TO: GOVERNANCE COMMITEE

FROM: STAFF OF THE EXECUTIVE DIRECTOR'S OFFICE

SUBJECT: SLURRY WALL STORAGE FACILITY APPROACH – PILOT OR FULL SCALE?

DATE: FEBRUARY 21, 2017

Slurry wall storage facilities are an important component of the Platte River Recovery Implementation Program's (Program) Water Action Plan (WAP). These projects would store water diverted from the Platte River when flows are in excess of target flows and release the water back to the river when flows are in deficit of target flows, much like a conventional reservoir. It is anticipated that approximately 9,000 AF of the remaining 40,000-plus AF reduction to target flows could be achieved through the construction and operation of slurry wall storage facilities.

The EDO is considering three approaches to implementation of an initial slurry wall storage project. The approaches are outlined below and addressed in detail in the attachments. The first two approaches are pilot-level projects that would test the construction, function and (potentially) operation of the slurry wall storage concept before advancing to a full-scale project. These approaches are site specific to the Elm Creek complex (Bartels property) and are discussed in detail in **Attachment A**, which is a memorandum authored by Mike Applegate, Special Advisor to the Program in slurry wall infrastructure. The third approach is simply to move towards implementing a full-scale project. This approach is not site-specific and is consistent with what was presented as part of the first increment extension language and budget development.

The EDO is requesting GC guidance on the preferred approach to slurry wall project implementation. This memorandum and its supporting documentation are intended to help guide discussions at the GC meeting on March 7-8, 2017. In addition, Mike Applegate will be in attendance and available to answer questions and support discussions.

<u>Approach 1 – Non-Functional Pilot Project at Elm Creek Complex</u>
This is the minimum size project (and consequently the lowest cost) necessary to field test the performance of the slurry wall and floor (i.e., the low permeability layer). Details are provided in **Attachment A**.

Project highlights:

- Constructed at the Elm Creek complex (Bartels property)
- Includes slurry wall and dewatering well
- Non-functional (i.e., does not allow for water deliveries and releases)
- No excavation necessary
- Simply tests the construction and function of the slurry wall and low permeability floor

The cost of a 10 acre non-functional pilot project is estimated to be on the order of $700,000 (**Attachment A**), and has an implementation time of about 1 year. Preliminary analyses show that pilot-project costs roughly scale with the size of the project (i.e., a 20-acre pilot would cost on the order of $1.2 million).

Approach 2 – Functional Pilot Project

This is consistent with Approach 1 but adds the necessary components to become a functional project involving deliveries and releases. Details are provided in **Attachment A**.

Project highlights:

- Constructed at the Elm Creek complex (Bartels property)
- Includes slurry wall and water delivery and release infrastructure
- Functional (i.e., can be operated as a Program water supply project)
- Excavated storage area (can also be unexcavated but storage area would be about 20% of that of the excavated option)
- Tests the construction, function and operation of the slurry wall storage facility, and will establish a process developing/acquiring permits, water service agreements, and other components that will be necessary for a full-scale project.

The cost of additional features to develop a 10-acre functional pilot project is estimated to be about $900,000, plus the $700,000 outlined in Approach 1, for a total on the order of $1.6 million (**Attachment A**). This project has an implementation time of about 2 years. The additional year of time when compared to Approach 1 is due to the need to work with NPPD to figure out how to withdraw water from the canal (operationally and structurally), the need to excavate the project and the need for additional permitting. The estimated Program score for a 10-acre project would be on the order of 150 to 200 AF, depending on final storage capacity, as well as inlet and outlet capacities. Preliminary analyses show that pilot-project costs and scores roughly scale with the acreage of the project (i.e., a 20-acre pilot would cost on the order of $2.5 to $3 million and would likely result in a score of 300 to 400 AF).

Approach 3 – Full-Scale Project

This approach is simply the implementation of a full-scale slurry wall storage project. This project would likely be in the form of a slurry wall aquifer storage facility on Program lands or a slurry wall storage facility using an existing sandpit to be acquired in the future. Details are provided in **Attachment B**.

