:15	56.8
26-Oct-21	2227	20	2207	10:21	56.9
26-Oct-21	2227	30	2197	10:27	56.8
26-Oct-21	2227	60	2167	10:31	56.3
6-Oct-21	2227	0	2227	9:06	63.8
6-Oct-21	2227	10	2217	9:11	63.9
6-Oct-21	2227	20	2207	9:16	63.7
6-Oct-21	2227	30	2197	9:23	62.6
6-Oct-21	2227	60	2167	9:33	62.4
8/30/2021	2229	2	2227	12:03	72.6
8/30/2021	2229	12	2217	12:15	67.6
8/30/2021	2229	22	2207	12:27	68.0
8/30/2021	2229	32	2197	12:39	63.0
7/26/2021	2231.15	4	2227.15	12:00	73.3
7/26/2021	2231.15	14	2217.15	12:20	70.9
7/26/2021	2231.15	24	2207.15	12:35	70.0
7/26/2021	2231.15	34	2197.15	12:50	73.0
7/26/2021	2231.15	64	2167.15	1:20	55.4

Table 6.16 Temperature for Various Depths July 2021 - July 2022

A note of caution regarding chloramines is kidney dialysis treatment which can be upset by the use of chloraminated water. Medical authorities, hospitals, and aquarium keepers should be notified of chloramine disinfection if these businesses connect to DRWA so they can take precautions.

6.8 Stability of Treated Water

DRWA's transmission and distribution pipes will be AWWA C-900 or HDPE. These materials do not corrode in "hot" soils like ductile iron pipe. The service line material will be HDPE. This material does not need cathodic protection to prevent corrosion and will not leach by-products into the homeowner's water.

For the towns that connect to DRWA and have older pipes made of cast iron or non-PVC pipes, they should consult with their engineer to determine the best way to protect their pipes from possible corrosion when changing their source water. Water tests samples were taken for each town that has their own municipal system. The pH for the towns was in the range of 8-9 and the pH of Fort Peck water is in the range of 8.5-9. The similarities between the towns' sources and DRWA's source, and DRWA's water not being more aggressive, should minimize scaling of the older pipes.

7.0 Pipeline Concerns

7.1 Bypasses Around In-Line Isolation Valves

The DEC report suggested using butterfly valves instead of gate valves as isolation valves and suggested installing bypasses around each butterfly isolation valve. Using this valve/bypass configuration, a gate valve would still be needed on the bypass line to isolate the line during breaks and repairs. Butterfly valves are typically used in situations where flow is throttled or on very large diameter pipes where operating a gate valve would be difficult and the butterfly/bypass valve combination would be more expensive than a single gate valve. The butterfly/bypass valve combination costs $636 for the butterfly valve and $526 for the bypass gate valve. Each butterfly/bypass valve combination costs $1,162, which doesn't include labor for installation. Butterfly valves prevent the cleaning pig from progressing down the pipeline during initial cleaning of a new line.

Gate valves are better suited as isolation valves in a regional water system. They are linear motion valves, and their function is to stop or allow flow. If a line breaks and needs repaired the flow would need shut off until repairs are completed. After repairs, the valve would be opened allowing the system to operate. For on or off situations, a gate valve is best and gate valves do not impede the pushing of the cleaning pig. Gate valve cost is $636 making these valves the more economical choice.

DRWA will be requesting a deviation from DEQ-1, Section 8.3 for valves. The current requirement of 800 feet maximum spacing between isolation valves for serving widely scattered customers becomes overly burdensome and expensive for a rural water system. DRWA will request the maximum spacing be increased to 4 miles. Additional isolation valves will be placed at pipe intersections, before and after pump stations, tank manifolds, PRVs, flow meter vaults, and all appurtenances that require isolation for repairs and/or replacement.

7.2 Air Valves

The DEC report believed the number air valves were underestimated and stated they should be located at all high points, on the downhill side of each isolation valve, and on both sides of isolation valves along the transmission line between Sidney and Ft. Peck due to the proposed change in service flow.

DRWA's project will use air release/vacuum valves (air/vac) and not air release valves. Air/vac valves are used to expel air during filling of a pipe and, in the case of a pipeline break, intake air to prevent the pipe from collapsing when emptying unexpectedly.

DRWA will be requesting a deviation from DEQ-1, Section 8.5.1 for valves to change requirements from ALL high points to needed high points. For this PDR, air/vac valve spacing is every 4 miles, and within each pump station. This is the number used in the FCE calculations. A deviation for air/vac valve placement was granted to Dry Prairie Rural Water and is anticipated that approval will be given to DRWA. See detail D9 and D10 in Appendix 6.12 for typical combination air/vac assembly. AWWA Manual of Water Supply Practice M51, Air Valves: Air-Release, Air/Vacuum & Combination, in Appendix 7.0 will be the guiding document to properly locate the air/vacs during the design phase.

Air/vac valves will be included in pump stations on the downstream side to prevent water hammer should the pump start or stop quickly.

7.3 Advanced Metering Infrastructure

Advanced Metering Infrastructure (AMI) provides consistent two-way communication between customers and the utility that gives both parties real-time data. AMI water meters have the capability to send water use data over a communications network. There are several different types of communications networks that can be used: broadband, radio frequency, public landline, cellphone, or satellite. AMI is the newest technology since automatic meter reading (AMR) in providing the best service to customers.

AMR meters allow meter readers to take readings of water usage without having to physically enter yards or homes, but they still must be near the meter. This allows for less estimated bills and in a large rural system would be time consuming to read all users' meters. During winter months, reading of most meters would be difficult or impossible depending on snow, wind, and muddy roads.

Using AMI smart meters, the utility or customer can go to a network and observe in real time how the water is being used and where, without having to go anywhere. The smart meters hold 15 minutes to hour intervals that send not only the general water use but additional information as well, such as peak water usage.

It is important to realize how smart meters benefit everyone. Smart meters have the potential to reduce water waste, provide higher reliability, and deliver water with excellent quality. Smart meters allow the customer to make resourceful decisions to save money such as managing decisions about service and usage, examples being cost and consumption. For utilities, they simply would save money after implementation because they would not have the need to send a worker to the individual meters for collection of data.

DRWA currently uses Badger Meters, both E-series and Disc meters, but primarily E-series. Meters are radio-read and there is a mix of both Orion SE and Orion ME endpoints currently in use. The software used to read is Beacon. Most of the residential meters are ¾", five 1" meters for large businesses, five 2" meters for industrial businesses, and one 3" meter for a large commercial/retail/fuel business. Currently the water operator reads the meters each month and provides the reading to DRWA via a spreadsheet. DRWA then keys the information into the billing software, Black Mountain Utility Billing Software, and completes the billing process.

A combination AMI system using cellular and satellite data collection should be employed to remotely collect usage readings for the entire service area. Informational Data Technologies (IDT) is an AMI solutions company out of Watertown, SD. IDT currently services Dry Prairie Rural Water with their infrastructure which is 99% satellite data collectors. IDT is compatible with Badger Meters and is a preferred partner with them. IDT also has a relationship with Verizon allowing them to test the feasibility of cellular data collection within a service area.

IDT saw no issue coordinating their AMI solution to DRWA's billing software, Black Mountain. IDT's product overview can be found in Appendix 7.1.

For areas within DRWA's service area that has cellular capability, the meters are read once every 15 minutes for a total of 96 readings every day. For the meters that would need to be satellite read, the meters are read once a day. This information is transmitted to DRWA's software on their main office computer.

Both options would provide DRWA with an accuracy that exceeds being manually read and producing a spreadsheet once a month. Daily readings allow DRWA and the users the ability to know within 24-48 hours if there is a leak in the homeowners' system thus conserving water. The daily readings automatically link with DRWA's billing software which reduces errors that can happen when manually transferring data from the spreadsheet to the billing software.

DRWA could apply for a Water SMART Program Water and Energy Efficiency Grant to upgrade their existing meters to AMI technology. This grant program is managed by the BOR and is a 50% non-federal grant cost share and is available to water districts. The grant is an annual grant.

7.4 Pipe Bedding

The DEC report wanted clarification for construction material quantities, sources identified, and haul distances considered in the cost estimates. Due to the over 1,200 miles of pipe that will be placed across DRWA's service area, the use of traditional pipe bedding from a gravel supplier or a gravel pit would be cost-prohibitive. On-site, trench excavation material will be used as pipe bedding and backfill and approved by the engineer during the design phase.

Using USDA Web Soils Survey, the soils were found to be consistent across the service area. Approximately 95% of the soils along these corridors are classified as lean clay (CL) and clayey sand-silty sand (SC-SM). No organic soils were found. Table 7.0 – Soil Classes for Pipe Installation in the AWWA manual of water supply practices M23 PVC Pipe Design and Installation shows these soil types fall under Soil Class II, III, and IV.

Soil Classes for Pipe Installation				
Soil Class	Description	USCS Symbol		
Class I	Crushed Rock			
Class II	Clean, coarse-grained soils	GW		GP
		SW		SP
Class III	Coarse grained soils with fines	GM		GC
		SN		SC
	Sandy or Gravelly fine-grained soils	ML		CL
Class IV	Fine-grained soils	ML		CL
Class V	Fine-grained soils, organic soils	MH		CH
		OL	OH	Pt
Source: Howard, A. 2015				

Table 7.0 Soil Classes for Pipe Installation

The soil types that are removed during trench excavation can be re-used as pipe bedding material. A bid item for Type 1 Pipe Bedding is added to the FCE but use of imported bedding should be minimal. Class II soils are considered cohesionless and are best compacted using vibration. Class III and IV soils are usually considered cohesive and are best compacted with pressure, impact, or kneading. Compaction is required when open trenching a road, driveway or service road. Trenching through areas other than roads does not require compaction. The soil that was excavated is used as trench fill and mounded over the top of trench to allow for trench settlement to match existing ground. This is shown in Trench Detail, Sheet D2 in Appendix 6.12.

AWWA M23 provides trench type recommendations for each type of soil classification. Type 4 and Type 5 trenches will be used on this project shown in Figure 7.0 below.

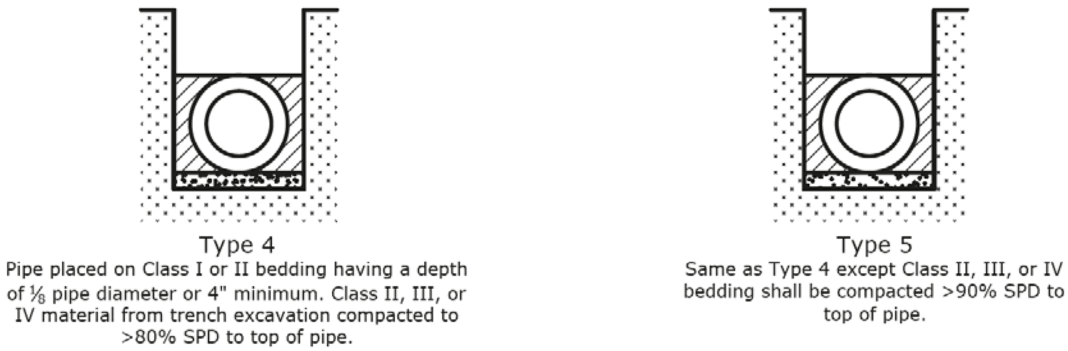


Figure 7.0 AWWA M23 Trench Types

SPD refers to Standard Proctor Density per ASTM D698.

When using native soils for pipe bedding, it will be screened on-site to remove rocks larger than ¾". The haunch zone and initial backfill will be screened on-site to remove rocks larger than 3". These steps will bring the bedding and initial backfill into compliance with the specifications. The contractor will follow OSHA standards when installing pipe.

Analysis of wells within the project area reflect deep groundwater levels. It is anticipated that groundwater will not be encountered in pipe trenches. Boring will be required under streams, creeks, irrigation ditches, and wetlands, further minimizing water in pipe trenches. If groundwater is encountered, the contractor is responsible for dewatering the trench until the pipe is backfilled above groundwater levels.

7.5 Plan & Profile Sheet Requirements

The DEC report requested plan and profile drawings for a portion of the system showing ground, pipe, and hydraulic grade line. Interstate Engineering used Highway 24 routing for the example Plan and Profile Sheets.

The 2012 hydraulic model showed the transmission main to be 15 miles of 36-inch and 12 miles of 30-inch diameter pipe running parallel to Highway 24 from the intersection of Highway 200 at Flowing Wells Rest Area north to North Rock Creek Road. The transmission pipe would be placed a minimum of 10′ from edge of asphalt towards the ROW fence. Beyond the edge of asphalt on both sides of Highway 24, the terrain consists mostly of ragged hills and deep ravines.

Installation of a large diameter pipe along this corridor requires a minimum of twenty-six bored 30-inch diameter pipe ravine/stream crossings, and forty-one bored 36-inch diameter pipe ravine/stream crossings. Mobilizing and placement of the equipment for these large diameter crossings would be difficult and costly to accomplish. With large diameter pipe sizes, specialized contractors and equipment are needed, which isn't common in eastern Montana. Therefore, the equipment would be transported to the project site from out of state, possibly North Dakota or Wyoming.

The large diameter fusing machine used for the bores requires a small crane to unload/reload each time the fusing machine is moved to the next location. Conceptual drawings were developed to show the plan and profile alignment for the 2012 transmission main routing. The drawings consist of an air/vac locations table, Highway 24 overview map and plan and profile sheets. See Appendix 7.2 for the plan set.

The profile shows the extreme highs and lows of the ragged and rough terrain. Air/Vac and air release valves have been placed at high points and a minimum of every ½ mile in accordance with AWWA M51-Air Valves: Air-Release, Air/Vacuum & Combination which can be found in Appendix 7.0. There are 73-4″ combination air valves required along Highway 24 for the 2012 alignment, and there is only one rural home. To compare costs of the 2012 and 2022 transmission mains, the route is from Hwy 24/N. Rock Creek Rd intersection to Circle, MT. Only the transmission pipe and appurtenances costs are included. The branch lines and appurtenances from 2012 and 2022 are not included in the costs for simplicity.

For 2012, Figure 7.1 shows the original transmission main. The total cost is $133,443,328.39 for 67 miles, shown in Table 7.1. The cost per mile is $1,993,923.47.

Figure 7.1 HWY 24 2012 Route

HWY 24 2012 COSTS					
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	36" PVC C900 Class 165 (DR 25)	94,331	LF	$435.89	$41,117,939.59
2	30" PVC C900 Class 165 (DR 25)	171,878	LF	$222.58	$38,256,605.24
3	30" PVC C900 Class 235 (DR 18)	46,082	LF	$303.79	$13,999,250.78
4	30" PVC C900 Class 305 (DR 14)	41,073	LF	$517.14	$21,240,491.22
5	30" Gate Valve and Box (1 per 4 miles)	18	EA	$58,087.63	$1,045,577.34
6	36" Gate Valve and Box (1 per 4 miles)	7	EA	$71,131.63	$497,921.41
7	4" Blow Off	4	EA	$8,716.57	$34,866.28
8	4" Combination Air Valve	73	EA	$28,194.84	$2,058,223.32
9	Gravel Surface Restoration	273	SY	$15.90	$4,346.00
10	Grass Restoration	295	ACRES	$714.34	$210,398.38
11	Type I Imported Bedding	589	CY	$55.00	$32,391.70
12	Rock Excavation	41,226	CY	$60.02	$2,474,565.92
13	Testing Laboratory Services ($250 per mile)	67	MILE	$250.00	$16,731.25
14	Dewatering	35	DAYS	$1,504.00	$52,640.00
15	Known Utility Crossing	30	EA	$745.00	$22,350.00
16	30" Ravine Crossing	11,881	LF	$338.84	$4,025,758.04
17	36" Ravine Crossing	18,872	LF	$422.89	$7,980,780.08
18	HDD Crossing Type 1	2	EA	$54,196.74	$108,393.48
19	HDD Railroad Crossing Type 1	2	EA	$67,353.08	$134,706.16
20	HDD Crossing Type 3	10	EA	$8,347.22	$83,472.20
21	Crossing Type 4	41	EA	$1,120.00	$45,920.00
				Subtotal	$133,443,328.39

Table 7.1HWY 24 2012 Alignment

An alignment change was made for the 2022 transmission with McCone County's assistance. The 2022 alignment begins on Highway 24 at North Rock Creek Road, continues south along Hwy 24 and turns east on Horse Creek Road. The 2022 route eliminates 13.0 miles of transmission main along Hwy 24 from Horse Creek Road to Flowing Wells. The diameter of the 2022 transmission main is decreased to 20-inches. The 2022 diameter for water delivery to rural residential connections, pasture taps, towns, and allows for future growth. The 4-inch combination air valves were reduced to 14 units and the 1-inch combination air valves were eliminated. For 2022, Figure 7.2 shows the new transmission main route. The total cost is $55,006,814.25 for 48 miles, shown in Table 7.2. The cost per mile is $1,157,978.17.

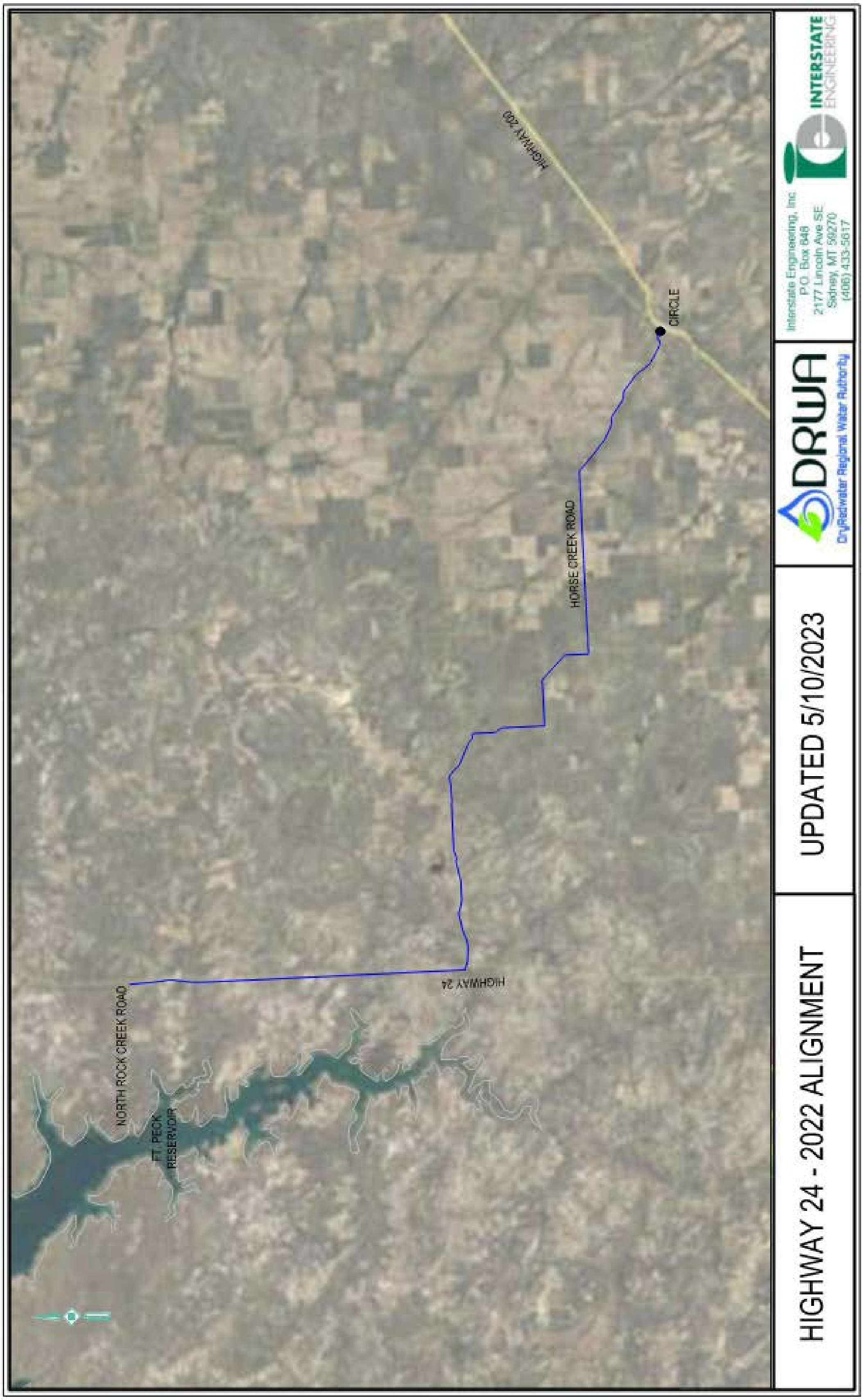


Figure 7.2 HWY 24 2022 Route

HWY 24 2022 COSTS					
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	20" PVC C900 Class 165 (DR 25)	4,903	LF	$161.43	$791,491.29
2	20" PVC C900 Class 235 (DR 18)	242,126	LF	$207.15	$50,155,190.27
3	18" PVC C900 Class 235 (DR 18)	3,784	LF	$159.66	$604,136.44
4	18" Gate Valve and Box (1 per 4 miles)	2	EA	$29,843.05	$59,686.09
5	20" Gate Valve and Box (1 per 4 miles)	16	EA	$31,999.63	$511,994.08
6	4" Blow Off	7	EA	$8,716.57	$61,015.99
7	4" Combination Air Valve	14	EA	$28,194.84	$394,727.76
8	Gravel Surface Restoration	213	SY	$15.90	$3,392.00
9	Grass Restoration	229	ACRES	$714.34	$163,350.08
10	Type I Imported Bedding	418	CY	$55.00	$22,991.19
11	Rock Excavation	29,262	CY	$60.02	$1,756,413.51
12	Testing Laboratory Services ($250 per mile)	48	MILE	$250.00	$11,875.62
13	Dewatering	25	DAYS	$1,504.00	$37,600.00
14	Known Utility Crossing	10	EA	$745.00	$7,450.00
15	20" HDD Crossing Type 2	540	LF	$466.65	$251,991.00
16	HDD Crossing Type 1	1	EA	$54,196.74	$54,196.74
17	HDD Crossing Type 3	10	EA	$8,347.22	$83,472.20
18	Crossing Type 4	32	EA	$1,120.00	$35,840.00
				Subtotal	$55,006,814.25

Table 7.2 HWY 24 2022 Alignment

By re-routing the transmission main from Hwy 24 to gravel county roads the cost savings to the project is $82,894,674.59. The new alignment is shown in Figure 6.1 – 2022 full pipeline buildout.

The BOR guidelines for pipeline plan and profile sheets suggest the vertical scale be 1″ =10′ so profile information can be easily viewed. These guidelines are for irrigation systems which usually have a small HGL, and all information can easily be viewed at the vertical scale. Hwy 24 plan and profile sheets have a vertical scale of 1″ = 20′ and was the best scale to show pipe profile and the extreme variations of the ground line. The HGL is over 200′ higher than the ground line. If the HGL was added, the profile scale would be so large that profile information would lose clarity and be difficult to read

7.6 Air Chambers

DEC report suggested air chambers in BPS to alleviate vacuum pressures due to mechanical or electrical failures. DEQ-1 requires pumps to be controlled so they will not create negative pressures in the suction lines. The current pump station design uses a soft start motor or a VFD motor to eliminate negative pressures and minimize transients. To prevent negative pressures, a pressure sustaining valve is installed on the pump suction side and set to 35 psi, which is the minimum pressure required by DEQ-1. If the pressure drops below 35 psi, the valve will slow-close, and the pumps will shut down. Each pump station has further protection with an automatic pump shut off should the pressure drop to 20 psi, also required by DEQ-1. With these safety features, air chambers are not needed.

7.7 Pipe Laying Considerations, Thrust Restraint

The DEC report requested fittings, thrust blocks, joint restraints be quantified and included in the construction costs estimates.

According to MDEQ Circular 1, Section 8.7.4, thrust blocks will be placed at all bends, tees, elbows, crosses, reducers, and ends. See Sheet D4 in Appendix 6.12 for thrust block installation. Thrust block design is based on AWWA Manual of Water Supply Practices M23, PVC Pipe – Design and Installation. Costs associated with thrust restraints are anticipated to be minimal and are included in the construction contingencies.