Project highlights:

- Constructed on Program lands (potentially the Plum Creek complex) or sandpits to be acquired in the future
- Full-scale, functional project
- Unexcavated (aquifer) storage or make use of existing sandpit

The cost of a full-scale project would depend on the form selected. A 116-acre unexcavated storage facility on Program lands would cost on the order of $5 million (**Attachment B**). This project would have an implementation time of about 2 years, once the site has been identified. The estimated Program score would be on the order of 800 AF, but would be highly dependent on inflow and outflow capacities (i.e., infiltration and pumping rates). Purchasing an existing sandpit and constructing a slurry wall around it as to create a storage domain would cost on the order of $6 million (**Attachment B**), including acquisition costs. This project would have an implementation time of about 2 years, once the existing pit has been acquired. Pit identification and acquisition could take 6 months to 2 years. Assuming a sand pit with a surface area of about 60 acres, the estimated Program score would be on the order of 2,000-3,000 AF, depending primarily on inlet capacity.

Attachment A:

Review of geotechnical information on PRRIP properties by Mike Applegate

Applegate Group, Inc.

Water Resource Advisors for the West

Memorandum

Date:	February 7, 2017	AG Job No.:	16-116
To:	Seth Turner, Kevin Werbylo		
From:	Mike Applegate		
Subject:	**Review of Geotechnical Information on PRRIP Properties**		

The Water Plan for the Platte River Recovery Implementation Program (Program) is primarily focused on re-timing and improving streamflow to reduce shortages to target flows by an average of 130,000 to 150,000 ac-ft per year. New storage would provide the ability for the Program to retime streamflow to be used to reduce shortages to target flows. Gravel pit storage is one approach that may provide the Program the ability to retime streamflows to meet the Water Plan objective of reducing shortages to target flows. As a special advisor to the Program Executive Director's Office (EDO), I am providing input on the feasibility of completing gravel pit storage projects.

The Program is considering several sites along the Platte River for gravel pit storage, including the Plum Creek, Elm Creek, Cottonwood Ranch Complex, Lindstrom and J-2 reservoir properties. I have reviewed the geotechnical reports provided by the EDO on these Program properties. The reports provided relevant site-specific information that would affect the viability of completing gravel pit storage at these sites. I have reviewed the information provided, and summarize the advantages/disadvantages of each of the sites for potential gravel pit storage. Additionally, steps are laid out for completing a gravel pit storage pilot project.

The purpose of the geotechnical exploration was to evaluate materials with respect to the feasibility of constructing slurry walls. The purpose of this work is to evaluate the potential to create below-grade storage as is commonly done with gravel pit reservoirs. The critical need for this approach lies with having an impermeable layer of clayey material underlying the property for a reservoir floor. This layer needs sufficient thickness to allow for a slurry wall to be keyed into it. The field thickness found in the testing would also provide some indicator of the ability of the reservoir floor to resist groundwater uplift in a reservoir drawn down condition, and also to prevent excessive leakage from the reservoir.

The geotechnical exploration for all the properties is summarized well in a memo prepared by the EDO. My review looked at these results to see if there were any concerns or questions about the results that might affect this project. I did not identify any results that seemed questionable or out of line with what would be expected.

Elm Creek Complex Pilot Project

A specific question was asked about the potential use of the Elm Creek complex for a small scale pilot test of the slurry wall concept. The property has 32 acres on the Bartels Property south of Interstate 80 that could potentially become gravel pit storage. The drilling program focused on the south side and the proposed pilot project is located there.