7.8 Insulation of Pipe Appurtenances and Structures

Per DEQ-1, all water mains must be covered with sufficient earth or insulation to prevent freezing. In DRWA's service area, water lines are buried between seven and eight feet deep to prevent freezing. DRWA does not expect pipe cover to be less than 7 feet. If there are areas where the cover is less than seven feet, 2 inches of blue Styrofoam insulation will be placed around the pipe during backfilling. The 7 to 8-foot cover is a requirement for valves and fittings to prevent freezing. No structures, valves, or piping will be exposed. Closed-cell spray polyurethane foam will be used for insulation of vaults. Steel pipe casing shall be filled with foam insulation between the casing pipe and carrier pipe. Costs associated with insulation are expected to be very minimal and is included in the construction contingencies. See detail D21 in Appendix 6.12 for casing with insulation.

7.9 Vault Requirements

PRVs and flow meters are contained in a 4-foot diameter, precast concrete manhole. The exterior of every concrete manhole will be insulated with closed-cell spray polyurethane foam a minimum of 6 feet down from bottom of manhole cover, and a minimum of 3 inches thick. Cost associated for each vault are subsidiary to the cost of the meter and therefore will not be broken out as a separate line item in the FCE. See details in Appendix 6.12.

7.10 Ductile Iron/Metallic Pipe Options

The DEC report required clarification of where the ½ mile ductile iron pipe would be placed. This item came from the printout of the 2012 water model and is the wrong material. PVC and HDPE pipe will be the only pipe materials used on this project.

Ductile iron pipe will not be used.

7.11 Dewatering

Dewatering was analyzed as a per day cost using two options. The first choice looked at purchasing a GP Series 3600-8000 Watts Portable Generator that would run a Tsurumi Cast Iron Submersible Trash Pump with ½ hp and 2-inch hose diameter. The second choice looked at using a Honda Self-Priming Construction Trash Pump with a 3-inch hose diameter. This pump is larger but is not submersible. In both options, a 1,000 ft trench with a width of 3 ft was used. To develop a volume, the water depth to be pumped was assumed to be 2 ft. Based on these dimensions, 44,880 gallons of water would need to be removed from the trench. In option one, this volume would require two submersible trash pumps to dewater the trench over a ten-hour day. In option two, only one pump would be needed to dewater the same trench. Table 7.3 below shows the breakdown of costs associated with each option.

DEWATERING COSTS					
Option 1					
Item	Description	Quantity	Unit	Price	Total $
1	Tsurumi Submersible Trash Pump	2	EA	$273.00	$546.00
2	Gas	16	GAL	$5.00	$80.00
3	Generac Generator	1	EA	$3,250.00	$3,250.00
*Calculations based on a 10 hr workday					**$3,876.00**
Option 2					
Item	Description	Quantity	Unit	Price	Total $
1	Honda Trash Pump	1	EA	$1,449.00	$1,449.00
2	Gas	6	GAL	$5.00	$30.00
*Calculations based on a 10 hr workday					**$1,479.00**

Table 7.3 Dewatering Costs

8.0 Studies / Reports / Analyses

8.1 Geological

Soil survey data was obtained through the USDA/NRCS website and uploaded into DRWA's GIS. The soil data was cross referenced with the waterline locations along Highway 24 to obtain specific soil data for the pipeline corridor for the plan and profile sheets. In each county, several pipe reaches were cross referenced with the soil survey data and found to be similar and therefore used across the entire project. A summary of the soil information can be found in Appendix 8.0.

Ninety-five percent of the soils along this corridor are classified as lean clay (CL) and clayey sand-silty sand (SC-SM). No organic soil was found. Table 7.0 – Soil Classes for Pipe Installation shows these soil types fall under soil classifications II, III, and IV. Class II soils are cohesionless and compaction efforts are maximized with the use of vibration. Class III and IV soils are cohesive and compact better with pressure and impact. The soil removed from trench excavation can be used as pipe bedding material. Imported pipe bedding is a bid item in the FCE and is further discussed in Section 12.1.4.

The groundwater levels throughout the DRWA service boundary were also analyzed using the Ground Water Information Center (GWIC) on the Montana Bureau of Mines and Geology website. Multiple well logs were pulled throughout the DRWA service area. Fifteen wells were selected in different areas of the DRWA project. Table 8.1 provides the data collected from the well log report for each well. A map showing the location of the 15 wells (orange symbol) and their logs can be found in Appendix 8.1. The wells are over 50 feet deep and are low flow wells. It is anticipated that minimal groundwater may be encountered in pipe trenches, if any. Dewatering is a bid item in the FCE and is further discussed in Section 12.1.4. Boring will be required under streams, creeks, irrigation ditches, and wetlands to minimize water in the pipe trench.

Well Data Across DRWA								
GWIC #	Township	Range	Section	County	Total Depth	Static Water Level	Production Rate	Location
296024	17N	38E	5	Garfield	120 ft	74 ft	10 gpm	South of Jordan
172433	18N	33E	28	Garfield	520 ft	420 ft	10 gpm	West of Jordan
2477	20N	37E	24	Garfield	197 ft	70 ft	10 gpm	North of Jordan
37777	25N	44E	17	McCone	210 ft	185 ft	4 gpm	North of HWY 24
294181	21N	45E	25	McCone	135 ft	61 ft	14 gpm	East of HWY 24
31261	18N	43E	34	Garfield	150 ft	130 ft	11 gpm	South of HWY 24
33879	20N	43E	1	McCone	282 ft	210 ft	12 gpm	West of HWY 24
32504	19N	48E	34	McCone	181 ft	130 ft	7 gpm	South of Circle
30246	17N	51E	28	Dawson	138 ft	110 ft	10 gpm	Southeast of Circle
211518	18N	48E	8	McCone	112 ft	56 ft	6 gpm	Southwest of Circle
36252	23N	51E	31	Richland	148 ft	130 ft	3 gpm	Northwest of Richey
288391	21N	52E	9	Dawson	183 ft	70 ft	12 gpm	South of Richey
219178	22N	53E	13	Richland	170 ft	100 ft	7 gpm	East of Richey
32571	19N	52E	5	Dawson	126 ft	60 ft	2 gpm	East of Circle
36276	23N	53E	16	Richland	105 ft	47 ft	5 gpm	Northeast of Richey

Table 8.1 Well Logs Showing Ground Water Levels

9.0 Geotechnical Engineering

Geotechnical engineering was not completed for this PDR since the soil data was used from the USDA/NRCS website for DRWA's service area. Geotechnical engineering should be completed during each phase's final design when final locations of the tanks, pump stations, and WTP are known.

10.0 Right of Way and Easement Requirements

The DEC Report requested clarification for pipe easements and the subsequent costs. In DRWA's Regulations, it is required that each user shall grant or convey to DRWA a temporary construction easement, a permanent pipeline easement, and right-of-way across any property owned by user at no cost to DRWA. This language is also stated in the DRWA User Agreement form that is signed by the landowners when purchasing a connection. The Regulations, appendices and User Agreement form are included in Appendix 10.0.

Pipe routing and easements are decided during the final design for each phase. Each landowner is met with individually before preparing plan and profile drawings. The landowner provides where they would like their service line and DRWA's pipeline routed across their property or properties. The right-of-way agent will obtain the signed documents and record the easement documents at the courthouse. For permanent structures such as tanks and pump stations, DRWA will buy the land from the landowner.

If a landowner does not want to purchase a rural residential connection and/or pasture tap, then DRWA's pipeline and appurtenances will remain in the road right-of-way and trigger a permit application to the correct governmental entity. However, residents that do not want to connect to DRWA's regional water system may allow an easement across their property at no charge to DRWA. It is expected that minimal pipe will be routed in highway and road rights-of-way.

Some pipe alignments may cross state and federal lands. Land owned by the state of Montana will fall under either the Trust Land Management Division, or the Montana Fish, Wildlife & Parks Division.

The Montana DNRC requires a right-of-way application and a notice of settlement of damages for lands that fall under the Trust Lands Management Division. The right-of-way application is $50 per tract of land that is crossed. In addition to the application, an easement will need to be purchased. The cost for the easement will be the fair market value of the land based on the total acreage across the property. The price is negotiated between the lessee and DRWA. This requirement may be waived in exchange for the benefit of the provided service in some cases.

If the alignment crosses Montana Fish, Wildlife & Parks land, an easement will need to be purchased. This process is time-consuming and involves an environmental assessment. The purchase price for the easement will be fair market value and based on the total acreage across the property.

If the alignment crosses BLM land, an SF-299 Right-of-Way Application needs submitted along with a Plan of Development for their review. This form is in Appendix 4.0. The purchase price for the easement will be fair market value.

Easements/Right-of-Way/Land Purchase costs are 0.75% of the FCE.

11.0 Electrical

The DEC Report requested a power supply study for the pump stations and WTP in the 2012 Feasibility Study. The 2012 Study had 71 BPS throughout DRWA's service area. Many of the BPS were small and designed to increase pressure along a branch line and there were several larger BPS designed to increase pressure along the transmission main and/or to fill storage tanks.

When the 2022 model was created, the number of BPS were decreased to 12, which includes the branch line BPS, the large BPS, and the WTP and intake. See Section 6.2.2 Pump Stations for a full discussion.

There are two electrical providers in DRWA's Service Area. McCone Electric (MEC) and Lower Yellowstone Rural Electric Cooperative (LYREC). Figure 11.0 below shows the service area for both providers. LYREC serves Richland County and a small part of east Dawson County. MEC serves a small part of west Richland County, a small part of north Prairie County and all McCone and Garfield Counties. LYREC is not included in this section since there isn't a BPS in Richland County.

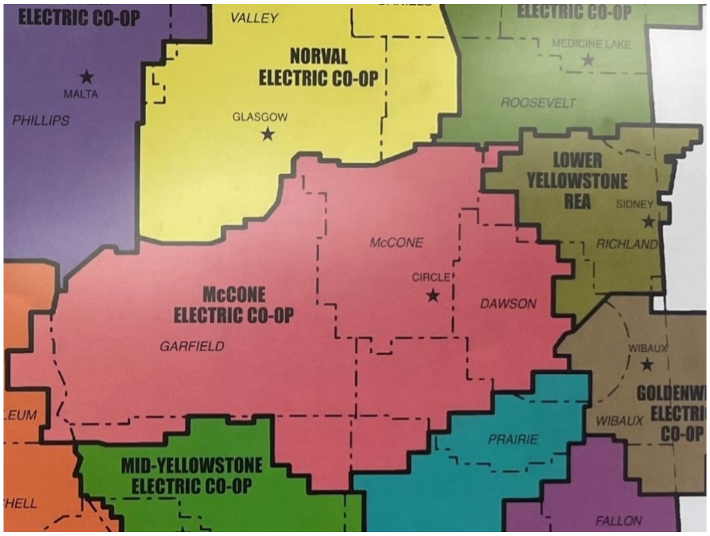


Figure 11.0 Electrical Service Area Providers

Currently, DRWA and MEC are working together to determine the best power line routing for DRWA's project. The estimates in this section are preliminary and DRWA/MEC will refine routing and costs over Summer 2023. The final routing costs will include design, construction, easements, and all mitigation required. The final routing costs will be transmitted to BOR by Fall 2023. The final cost estimate will be used by their Contractor when preparing the Final Feasibility Study.

11.1 McCone Electric Co-Op

MEC's electrical grid is mostly single-phase distribution lines and a 69 kV, three-phase transmission line. Their transmission line follows Hwy 200 from Circle to Jordan, Hwy 13 from Circle to Wolf Point, and from Circle to a substation 18 miles, as the crow flies, SE of Circle located at the intersection of Rd 422 and Rd 452 shown in Figure 11.1.

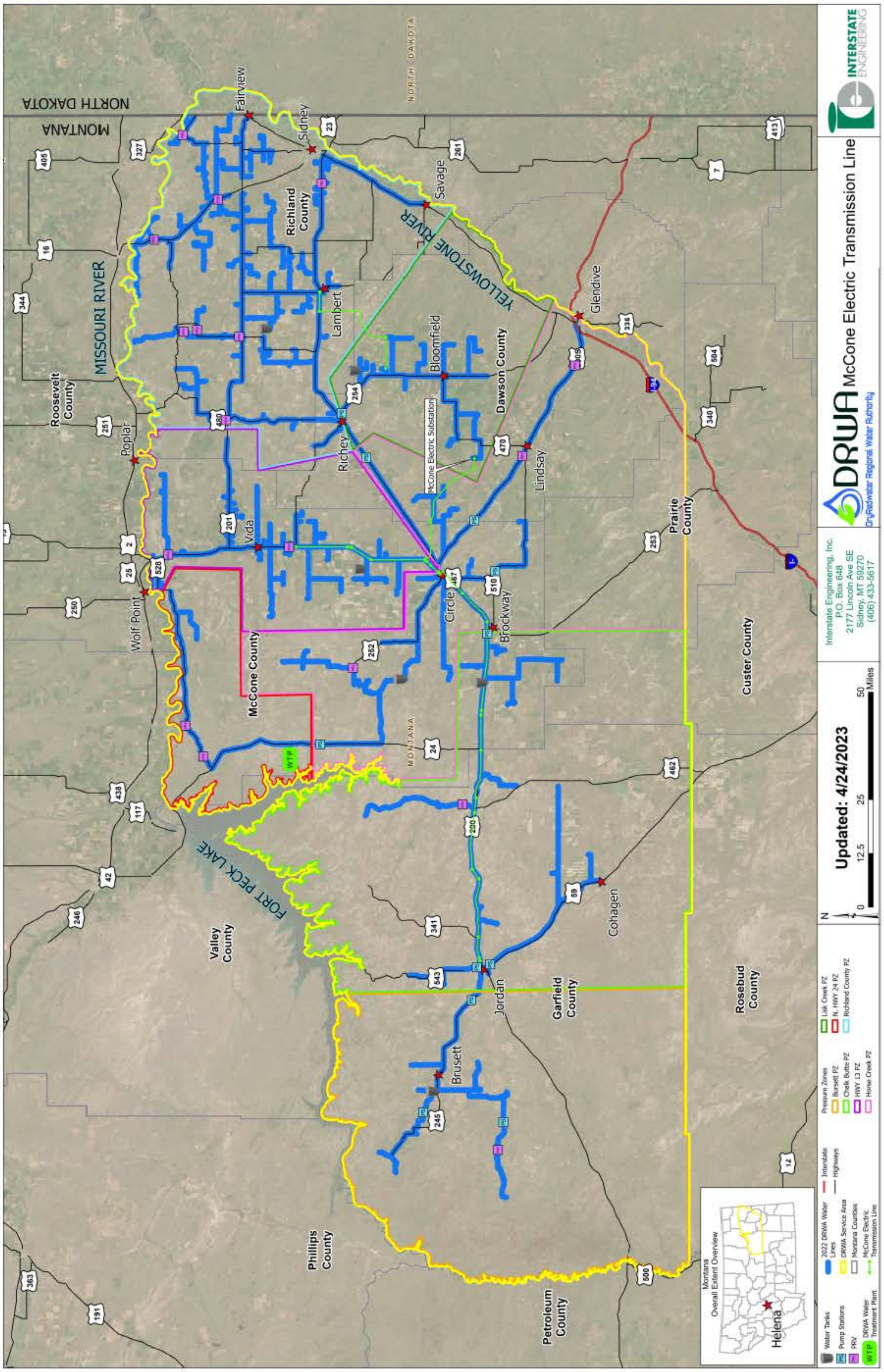


Figure 11.1 McCone Electric Transmission Line

MEC's distribution lines are dispersed throughout DRWA's service area. The distribution lines are typically lower voltage, single-phase power lines shown in Figure 11.2.

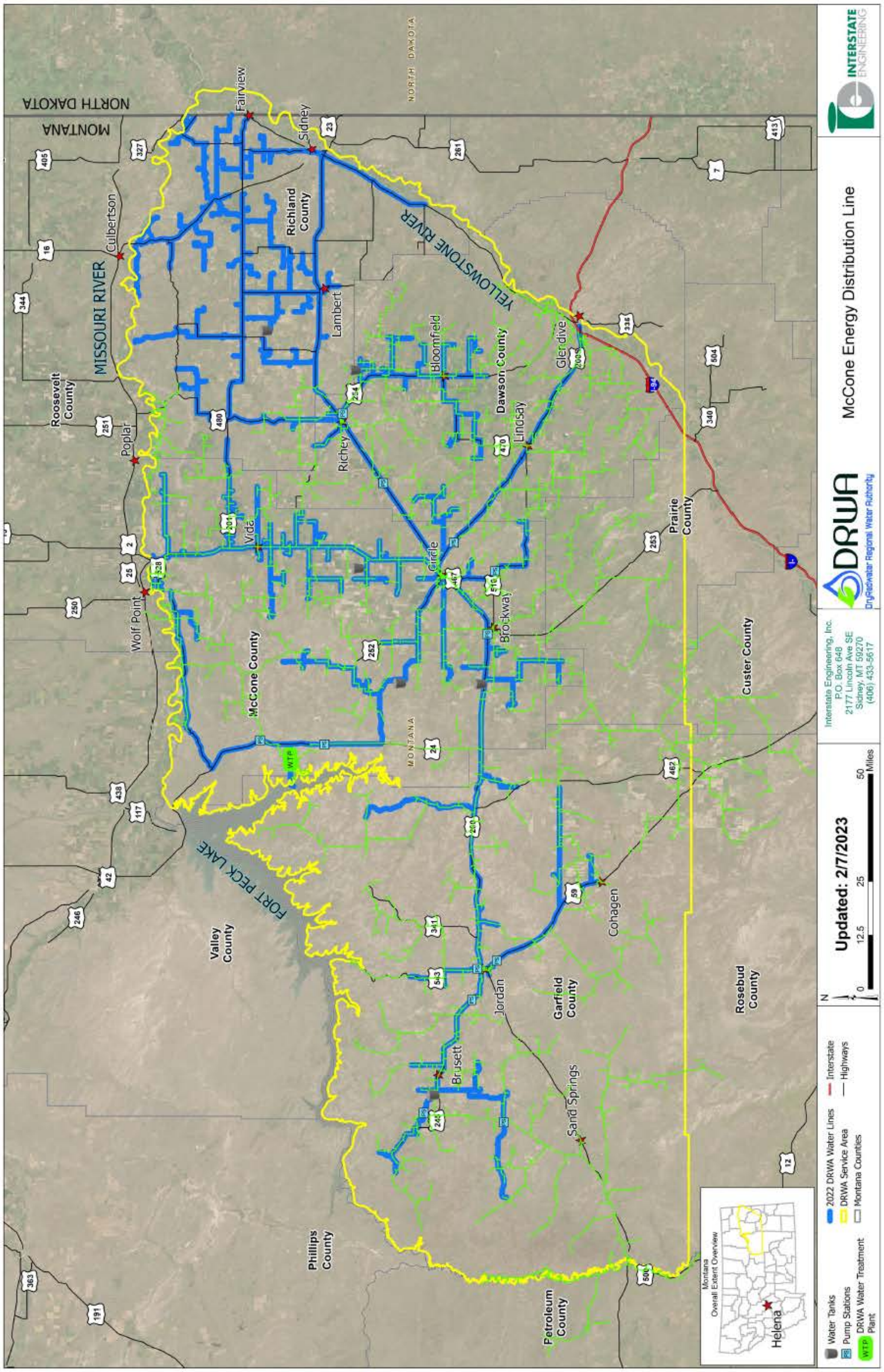


Figure 11.2 McCone Electric Distribution Line

11.2 Western Area Power Administration

WAPA has several Bulk Power 230 kV transmission lines within DRWA's service shown in Figure 11.3. There is a three-phase 230 kV transmission line that begins at Fort Peck's Power Plant and runs in a southeasterly direction to Glendive. This transmission line comes within 4 ½ miles of the WTP. WAPA does not contract directly with power users but may contract with MEC to construct a three-phase transmission line for the WTP and intake. DRWA and MEC will determine if this alternative is feasible.

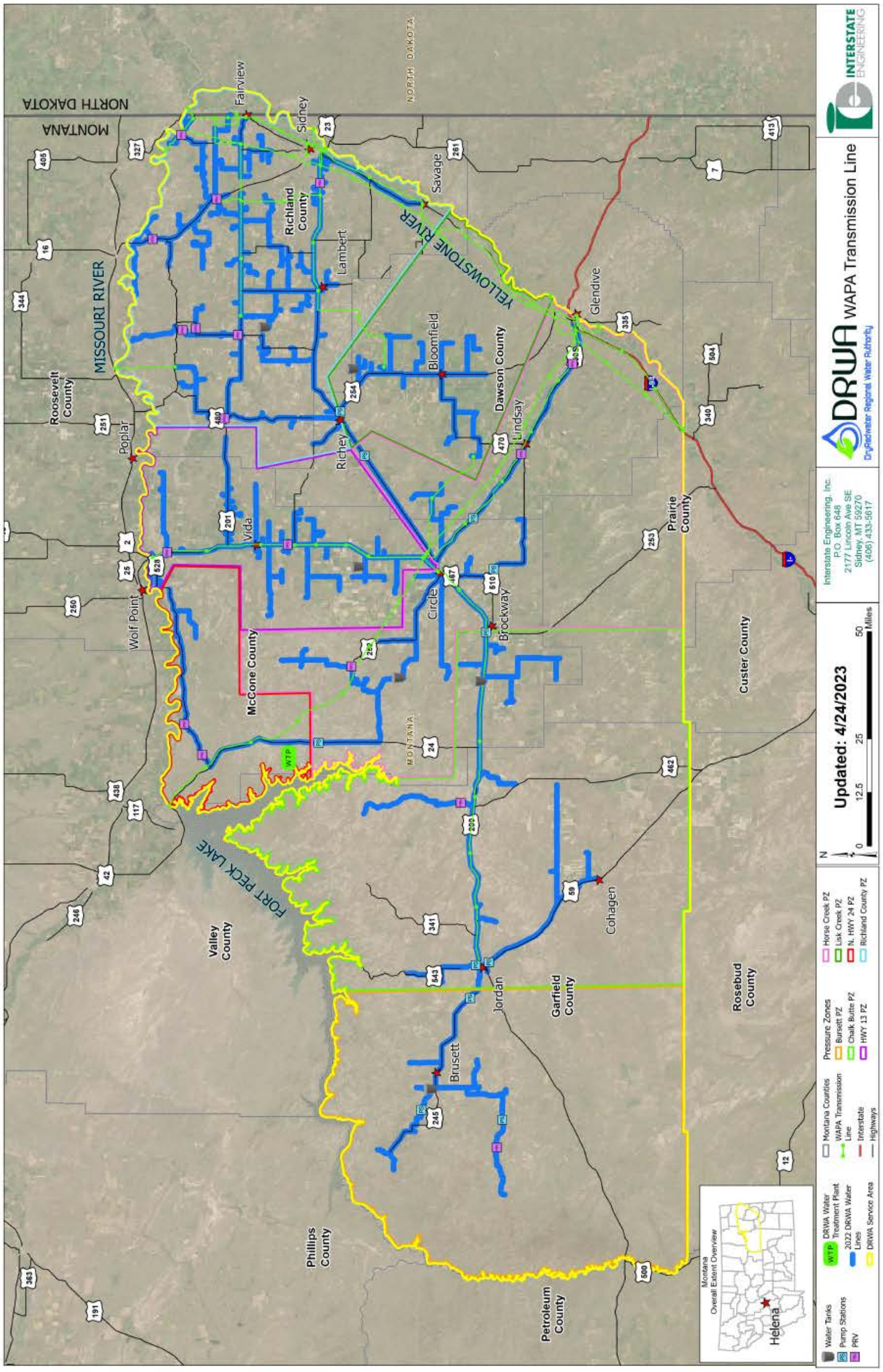


Figure 11.3 WAPA Transmission Line

INTERSTATE ENGINEERING

11.3 Review Availability of Power Supply for Pump Stations

DRWA and MEC are currently working together to find the best alternative for power supply to the pump stations. The worst-case scenario is included in this report. After negotiations between DRWA and MEC regarding which entity will pay for the engineering fees for a 30% power supply design, this section will be updated by letter and sent to the BOR.

11.3.1 Ft. Peck Water Treatment Plant and Intake Power Supply

WAPA's transmission line comes within 4 ½ miles of the WTP and Intake. DRWA, MEC and MEC's electrical engineer will determine if a new connection to WAPA is feasible.