This proposed pilot project would field test the performance of the reservoir floor. It would involve designing and constructing a slurry wall around a small portion of the property. The larger the area that is enclosed in the slurry wall perimeter, the more representative the seepage data would be. An area of approximately 10 acres is the minimum acreage needed that would give the ability to monitor performance, and provide an estimate of storage potential that would be representative of the overall site conditions. The 10 acre pilot project could be scaled up if increased storage volume is needed by the Program, and the increased storage volume may provide additional operational information as described further below (e.g., proof of continuity of the clay reservoir floor throughout the larger Elm Creek Complex site). A 10 acre pilot project would require about 3,000 linear feet of slurry wall construction. Figure 1 attached is a conceptual plan for a pilot project. This concept will likely be modified after further discussions with the EDO. The following is a preliminary plan for executing a pilot project:

1. A slurry wall would be constructed from existing grade into the clay layer, about 18 to 20 feet below grade based on the geotechnical information provided by the EDO. It would be recommended to penetrate a minimum of three feet into this layer.
2. A series of piezometers would be installed within the perimeter to monitor groundwater table depths. Another few would be installed along the outside perimeter to see if there are any noticeable fluctuations in groundwater levels caused by dewatering operations inside the perimeter. Drawdown outside the perimeter would indicate that the slurry wall or reservoir floor may have a seepage problem.
3. A dewatering well system would be installed that could pump down the groundwater contained within the slurry wall. At this point the selection of a specific type of dewatering system has not been finalized. The dewatering pumps would be equipped with totalizer meters to measure the volume pumped. The temporary nature of this installation may warrant finding equipment that is portable and can be easily moved to future sites.
4. The geotechnical information collected gives some indication of the average void space that is contained in the alluvium. Empirical calculations would be made to estimate the volume of water that would need to be pumped to effectively evacuate the enclosed space. These calculations would be compared to the actual drawdown to determine if inflow from seepage meets acceptable levels for dominion and control of the water. If necessary, a groundwater model could be constructed to simulate the field data and get more precise estimates.
5. Piezometer levels would be checked at the start of the pumping operation. The pumps would be operated continuously to drawdown the water table inside the slurry wall. As piezometer levels dropped, the volume pumped would be compared to the empirical calculations for a mathematical check. The results would estimate the performance of the slurry wall and the reservoir floor as a unit.
6. Once the water level has been drawn down to the floor of the reservoir (about 18 to 20 feet below grade), the pumps would be shut down and piezometer measurements would continue to be taken. A weekly time step would be sufficient for this pilot test. In addition, a rain gage would be installed at the property to measure water added by precipitation. Some grading of the property may be necessary to keep surface drainage from entering the pilot site.
7. A mass balance calculation would be performed to determine the amount of seepage into the pilot test area. This would yield an estimated seepage rate that would be compared against the permeability information in the geotechnical report.
8. This information would provide a snapshot of how a large scale project might perform. The standards set by Colorado for seepage into gravel pits can provide one measurement for comparison. Discussions with the program office after the results are determined can make a decision on what standard is appropriate for the program.

There are pros and cons to using this approach.

Pros

1. The project does not require large scale excavation of gravel which saves construction costs and time. This also reduces risk in the event that the pilot does not meet the needs of the program for a reservoir. It is difficult to assign a specific number quantifying risk in this approach.

2. The shallow depth of the Elm Creek complex would allow for relatively small equipment to be used to install the slurry wall. This cuts down on costs for mobilization
3. The area is small enough to allow for rapid drawdown of the water table. If it does not drop quickly in comparison to the expected void space storage, that is an immediate indicator that the reservoir floor might lack a continuous monolithic type of clay formation. The borehole spacing cannot be expected to find every anomaly in the underlying formations. Additional boreholes would give better data and identify engineering properties of the existing soils for pre-design purposes. The goal is to have enough continuity to provide dominion and control over the storage within a predefined specification.
4. The recovery rate of groundwater levels inside the slurry wall will be a good comparison to the permeability tests that were estimated in the geotechnical report.
5. The Elm Creek complex is adjacent to the Kearney Canal which could be an inexpensive source of fill water. This water carries some suspended sediment from the Platte River. This pilot project, if successful might be turned into a sediment trap to keep a future larger reservoir cell cleaner from sediment deposition. Maintenance can less expensive if sediment is confined to a smaller space.