The other alternative for power at the WTP and intake is from MEC's grid. MEC proposes to upgrade their 33 mile power line from Circle to Flowing Wells Substation at Hwy 24/Hwy 200 intersection from 69 kV to 115 kV with a 25 kV three-phase underbuild line. Along this upgraded route, the Brockway and Flowing Wells Substations would be upgraded to 115 kV. A new 35-mile, 115 kV three phase transmission line would be constructed from Flowing Wells Substation to North Rock Creek Rd. A new 115 kV substation at North Rock Creek Rd would be constructed. A distribution line to the WTP and intake from the North Rock Creek Substation would be constructed. The power line costs for this option are in Table 11.0.

DRWA 115 kV Line from Circle to Rock Creek Cost Estimate			
Location	Price Per Mile	# Of Miles	Total
Building New 115KV line from Circle to Flowing Wells	$450,000.00	33	$14,850,000.00
Building New 115KV Line from Flowing Wells to Rock Creek	$450,000.00	35	$15,750,000.00
Building 25 KV 3Ø Underbuild from Circle to Flowing Wells	$80,000.00	33	$2,640,000.00
New 115 KV Substation Transformer @ Brockway Sub			$1,000,000.00
New 115 KV Substation Transformer @ Flowing Wells Sub			$1,000,000.00
New 115 KV Substation @ Rock Creek			$1,500,000.00
Upgrade Flowing Wells Sub to 115 KV (switches, Clothes Line, Etc.)			$500,000.00
Upgrade Brockway Sub to 115 KV (switches, Clothes Line, Etc.)			$500,000.00
		Total	$37,740,000.00

Table 11.0 DRWA 115kV Line Circle to Rock Creek

Upgrading to a 115 kV transmission line triggers Sage Grouse mitigation along the 68-mile easement corridor, however these costs are not included with this estimate. Upgrading to a 115 kV transmission main triggers NERC reporting and all applicable standards by MEC, which they are currently not required to do. The cost of the Sage Grouse mitigation has not been included in these costs since DRWA and MEC are still analyzing the best power line routing with MEC's electrical engineer.

11.3.2 Pump Stations Power Supply

Using DRWA's GIS, Interstate Engineering was able to calculate the distance of each BPS to the nearest power line, excluding the WTP and intake. Table 11.1 shows the BPS name and horsepower along with the distance to nearest MEC powerline, and other properties of their powerline. The map showing the location of each BPS can be found in Figure 6.1 and in Appendix 12.10.

Pump Station	Location	HP	Phase	Coordinates	Distance to Power (miles)	Direction to Power from Pump Station	UG or OH	Pump Station Type
Loomis & Clark	Loomis & Clark Rd	2.2	Single	Lat: 47º27’28.80”N Long: -107º23’34.80”W	0.7	West	OH	Distribution
N. Lodge Pole	N. Lodge Pole Rd	0.9	Three	Lat: 47º16’26.40”N Long: -107º25’30”W	0.6	East	OH	Distribution
Brusett Rd	Brusett Rd	24	Three	Lat: 47º20’52.80”N Long: -107º00’50.40”W	Adjacent	NE	OH	Transmission (2-Pump)
Hell Creek Rd	Hwy 541/Hell Creek Rd	1.3	Three	Lat: 47º20’02.40”N Long: -106º54’32.40”W	0.5	South	OH	Distribution
Hwy 59	Hwy 59N	4.3	Single	Lat: 47º17’24”N Long: -106º52’55.20”W	0.7	NW	OH	Distribution
Brockway	Hwy 200E	37	Three	Lat: 47º18’39.59”N Long: -105º47’01.85”W	Adjacent	North	OH	Transmission (2-Pump)
S. Hwy 24	S Hwy 24	310	Three	Lat: 47º40’58.80”N Long: -106º09’18”W	32.3	SE	OH	Transmission (3-Pump)
Union Rd	Union Rd	2.5	Single	Lat: 47º17’38.40”N Long: -105º34’22.80”W	Adjacent	NE	OH	Distribution
Hwy 200S	Hwy 200S	48	Three	Lat: 47º23’24.16”N Long: -105º28’37.39”W	Adjacent	SW	OH	Transmission (2-Pump)
Hwy 200	Hwy 200	227	Three	Lat: 47º32’59.80”N Long: -105º16’37.14”W	9.5	NE	OH	Transmission (3-Pump)
Hwy 254	Hwy 254	52	Three	Lat: 47º38’31.20”N Long: -105º02’34.80”W	Adjacent	NE	OH	Transmission (2-Pump)

Table 11.1 Pump Station Electrical

The pumps that are 10 hp and less can be served from MEC’s single phase power lines but must be equipped with soft start motors. MEC doesn’t allow VFD motors on their single-phase lines due to harmonic interference with the older, single phase power lines and the VFD. There are 6 pump stations that require 3 phase power, in addition to the WTP and intake as discussed in Section 11.3.1. They are Brusett Rd, Brockway, S. Hwy 24, Hwy 200S, Hwy 200, and Hwy 254 pump stations.

MEC provided the Pump Station Power Costs outlined in the table below. The easement costs were calculated using the average land cost from several real estate websites then multiplying by 10% to calculate the easement purchase cost.

The total costs for extending power to each BPS is shown in Table 11.2.

Pump Station Power Costs (MEC Option)				
Location	Dist. to Eisting Power Line (ft)	Cost to Extend Power Line	Cost for Easement	Total Cost to Deliver Power
Loomis and Clark Road	3,696	$45,000.00	$10,200.00	$55,200.00
North Lodgepole Road	3,168	$36,000.00	$8,800.00	$44,800.00
Brusett Road	317	$0.00	$0.00	$0.00
Hell Creek Road	2,640	$30,000.00	$7,300.00	$37,300.00
Highway 59	3,696	$42,000.00	$10,200.00	$52,200.00
Brockway	264	$90,000.00	$800.00	$90,800.00
South Highway 24	1,320	$0.00	$6,000.00	$6,000.00
Union Road	158	$120,000.00	$500.00	$120,500.00
Highway 200 South	528	$570,000.00	$1,500.00	$571,500.00
Highway 200	50,160	$1,380,000.00	$138,200.00	$1,518,200.00
Highway 254	1,056	$0.00	$3,000.00	$3,000.00
Totals		**$2,313,000.00**	**$186,500.00**	**$2,499,500.00**

Table 11.2 Pump Station Power Costs (MEC Option)

The three BPS that cost $0 is because the single-phase distribution line is adjacent and would be considered a service line.

Adding both the costs for the power to the WTP and Intake, and the BPS within DRWA's system brings the total power costs to $85,993,733.70. These costs were added to the FCE.

11.4 SCADA

SCADA was not developed for this report since the NED hasn't been completed by BOR and their Contractor which determines the final project size.

12.0 Construction Cost Estimate & Phasing Plan

The DEC Report required cost estimates from the 2012 Feasibility Study be re-evaluated to accurately represent the total project cost. The DEC Team raised concerns with missing or underestimated items, lump sum items, allowances for construction contingencies, missing non-contract costs, allowance for escalation, and miscellaneous other items which when taken collectively represent a significant cost that is missing from the total project estimate. The DEC Report requests the preparer, checker, and peer reviewer names/signatures added to the quantities and cost estimates. The 2012 feasibility cost estimate terminology did not match BORs.

Interstate Engineering addressed the concerns raised in the DEC Report and prepared a detailed Field Cost Estimate (FCE), Construction Cost Estimate (CCE), Phasing Plan, and Project Cost Estimate (PCE) in 2026 dollars to reflect the preliminary layout and design of the DRWA Regional Water System using Reclamation Directives and Standards. The FCE is an estimate of the capital costs of a project from award to construction closeout and includes mobilization, procurement strategies, and contingencies. The CCE is developed by adding the noncontract costs to the field cost estimate. The PCE is used for seeking congressional authorization and funding. Reclamation allows third parties (consultants) to prepare cost estimates per FAC 09-01 & FAC 09-02. Reclamation reviews the cost estimate following FAC 09-03. The consultant preparing the cost estimate oversees the technical adequacy of the design and the accuracy of the associated cost estimates.

The CCE was inflated from 2022 dollars to 2026 dollars in anticipation of FY 2026 Authorization and Appropriation from Congress. Design and construction are planned to begin at the end of FY 2026 and phased over a 10-year period with completion in 2035. The BOR requires the future annual phase costs to be discounted by the rate published in the Federal Register each November. The discount maximum adjustment allowed for the current fiscal year is ¼ of 1 percentage point. The discount rate to be used for the period of October 1, 2022, through and including September 30, 2023, for this project is 2.50%. For Federal water resources planning, the discount rate is used to discount future benefits and costs and convert them to a present value basis. The year for each phase is discounted back to 2026 present-value dollars for the final PCE. The 2026 discounted PCE will be used by Reclamation to analyze the Feasibility of the DRWA's Regional Water System.

12.1 Development of the FCE

The FCE reflects multiple items that have been addressed by this report. The updating of the 2012 hydraulic model to 2022 and the advancements in water treatment process and design has brought the individual items in the FCE up to BOR estimating standards. Additionally, development of construction details and engineering judgement has further refined the FCE. The DRWA GIS has been instrumental in setting up the 2022 pipeline routes which serve possible users within DRWA's service area.

12.1.1 Bid Tabs

Using Interstate Engineering's and DPRW's Scobey-Flaxville previous bid tabs from 2015 through 2022, Interstate Engineering compiled a master field cost estimate spreadsheet. Interstate Engineering further refined the spreadsheet by contacting utility contractors within DRWA service area to supply information and pricing from their past rural water design and construction engineering experience. It should be noted that profit and overhead is included in each bid item.

These projects varied from municipal water to rural water and were located across Montana and North Dakota. Each bid item pulled from the bid tabs are summarized in Appendix 12.0.

Three different inflation sources were compared: US Government Consumer Price Index, BOR Construction Cost Trends Pertaining to Distribution Pipelines, and Engineering News Record Construction Cost Index. Table 12.0, on the next page, shows the three sources.

CPI Construction Cost Trends			BOR Construction Cost Trends			ENR Construction Cost Trends		
Year	Cost Trend No.	Ratio	Year	Cost Trend No.	Ratio	Year	Cost Trend No.	Ratio
2022	281.148	1.0000	2022	440	1.0000	2022	12555.55	1.0000
2021	261.582	1.0748	2021	405	1.0864	2021	11627	1.0799
2020	257.971	1.0898	2020	396	1.1111	2020	11392	1.1021
2019	251.712	1.1169	2019	386	1.1399	2019	11206	1.1204
2018	247.867	1.1343	2018	377	1.1671	2018	10878	1.1542
2017	242.839	1.1578	2017	372	1.1828	2017	10542	1.1910
2016	236.916	1.1867	2016	362	1.2155	2016	10132	1.2392
2015	233.707	1.2030	2015	358	1.2291	2015	9972	1.2591

Table 12.0 Inflation Sources

Each source's method is similar. Interstate Engineering used the BOR Construction Cost Trends for distribution pipelines. The BOR CCT Tables were used to inflate previous year's bid items to year 2022. Each 2022 bid item cost was calculated by using the ratio of the 2022 Cost Trend No. to the Cost Trend No. of the year of the bid item and multiplied by each bid item.

An example of calculating the 2022 unit price from a 2020 unit price is shown below:

Year 2022 Cost Trend No. = 440 (BOR CCT table)

Year 2020 Cost Trend No. = 396 (BOR CCT table)

Ratio = 440 ÷ 396 = 1.11 (BOR CCT Table)

Year 2022 Unit Price = Year 2020 Unit Price × 1.11

The above construction cost trend tables from each source are in Appendix 12.1.

12.1.2 Vendor Pricing

After all bid items had been collected and pricing from past projects were inflated, vendors such as Northwest Pipe and Fittings out of Billings, MT, Forterra Pipe & Precast out of Billings, MT, and Sidney Red-E-Mix out of Sidney, MT were contacted for current material pricing. Northwest Pipe was also able to supply material costs for specific bid items that were used on the projects bid between 2015 and 2021. Copies of the vendors price quotes are in Appendix 12.2.

Interstate Engineering has concerns over the current economy, price of materials, and labor shortage. The vendor price quotes in Appendix 12.2 exceeded the bid item costs inflated from 2015-2022.

12.1.3 Labor and Equipment Pricing

Agri Industries out of Sidney, Montana, Accel Fusion out of Odessa, Texas, and Fusion Technologies, Inc out of Billings, Montana were all contacted to supply installation pricing. Using the pricing from previous years provided by Northwest pipe, the material price of the bid item was subtracted from the total cost of the corresponding bid item, leaving a price for labor and equipment. The remaining labor and equipment price for each bid item was inflated to 2022 dollars using the applicable BOR CCT Tables. This method established a baseline and starting point to compare similar bid items.

Labor and equipment prices could not be established for every bid item. Therefore, prices for labor and equipment were ratioed using engineering judgement for similar bid items. Table 12.1 presents the established labor and equipment price for bid items and the corresponding increase/decrease to reflect the labor and equipment price for the remaining similar bid items. Ratios are not linear and are indicative of size as it relates to challenges with handling and installation of larger pipes and appurtenances. The ratios in the table correlate to the adjacent size of bid item and do not reflect the established bid price.

LABOR & EQUIPMENT RATIOS		
PVC Pipe		
Size	$	% Increase/Decrease
4"-6"	$5.40	Established Bid Price
8"	$6.35	+17.5%
10"-12"	$7.30	+15%
14"	$8.40	+15%
16"-18"	$9.66	+15%
HDPE Pipe		
Size	$	% Increase/Decrease
3" CL 125	$4.58	85% of 4"-6" PVC Price
3" CL 160	$4.67	+2%
3" CL 200	$4.77	+2%
3" CL 250	$4.86	+2%
Gate Valves		
Size	$	% Increase/Decrease
3"	$426.61	-5%
4"	$449.07	-33%
6"	$673.60	Established Bid Price
8"	$712.27	Established Bid Price
10"	$854.72	+20%
12"	$1,111.14	+30%
14"	$1,444.48	+30%
16"	$2,022.28	+40%
18"	$3,033.42	+50%
Blow Off Assembly		
Size	$	% Increase/Decrease
2"	$1,672.00	Established Bid Price
4"	$2,006.40	+20%
2" Water Meter Manhole Assembly		
Size	$	% Increase/Decrease
2"	$2,508.00	+50% of 2" Blow Off
4"	$2,508.00	+50% of 2" Blow Off
CAVs		
Size	$	% Increase/Decrease
1"	$3,762.00	+50% of 2" Water Meter MH
2"	$3,762.00	+50% of 2" Water Meter MH
4"	$5,016.00	+33%

2" Rural Residential Service Assembly		
Size	$	% Increase/Decrease
2"	$2,090.00	+25% of 2" Blow Off
Pasture Tap w/Meter Assembly		
Size	$	% Increase/Decrease
2"	$2,590.00	2" Residential Service +$500
PRVs		
Size	$	% Increase/Decrease
2"	$2,508.00	2" Water Meter MH
4"	$2,508.00	2" Water Meter MH
6"	$2,508.00	2" Water Meter MH

Table 12.1 L&E Ratio

12.1.4 Bid Item Quantities

The FCE was refined to quantify bid items specific to the design of DRWA Regional Water System. A portion of bid items listed reference specific detail sheets included that are found in Appendix 6.12. The first six bid items listed below have been further broken down to reflect the parts and pieces shown in the details. The prices for these bid item breakdowns can be found in Appendix 12.3. The pricing associated with each item includes labor, material, equipment, profit and overhead.

The following list of bid items, apart from piping, provides a description of the design assumptions Interstate Engineering made using engineering judgement to calculate the FCE quantities.

Gate Valves

Gate valves are placed at every location in the hydraulic model where the watermain branches off a mainline and spaced four miles along each straight run of watermain. See Detail D5 in Appendix 6.12 for a typical gate valve installation. The placement of gate valves is conservative at the feasibility level.

Blow Off Assemblies

Blow off assemblies are found at the end of each branch line and every eight miles of mainline in the hydraulic model. Refer to Section 6.1 for branch and mainline descriptions. Pipe sizes smaller than 8-inches have been assigned a 2-inch blow off assembly and pipe sizes greater than 8-inches have been assigned a 4-inch blow off assembly to achieve flushing velocities required per AWWA C651. Blow off assemblies will be used to facilitate maintenance and construction operations. See Details D6 & D7 in Appendix 6.12 for 2” and 4” blow off assemblies. The sizing and placement for blow off assemblies are conservative at the feasibility level.

Combination Air Valves

Combination air valves are spaced along all pipelines every four miles. Pipe sizes greater than 8-inches and pipelines along major highways have been assigned a 4” combination air valve. All other lines have been assigned a 1” combination air valve. For more information on air valves, refer to Section 7.2. See Detail D9 & D10 in Appendix 6.12 for 1” and 4” combination air valves. The sizing and placement of combination air valves are conservative at the feasibility level.

2" Rural Residential Service Assembly and Pasture Taps

Each household and pasture tap will be delivered water using a 2" rural residential service assembly. For the feasibility study, each household is estimated to have 1,000 feet of 2" service line and metered using an 18" meter pit with a ¾" flow meter. Each pasture tap is estimated to have 325 feet of 2" service line and metered using an 18" meter pit with a ¾" flow meter. The quantity of rural residential service assemblies and pasture taps in the FCE was discussed in Section 6.1. See Details D13 & D14 in Appendix 6.12 for a typical 2" rural residential service assembly and meter pit assembly.

4" Water Meter Manhole Assembly

The FCE assumes each community and water district with an existing distribution system will be metered using a 4-inch water meter manhole assembly. See Detail D12 in Appendix 6.12 for a typical 4" water meter manhole assembly. The size of the meter may be reduced after consultation with each Town and their engineer. A 4-inch water meter manhole assembly is conservative at the feasibility level.

Pressure Reducing Valves

Pressure reducing valve sizes and locations are determined using the 2022 hydraulic model. Pressure Reducing Valves are sized based on the flow that goes through them. See Section 6.1 for discussion on the hydraulic model. See Detail D11 in Appendix 6.12 for a pressure reducing valve in a manhole.

Gravel Restoration

Gravel restoration was calculated using the number of Type 4 crossings. Type 4 crossings were identified using the DRWA GIS Database. For the feasibility level, each crossing was estimated to be 20 ft in length and 3 ft wide.

For example, Line 18 has a total of eight Type 4 crossings.

Gravel Restoration Area = 8 x 20 ft x 3 ft = 480 sf
480 sf ÷ 9 sy/sf = 53 sy

The unit price for gravel restoration assumed a depth of 4" crushed aggregate base course and compacted trench backfill. The breakdown for a Typical Type 4 crossing is included in Section 6.4.

Grass Restoration

Grass restoration was calculated by subtracting the total length of crossings from the total length of pipeline in the Project and multiplying the length by a 40 ft easement width. Typical crossing lengths can be found in Section 6.4.

Continuing with Line 18 as an example, Line 18 is 91,242 ft long.

Total Length of Pipe = 91,242 ft
Total Type 2 Crossings = 2 x 200 ft = 400 ft
Total Type 3 Crossings = 2 x 100 ft = 200 ft
Total Type 4 Crossings = 8 x 20 ft = 160 ft
Total Grass Restoration = 91,242 ft – 400 ft – 200 ft – 160 ft = 90,482 ft
90,482 ft x 40 ft ÷ 43560 sf/ac = 83 acres.

Tanks
Tank sizes and locations are determined by using the 2022 hydraulic model. Refer to Section 6.2.1 for tank information and cost breakdowns. Quotes and added tank pricing breakdowns are included in Appendix 12.4.

Electrical Services
McCone Electric supplied quotes to extend electrical service to each pump station and the water treatment facility. Easement costs to extend electrical service for McCone Electric were added to the FCE by the Team. All electrical information and price breakdowns can be found in Section 6.2.2. McCone Electric has had high turnover throughout the creation of the Predesign Report. Alignments have been revised and estimates have varied throughout the creation of this report. The cost for electrical service for the FCE is currently being refined with McCone Electric and will include costs for engineering, construction, and right-of-way acquisition. The FCE, CCE and PCE will be updated when final estimates are received from McCone Electric.

Pump Stations
Pump station sizes and locations are determined using the 2022 hydraulic model. Refer to Section 6.2.2 for pump station information and cost breakdowns. Quotes and added pump station pricing breakdowns can also be found in Appendix 12.4.

Rock Excavation
Rock excavation was calculated by cross-referencing the USDA Soil Survey Information with the location of the 2022 DRWA pipelines in the DRWA GIS. The footage of bedrock is calculated at 29% of the total pipe length. Soils that have bedrock between 1 ft and 6 ft in depth along the pipe corridor were sorted using the DRWA GIS. A map of these locations is included in Appendix 12.5. The quantity for rock excavation was estimated using a trench width of 3 feet wide, the length as shown above, and the depth as indicated by USDA.

Continuing with Line 18 as an example, Line 18 is 91,242 ft long.

Total Length of Pipe = 91,242 ft
Approximate Depth of Rock = 3.62 ft
Trench Width = 3 ft
Total Rock Excavation Area = 91,242 ft x 3.62 ft x 3 ft x 29% = 287,358 cf
287,358 sf ÷ 27 sy/sf = 10,645 cy

Table 12.2 below shows the total volume of rock excavation at each foot of depth across the Project.

ROCK EXCAVATION QUANTITIES		
Depth (FT)	Total Length (LF)	Total Volume (CY)
5	32,330.33	17,961.29
4	1,079,929.12	479,968.50
3	3,638.54	1,212.85
2	726,996.20	161,554.71
	1,842,894.19	660,697.35

Table 12.2 Rock Excavation Quantities

There are concerns with the high percentage of soil classified as bedrock in the Project's area; however, the calculated quantity is conservative for the feasibility study. During construction, the Contractor will have the ability to work with DRWA and Engineer to relocate pipelines in bedrock areas, as appropriate. Additionally, geotechnical investigations can be performed at the feasibility level to provide higher reliability with the amount of rock excavation that can be expected across the service area, if required.

Type I Imported Pipe Bedding

Type I imported pipe bedding was assumed to be 3% of the total length of pipe over the entire Project. A bedding depth of 6" in a trench width of 3 feet was used to estimate the quantity for Type I imported pipe bedding.

Continuing with Line 18 as the example, Line 18 is 91,242 ft

Type I Imported Pipe Bedding Length = 91,242 ft x 3% = 2,737.26 ft

Type I Imported Pipe Bedding Volume = 2,737.26 ft x 3 ft x 0.5 ft = 4105.89 cf

4,105.89 cf ÷ 27 cf/cy = 152 cy

The quantity for Type I Imported Pipe Bedding is conservative at the feasibility level. See Section 7.4 for further discussion on the requirements of pipe bedding.

Testing Laboratory Service

Testing laboratory services was estimated using the assumption of one compaction test every mile of watermain. Testing is required when the water main is placed underneath a gravel or asphalt roadway. No compaction is required for water main installed outside of travelled surfaces. Testing and laboratory services are supplied for rural water projects by a third-party testing agency. The Contractor is reimbursed by the Owner for the actual price of testing services with a 0% mark-up. The price for retesting of any kind is not allowed for reimbursement.

Dewatering

The number of dewatering days is estimated in ranges of pipe length segment. Dewatering was estimated to be 5 days for lines less than 100,000 ft of pipe, 10 days for lines between 100,000 and 150,000 ft of pipe, 15 days for lines between 150,000 and 200,000 ft of pipe, and 20 days for lines greater than 200,000 ft of pipe. The longest pipe segment in the FCE is Line Segment 60 at 240,148 ft. The quantity for dewatering is conservative at the feasibility level for this Project's area. Additional information on dewatering and pricing can be found in Section 7.11.

Utility Crossings

Utility crossings were calculated by cross-referencing the available utility shapefiles with the location of the 2022 DRWA pipelines in the DRWA GIS Database. A map showing known utility crossings can be found in Appendix 12.5. The project will encounter additional utility crossings during construction, not currently identified in DRWA's GIS Database. Costs for additional utility crossings not included in the DRWA GIS Database are accounted for in Design Contingencies. During design, the Engineer will route the pipeline to minimize utility crossings and project cost.

Type 2 Stream Crossings

Type 2 Stream Crossing lengths were measured and totaled using the DRWA's GIS Database. Where each pipeline crossed a stream, the crossing length was measured and totaled for that line number and pipe size. The totals are included in the individual line number estimates. A map showing stream crossing can be found in Appendix 12.5. See Detail D18 in Appendix 6.12 for a typical Type 2 Stream Crossing.