Cons

1. The area of the pilot project would not provide absolute proof of continuity of the reservoir floor clay layer for the entire property.
2. The project does not provide significant usable storage space without additional excavation. This would require approximately 200,000 cubic yards of additional material removal , increased construction costs with the extra work yielding about 123 acre-feet of storage (assuming 3H:1V side slopes and 20 percent porosity). This storage volume is conservative and includes some freeboard and the potential to leave some material in the bottom to provide cover over the clay layer for protection.
3. The Elm Creek complex has a relatively shallow depth to the clay layer. A pilot project in an area where depths are down to the 30 to 40 foot level would provide a better indicator of how this clay layer would perform under higher uplift pressures.
4. If this pilot project is unsuccessful, the area that was ringed with a slurry wall may become unusable for future agricultural uses. The slurry wall would create an artificial barrier in the aquifer which could cause changes to the historic water table conditions. Impacts to the historic water table can be mitigated with French drains on the outside perimeter of the wall, but this adds to the construction costs.

Elm Creek functional pilot project

An alternate scenario of the Elm Creek pilot project would be to go directly to excavation of the sand and gravel inside the slurry wall, as described in Con #2 above, and build a small scale reservoir complete with inlet structure from the Kearney Canal and an outlet structure that pumps back to the Platte River. This would eliminate the installation of piezometers inside the reservoir and would reduce the time needed to test for seepage inflow. It would also stress test the reservoir floor to buoyant uplift by removing the sand and gravel which acts as a ballast. The excavation would be completed to the final shoreline slopes. A minimum of 3:1 is recommended at present.

Depending on how floodplain issues can be addressed, there may be additional opportunity to build a berm around the reservoir and raise it to add storage. The construction of a berm would require sufficient on-site soils with engineering properties that provide a safe impermeable dam that could be tied into the slurry wall.

A pump station for a pilot project would be relatively small. The small surface area limits discharge rates because of the need to protect shoreline slope stability from rapid drawdown. This project would use a 5 cfs pump. The present concept would be to have a float mounted pump that could rise and fall with reservoir levels. A floating discharge line to the pump with electrical service attached would be used. The pump would be about 50 to 60 horsepower in size and run on three phase power.

The ability to fill the reservoir by gravity from the Kearney Canal would be one limiting factor in berm height. Floodplain issues on the Platte River would also need to be addressed. The Elm Creek pilot project would likely be located outside of the regulatory floodplain, minimizing the floodplain permitting constraints.

A second cost estimate was prepared for this scenario. The major line item cost would be removal of the sand and gravel. If there is no market to sell the material to, then a stockpile area would be needed.

<u>Additional comments related to other properties tested</u>

The remaining four sites that were also explored for geotechnical data seem to have thicker underlying layers of clayey sands that are relatively impermeable and exhibit more continuity. The depths are significantly deeper than Elm Creek which would lead to more efficient storage. A pilot project on one of these properties would cost more to construct but may yield better performance information to use in implementing a full scale project. The Elm Creek site was the only one evaluated with a cost estimate.

<u>Plum Creek Complex</u>

This property covers about 180 acres in surface. Potential slurry wall containment areas for gravel pit reservoirs would be 43 acres on the Dyer property and 96 acres on the Cook property. The boreholes identified a good thick clay layer down to almost 40 feet. It appears to have contiguity for a good impermeable layer based on the results of the permeability tests.

<u>Cottonwood Ranch Complex</u>

This property has 875 acres and would be the largest potential reservoir(s) site. The boreholes identified an impermeable cemented sandstone layer down to about 40 feet as well and seems to also display contiguity. This is specifically called out as the Ogallala formation. This is a sandstone water bearing formation. However the permeability tests show it to be fairly impermeable on the surface. Depending on location, the Ogallala can be highly fractured which contributes to being a good water source. This may serve adequately as a reservoir floor based on these preliminary results. The risk of uplift from groundwater would seem to be reduced with this massive formation underlying the property.

<u>Lindstrom and Stall Property</u>

This property has an active gravel pit on it about 40 acres in size that could potentially be expanded to 60 acres. There is cropland that adds another 64.5 acres of potential storage area. The drilling company describes the formation as a cemented sandstone which may be the Ogallala. This is a sandstone water bearing formation. However the permeability tests show it to be fairly impermeable on the surface, and permeability is likely one to two orders of magnitude less than the alluvial material. Depending on location, the Ogallala can be highly fractured which contributes to being a good water source. Like the Cottonwood Ranch Complex, the Ogallala formation may serve adequately as a reservoir floor pending further information on the level of fracturing. Additional data on local groundwater levels in the underlying bedrock aquifer would also help to form a better understanding of the potential effects of fracturing in the underlying sandstone.