Road Crossings

Type 1 Highway and Railroad Crossings, Type 3 Road Crossings, and Type 4 Road Crossings were manually counted using DRWA's GIS Database along each pipe alignment and provided a standard length for the feasibility level FCE. The breakdown for road crossings can be found in Section 6.4. See Details D17 & D19 in Appendix 6.12 for typical road crossing details.

Mobilization

Mobilization is set for the Project at 5% and is the industry standard for rural water projects in the area.

All bid items summarized in the design assumptions have been totaled for each line number and used to create a portion of the Project's FCE. A summary of major field items and unit prices used for the FCE can be found in Appendix 12.6. The Project's total FCE can be found in Appendix 12.7. The total of major field items including mobilization is:

Total Major Field Items =	$412,830,000
Mobilization (5%) =	$20,641,500
	$433,471,500

12.1.5 Special Allowances

Special allowances for Reclamation's rural water projects are defined and outlined in FAC 09-01. These allowances consist of design contingencies, allowance for procurement strategies, and construction contingencies.

Design Contingencies

Design contingencies for the Project account for minor unlisted items, design and scope changes, and cost estimating refinements. The allowance for design contingencies normally ranges from 2 to 20% of the total major field items plus mobilization.

Known minor unlisted items for the Project include unknown utility crossings, disinfection and pressure testing of pipelines and fitting costs. Unknown utility crossings were discussed above. Disinfection and pressure testing of pipelines is based on Contractor means and methods and is challenging to calculate accurately at a feasibility level. Material costs for minor fittings and appurtenances were not broken out as a separate bid item at the feasibility level. Minor costs for fittings and appurtenances in the bid tabs from 2015 through 2022 account for 2-4% for municipal projects, and 0.2 – 3% on rural projects. See Appendix 12.8 for the fitting cost percentages used.

A considerable effort was spent by Interstate Engineering to minimize the amount of design and scope changes on the Project. A geotechnical investigation will be performed for the Intake and Water Treatment Plant as well as Booster Pump and Tank locations. Any added work associated with site-specific data obtained is included in design contingencies. Assuming 100% of current households will be served by the Project helps reduce the design contingencies associated with quantity variations and provides another level of conservatism to the Project's FCE.

Interstate Engineering has established Design Contingencies at 10% for the Project. The percentage chosen is indicative of the effort Interstate Engineering has placed in preparing the FCE using the cost risk analysis that has previously been performed by the DEC Team. However, Interstate Engineering has concerns with the current state of the economy. Interstate Engineering may need to revisit the Design Contingencies as the feasibility study advances to account for unanticipated price adjustments and escalations.

The Project's FCE can be found in Appendix 12.7. Design Contingencies for the Project is calculated below:

Total Major Field Items + Mob (5%) =	$433,471,500
Design Contingencies (10%) =	$43,347,150
	$476,818,650

Allowance for Procurement Strategies

The Project is intended to be advertised and awarded under full and open competition in a minimum of 10 phases. This approach is common for Reclamation rural water projects. However, Interstate Engineering recognizes that procurement strategies may change throughout the course of the project depending on geography, Contractor availability and Contractor specialties. As a result, Interstate Engineering assigned 3% contingency to the Project for Procurement Strategies. Reclamation typically uses a range of 3 to 5% for procurement strategies. See Section 12.3 for further discussion on the Project's phases.

The Project's FCE can be found in Appendix 12.7. Allowance for Procurement Strategies for the Project is calculated below:

Total Major Field Items + Mob (5%) + D.C. (10%) =	$476,818,650
Allowance for Procurement Strategies (3%) =	$14,304,560
	$491,123,210

Construction Contingencies

Construction contingencies for the Project accounts for minor differences in actual and estimated quantities, unforeseeable difficulties at the site, changed site conditions, possible minor changes in plans, and other uncertainties. The allowance for construction contingency normally ranges from 20 to 25% of the total major field items and mobilization, including the allowance for design contingencies and procurement strategies.

One known uncertainty for the Project is prevailing wage rates. Based on each Phase's funding package, wage rates for the project will either be Davis-Bacon or the higher of Montana Prevailing Wage & Davis-Bacon. With the recent addition of the City of Miles City and the City of Sidney as Dispatch Cities, Interstate Engineering does not expect large variations in the zone pay that is attributed to the prevailing wage rate.

Interstate Engineering has established Construction Contingencies at 20% for the Project. Items such as the SWPPP permitting, thrust restraints, and insulation will be covered within this percentage. The percentage chosen is indicative of the effort Interstate Engineering has placed in preparing the FCE using the cost risk analysis that has previously been performed by the DEC Team. However, Interstate Engineering has concerns with the current state of the economy. Interstate Engineering may need to revisit the Construction Contingencies as the feasibility study advances to account for Contractor availability and specialties along with the state of the economy.

The Project's FCE can be found in Appendix 12.7. Construction Contingencies for the Project is calculated below:

Total Major Field Items + Mob (5%) + D.C. (10%) + A.F.P.C. (3%) =	$491,123,210
Construction Contingencies (20%) =	<u>$95,363,730</u>
	$586,490,000

12.2 Developing the Construction Cost Estimate

The CCE was developed by adding Non-Contract Costs to the FCE.

12.2.1 Non-Contract Costs

Non-contract costs include items for services provided in support of the project. Non-contract costs for the Project include the following: USBR Facilitating Services, Environmental, Easements/Right-of-Way/Land Purchases, Geotechnical Investigations of tank and pump stations, Archaeological Surveys, Design Surveys, Design Engineering, Project Management, Construction Observation, Construction Management, and Other (office). Environmental surveys and assessments have been specifically excluded from the CCE. Reclamation will perform the NEPA for the Project during the feasibility study.

Percentages for each Non-Contract cost were set using engineering judgement in conjunction with the recent DRWA Culbertson-Lambert-Fairview (CLF) Project, the current DRWA Highway 200 West project, and other recent Interstate Engineering rural water projects in North Dakota. Supporting information can be provided upon request. Table 12.3 on the next page shows the percentages Interstate Engineering has established for the Project's Non-Contract Costs.

Contract & Non-Contract Cost Percentages	
Contract Costs	
Mobilization	5.00%
Design Contingencies (2%-20%)	10.00%
Procurement Strategies (3%-5%)	3.00%
Construction Contingencies (20%-25%)	20.00%
Non-Contract Costs	
USBR Facilitating Services	4.00%
Environmental	0.50%
Easements/Right-of-Way/Land Purchases	0.75%
Geotechnical Investigation	0.50%
Archeological	0.25%
Design Surveys	2.00%
Design	6.50%
Project Management	1.50%
Construction Observation	9.00%
Construction Management	1.50%
Other (Office)	2.00%

Table 12.3 Contract & Non-Contract Cost Percentages

Non-Contract Costs for Reclamation's rural water projects typically range from 20 to 40% of the Total FCE. The total Non-Contract Costs for the Project are 29.25% of the FCE.

12.2.2 Construction Cost Estimate

The Construction Cost Estimate for the Project was created by adding the above Special Allowances to the FCE. Project's CCE can be found in Appendix 12.7 and is shown in Table 12.4, below.

Master CCE		
Subtotal Major Field Items		**$412,830,000.00**
Mobilization	5%	$20,641,500.00
Subtotal with Mobilization		**$433,471,500.00**
Design Contingencies (2%-20%)	10%	$43,347,150.00
Subtotal with Design Contingencies		**$476,818,650.00**
Procurement Strategies	3%	$14,304,560.00
Subtotal with Procurement Strategies		**$491,123,210.00**
Construction Contingencies (20%-25%)	20%	$95,363,730.00
Subtotal with Construction Contingencies		**$586,490,000.00**
Total Field Costs		$586,490,000.00
Non-Contract Costs		
USBR Facilitating Services	4.00%	$23,459,600.00
Environmental	0.50%	$2,932,450.00
Easements/Right-of-Way/Land Purchases	0.75%	$4,398,675.00
Geotechnical Investigation	0.50%	$2,932,450.00
Archeological	0.25%	$1,466,225.00
Design Surveys	2.00%	$11,729,800.00
Design	6.50%	$38,121,850.00
Project Management	1.50%	$8,797,350.00
Construction Observation	9.00%	$52,784,100.00
Construction Management	1.50%	$8,797,350.00
Other (Office)	2.00%	$11,729,800.00
Subtotal Non-Contract Costs		$167,149,650.00
Total Construction Cost		$753,640,000.00

Table12.4 Master CCE

The Project will supply safe and reliable drinking water to 4,403 rural and municipal connections within DRWA's service area. The total water main service pipe length is 6,743,843 LF and the total construction cost estimate is $753,640,000. Therefore, the cost per lineal foot is $111.75/LF. The cost per rural and municipal connection is $171,165.12/connection. The worth of this Project is increased dramatically when factoring in pasture taps and the increase in livestock production which benefits the nation as a whole. Reclamation is performing the economic analysis of the Project during the feasibility study.

12.3 Development of the Phasing Plan

The construction duration for the Project is 10 years, beginning from the Notice to Proceed, as is recommended by and typical of Reclamation's rural water projects. Phases were assigned by Interstate Engineering based on pipeline orientation within the Project and pipeline length. The duration of each Phase was established by assigning installation rates to each size of pipeline and verified against the area's construction season. The Phasing Plan is not only used to plan construction of the Project but also used to lobby the federal, state, and local funding needed ahead of design and construction activities.

12.3.1 Assigning Phases

The Project was split into 141 individual line numbers. Each line number is assigned quantities using the hydraulic model, the "100% Saturation for Year 2022" spreadsheet, design assumptions discussed above, and the DRWA GIS database. Unit prices were assigned to each line number. Cost estimates for individual line numbers are found in Appendix 12.9. Line numbers are labeled on the Project Map, which is in Appendix 6.6. The Project consists of 16 Phases over 10 years and is illustrated in Appendix 12.10. Phases were established using a combination of cost estimates for each line number, pipeline lengths and quantity of residential meters. The size of each phase was verified by Interstate Engineering using reasonable construction milestones and verified against installation rates. With the duration of the Project set at 10 years, Phases were combined to maximize each year / construction season.

Phases were organized to capture the bulk of revenue from the Project's bulk users in the first years of the Project to cover OM&R costs and provide coverage for construction loans. After all bulk users are connected, prioritization of the Phases shifted to those rural reaches with the greatest quantity of residential meters through Project completion. Appendix 12.11 breaks down each line number by phase. Each line number shows the pipe lengths, residential meters, installation time, and total costs to construct.

The Water Treatment Facility and the Town of Circle will be reached within the first year of construction. Richey and Lambert will be connected in the second year and Fairview at the end of the third year. Jordan will be connected in year five and West Glendive in year six. The Project is planned to be complete in 10 years.

12.3.2 Installation Rates

Contractors familiar with nuances of the Project area such as weather patterns, soil conditions, labor rates, etc. were consulted. Agri Industries out of Sidney, MT, Western Municipal out of Billings, MT, and Macon Supply out of Sidney, MT supplied average installation rates within the Project's area for ranges of pipe sizes. Ranges are based on a combination of installation techniques and weight of materials per one crew. Pipes below 4" in diameter are assumed to be installed using plowing and/or trenching methods. Pipes greater than 6" are assumed to be installed using traditional open cut methods; however, pipes greater than 12" in diameter are considerably more difficult to handle. Table 12.5 below shows the ranges of installation rates by pipe size.

Installation Rates Per One Crew		
Pipe Size		Installation Rate (ft/day)
3"-4"	=	10,000
6"-10"	=	1,800
12"-24"	=	1,200

Table 12.5 Installation Rates

Installation rates were applied to each line number. Construction of rural water pipelines in the Project's area is limited to nine months out of the year, or 200 working days. Components of features such as the water treatment facility, pumping stations, and storage tanks can be completed year-round and constructed simultaneously with pipeline installations. As a result, the total number of construction days for each Phase is controlled by the lineal footage of pipeline within each segment. If the total construction days for the combined Phases in each construction year are greater than 200 calendar days, the Contractor is assumed to have more than one crew on site. Contractors typically assign more than one crew to rural water projects.