This Lindstrom Property may offer a second option for a pilot project. Installing a slurry wall around a mined pit would eliminate piezometers inside the slurry wall and develop gravel pit storage capabilities immediately if the seepage levels are within tolerances.

<u>J-2 Reservoir Site</u>

This property is 800 acres in size and is already in the planning stages as an above grade reservoir. The drilling program identified the Ogallala formation at about 40 feet in depth. The borehole information was all that is currently available to review, however, the summarizing memo from the EDO indicates that the permeability found at this formation is consistent with those found at the other properties.

Costs for Pilot Project on Elm Creek

Attached is a preliminary opinion of costs to construct a pilot project slurry wall around 10 acres of land at the Elm Creek site. It is associated with a project strictly for data gathering and would not function as a reservoir without additional infrastructure.

A storage project would need a turnout from the Kearney Canal and a turn back to the Platte River using a pump for accessing storage. The added cost of removing alluvial material from the site to create an open water reservoir would lengthen the project time schedule and add costs for excavation. However, it would give a quicker result in testing the reservoir floor for seepage.

There would be additional costs incurred in monitoring groundwater levels at the site as dewatering occurred. This is not included in the construction estimate. It should be anticipated that at least 6 months of pumping and monitoring on both sides of the slurry wall may be needed to arrive at a good conclusion. This testing schedule could be reduced by ½ if it is excavated, as any infiltration through the slurry wall could be measured more quickly when the dampening effect of the aquifer material is removed.

Schedule for Elm Creek Pilot Project

The estimated time frame for a pilot project is given in time ranges to try and account for unknowns that may be encountered.

1. Additional geotechnical exploration and testing for slurry wall design. 4 to 6 weeks
2. Topographic survey and boundary mapping – 2 to 3 weeks (concurrent with geotechnical work)
3. Slurry wall design and construction plans and specifications – 4 to 5 weeks
4. Construction pre-qualifications, and bidding to notice of award – 4 to 6 weeks
5. Notice of Award, Bonding, Notice to Proceed, Pre-Construction meetings, Contractor fully mobilized – 4 to 6 weeks
6. Construction of slurry wall , site cleanup and installation of monitoring wells– 6 to 8 weeks
7. Site monitoring – 6 months
8. Summary report of Pilot Project results – 3 weeks