12.3.3 Phasing Plan

The Phasing Plan is intended to be a living document and may be altered during construction with input from the DRWA Board of Directors and coordination with applicable Funding Agencies, most importantly Reclamation. The timeliness of the Project's Phases and overall completion is contingent on availability of federal funding. Table 12.6 below shows Interstate Engineering's selected Phasing Plan. Table 12.6 shows the year each Phase is constructed and placed in service, each Phase's rural and fixed demands, and each Phase's total pipeline length.

PHASING PLAN									
Location	Installation Year	Phase		# of Residences	Rural Curve (gpm)	Town Fixed Demand (gpm)	Total Demands (gpm)	Length of Pipe (ft)	Length of Pipe (miles)
Ft. Peck→Circle	1	A→B	=	174	159.9	311	470.9	446,316	84.5
Circle→Richey	2	B→C	=	12	22.2	125	147.2	146,462	27.7
Richey→HWY 200/RD 317		C→D	=	6	15.0		15.0	64,928	12.3
HWY 200/RD 317→Lambert	3	D→K	=	314	266.1	101	367.1	460,204	87.2
HWY 200/RD 317→HWY 201/RD 328	4	D→P	=	51	59.8		59.8	335,117	63.5
HWY 201/RD 328→HWY 16	5	P→E	=	43	52.6		52.6	279,278	52.9
HWY 16→Fairview		E→J	=	94	96.2	312	408.2	263,417	49.9
Circle→Jordan	6	B→H	=	138	131.6	217	348.6	921,741	174.6
Circle→Glendive	7	B→G	=	55	63.3	353.5	416.8	353,425	66.9
Circle→Missouri River		B→F	=	258	224.1		224.1	987,082	186.9
Richey→S. Richey	8	C→I	=	105	105.2		105.2	519,419	98.4
Hwy 16→Culbertson		E→L	=	75	80.4		80.4	433,898	82.2
Jordan→Lodge Pole Rd	9	H→N	=	66	72.8		72.8	539,800	102.2
Jordan→Cohgen		H→O	=	65	71.9		71.9	263,867	50.0
Richey→HWY 201/RD 328	10	C→P	=	62	69.3		69.3	458,146	86.8
Ft. Peck→HWY 528		A→M	=	46	55.3		55.3	270,743	51.3
				1564	1545.7	1419.5	2965.2	6,743,843	1277.2

Table 12.6 Phasing Plan

Table 12.7 shows the year each Phase is constructed and placed in service, each Phase's total pipeline length, associated installation rate and time, and the total project phase cost. Appendix 12.12 includes tables that show which pipelines are included in each phase and breaks down the material and installation costs for each phase. The map in Appendix 12.10 shows the corresponding year and which Phases will be constructed.

PHASING PLAN COSTS

Location	Installation Year	Phase		Install Rate (miles/day)	Length of Pipe (miles)	Installation Time (days)	$/Day	Total $
Ft. Peck→Circle	1	A→B	=	0.35	84.5	239	$575,504.81	$137,489,173.67
Circle→Richey	2	B→C	=	0.13	27.7	222	$72,972.28	$16,179,988.02
Richey→HWY 200/RD 317		C→D	=	0.10	12.3	122	$54,440.51	$6,644,554.55
HWY 200/RD 317→Lambert	3	D→K	=	0.60	87.2	145	$243,351.05	$35,223,423.28
HWY 200/RD 317→HWY 201/RD 328	4	D→P	=	0.25	63.5	254	$60,940.31	$15,459,033.55
HWY 201/RD 328→HWY 16	5	P→E	=	1.09	52.9	48	$293,616.98	$14,223,295.69
HWY 16→Fairview		E→J	=	0.47	49.9	106	$105,086.82	$11,127,420.60
Circle→Jordan	6	B→H	=	1.30	174.6	134	$327,984.68	$43,886,340.19
Circle→Glendive	7	B→G	=	0.28	66.9	237	$93,696.84	$22,227,479.18
Circle→Missouri River		B→F	=	3.16	186.9	59	$547,649.37	$32,417,751.57
Richey→S. Richey	8	C→I	=	1.04	98.4	95	$153,133.97	$14,509,940.02
Hwy 16→Culbertson		E→L	=	1.33	82.2	62	$189,884.08	$11,710,733.64
Jordan→Lodge Pole Rd	9	H→N	=	1.43	102.2	71	$245,710.28	$17,555,191.67
Jordan→Cohgen		H→O	=	0.44	50.0	115	$61,565.99	$7,061,167.60
Richey→HWY 201/RD 328	10	C→P	=	0.80	86.8	108	$153,961.65	$16,639,186.56
Ft. Peck→HWY 528		A→M	=	1.72	51.3	30	$351,091.55	$10,472,027.10
					1277.3	2046		$412,826,706.89

Table 12.7 Phasing Plan Costs

Construction of the Project will take more than 10 years should federal funding not be made available in accordance with the Phase Plan and in a timely matter. This shortfall may result in expenditure of the Project's contingencies early in the construction schedule of the Project if construction costs do not increase annually according BOR Construction Cost Trends Pertaining to Distribution Pipelines. Therefore, it is prudent for DRWA and Reclamation to work together to advocate for the necessary funding to complete the Project as shown in the Phasing Plan.

12.4 Development of the Project Cost Estimate

12.4.1 Inflation of CCE to Notice to Proceed and Project Completion

The developed CCE for the Project is escalated from 2022 dollars to 2026 using an inflation rate of 4%. The inflation rate was selected as a balance between a normal inflation rate of 2% and recent inflation rates of 8.5%. A Notice to Proceed is planned to be issued for the Project in 2026.

Construction is planned to commence in the beginning of 2026. As a result, Year 1 in Table 12.6 and Table 12.7 of the Phasing Plan is expected to be constructed and placed in service by the end of Year 2026. Year 2 will be constructed and placed in service by the end of Year 2027 and so forth with the

Project completion planned for the end of year 2035. The CCE for each installation year is escalated using an inflation rate of 4%, beginning in 2026.

12.4.2 Project Cost Estimate

The CCE of each installation year was discounted back to the year 2026 to calculate the total PCE in 2026 dollars using a rate of 2.50%. The discount rate was taken from OMB Circular No. A-94. PCE for the Project is estimated at $891,957,210.33 in 2026 dollars. Table 12.8 shows the FCE, CCE, and PCE broken out by installation year.

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		Year 1 (2026)	Year 2 (2027)	Year 3 (2028)	Year 4 (2029)	Year 5 (2030)	Year 6 (2031)	Year 7 (2032)	Year 8 (2033)	Year 9 (2034)	Year 10 (2035)
Subtotal		$116,255,938.10	$35,348,201.21	$17,810,824.93	$36,691,612.95	$17,531,218.64	$42,081,925.39	$36,294,493.13	$48,804,844.41	$40,131,468.98	$21,876,179.14
Mobilization	5.00%	$5,812,796.91	$1,767,410.06	$890,541.25	$1,834,580.65	$876,560.93	$2,104,096.27	$1,814,724.66	$2,440,242.22	$2,006,573.45	$1,093,808.96
Subtotal with Mobilization		$122,068,735.01	$37,115,611.27	$18,701,366.18	$38,526,193.60	$18,407,779.57	$44,186,021.66	$38,109,217.79	$51,245,086.63	$42,138,042.43	$22,969,988.10
Design Contingencies (2%-20%)	10.00%	$12,206,873.50	$3,711,561.13	$1,870,136.62	$3,852,619.36	$1,840,777.96	$4,418,602.17	$3,810,921.78	$5,124,508.66	$4,213,804.24	$2,296,998.81
Subtotal with Design Contingencies		$134,275,608.51	$40,827,172.40	$20,571,502.79	$42,378,812.96	$20,248,557.53	$48,604,623.83	$41,920,139.57	$56,369,595.29	$46,351,846.67	$25,266,986.91
Construction Contingencies (20%-25%)	20.00%	$26,855,121.70	$8,165,434.48	$4,114,300.56	$8,475,762.59	$4,049,711.51	$9,720,924.77	$8,384,027.91	$11,273,919.06	$9,270,369.33	$5,053,397.38
Subtotal with Construction Contingencies		$161,130,730.21	$48,992,606.88	$24,685,803.35	$50,854,575.55	$24,298,269.04	$58,325,548.59	$50,304,167.48	$67,643,514.35	$55,622,216.01	$30,320,384.29
Total Field Costs		$161,130,730.21	$48,992,606.88	$24,685,803.35	$50,854,575.55	$24,298,269.04	$58,325,548.59	$50,304,167.48	$67,643,514.35	$55,622,216.01	$30,320,384.29
Non-Contract Costs											
USBR Facilitating Services	4.00%	$6,445,229.21	$1,959,704.28	$987,432.13	$2,034,183.02	$971,930.76	$2,333,021.94	$2,012,166.70	$2,705,740.57	$2,224,888.64	$1,212,815.37
Environmental	0.50%	$805,653.65	$244,963.03	$123,429.02	$254,272.88	$121,491.35	$291,627.74	$251,520.84	$338,217.57	$278,111.08	$151,601.92
Easements/Right-of-Way/Land Purchases	1.50%	$2,416,960.95	$734,889.10	$370,287.05	$762,818.63	$364,474.04	$874,883.23	$754,562.51	$1,014,652.72	$834,333.24	$454,805.76
Geotechnical Investigation	0.50%	$805,653.65	$244,963.03	$123,429.02	$254,272.88	$121,491.35	$291,627.74	$251,520.84	$338,217.57	$278,111.08	$151,601.92
Archeological	0.25%	$402,826.83	$122,481.52	$61,714.51	$127,136.44	$60,745.67	$145,813.87	$125,760.42	$169,108.79	$139,055.54	$75,800.96
Design Surveys	2.00%	$3,222,614.60	$979,852.14	$493,716.07	$1,017,091.51	$485,965.38	$1,166,510.97	$1,006,083.35	$1,352,870.29	$1,112,444.32	$606,407.69
Design	6.50%	$10,473,497.46	$3,184,519.45	$1,604,577.22	$3,305,547.41	$1,579,387.49	$3,791,160.66	$3,269,770.89	$4,396,828.43	$3,615,444.04	$1,970,824.98
Project Management	1.50%	$2,416,960.95	$734,889.10	$370,287.05	$762,818.63	$364,474.04	$874,883.23	$754,562.51	$1,014,652.72	$834,333.24	$454,805.76
Construction Observation	9.00%	$14,501,765.72	$4,409,334.62	$2,221,722.30	$4,576,911.80	$2,186,844.21	$5,249,299.37	$4,527,375.07	$6,087,916.29	$5,005,999.44	$2,728,834.59
Construction Management	1.50%	$2,416,960.95	$734,889.10	$370,287.05	$762,818.63	$364,474.04	$874,883.23	$754,562.51	$1,014,652.72	$834,333.24	$454,805.76
Other (Office)	2.00%	$3,222,614.60	$979,852.14	$493,716.07	$1,017,091.51	$485,965.38	$1,166,510.97	$1,006,083.35	$1,352,870.29	$1,112,444.32	$606,407.69
Subtotal Non-Contract Costs		$47,130,738.59	$14,330,337.51	$7,220,597.48	$14,874,963.35	$7,107,243.69	$17,060,222.96	$14,713,968.99	$19,785,727.95	$16,269,498.18	$8,868,712.40
Total Phase Cost		$208,261,468.79	$63,322,944.39	$31,906,400.83	$65,729,538.90	$31,405,512.73	$75,385,771.55	$65,018,136.47	$87,429,242.30	$71,891,714.19	$39,189,096.69
Construction Cost (with Escalation to NTP, Price Level 2026)		$243,636,461.99	$77,042,044.08	$40,371,775.79	$86,495,589.07	$42,980,612.74	$107,297,459.14	$96,242,724.92	$134,593,301.70	$115,100,950.68	$65,252,726.67
2026 Present Value		$237,694,109.26	$73,329,726.66	$37,489,207.22	$78,360,734.69	$37,988,598.86	$92,522,262.74	$80,965,658.60	$110,466,990.83	$92,164,595.67	$50,975,325.79

Table 12.8 Inflation and Discount Costs

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As discussed throughout this Section, there are opportunities to refine the FCE, CCE and PCE as work continues to progress with DRWA and Reclamation through development of the Feasibility Study. The biggest variable attributable to the FCE and CCE continues to be the state of the economy. The PCE is contingent upon the timeliness of the federal funding.