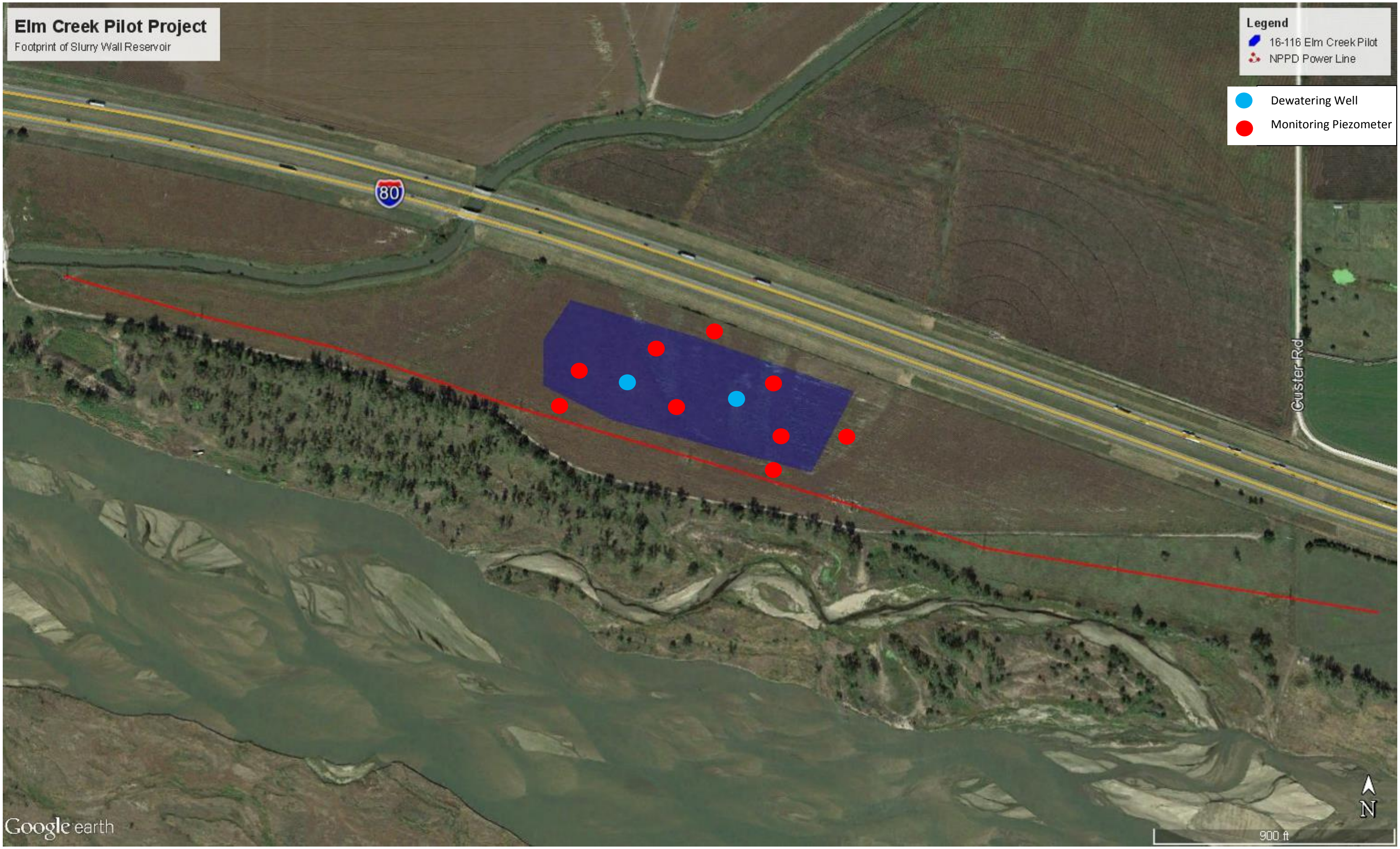
This schedule would put a pilot project timeframe of approximately 1 year if no significant permitting is required. The schedule for a pilot project may be longer if delays are encountered in any of the above steps (e.g., contractor procurement and mobilization). The timeframe for a small excavated and fully functional pilot project (i.e., storage and associated infrastructure for deliveries to and from storage) would be approximately two years.

The timing for completion on a full scale project will be dependent on the approach taken. If a gravel mining and sales of material approach is taken to build the project, it could lengthen the schedule. If mass excavation and stockpiling is done, it could be completed in a much shorter time frame. A full scale project could attract larger construction contractors that have higher earth excavation production capacities, which may also reduce the schedule.

Original estimates given to the Governance committee were 2 years for a full scale project. We believe that time frame is still a valid one given that infrastructure is a significant component for a full scale project. A full scale project would also envision significant excavation required for removal of sand and gravel unless an existing gravel pit is selected to be ringed by a slurry wall. Even then, a mined gravel pit would probably still require grading work and slope stabilization depending on how material was removed during the mining operation.

Summary of Conclusions and Recommendations

The results of the geotechnical testing done for the properties discussed have not exposed any fatal flaws to development of gravel pit reservoir storage. We would encourage the development of a pilot project to ground truth the idea of keying into a clay layer before spending money on a full scale project. The permeability rates for the underlying clay layers appear to be low enough to meet a reasonable standard of seepage control into the reservoir from groundwater. The contiguity of the clay layer that was identified on each site is the major risk factor to consider. Additional drilling on a specific property, if it is selected for development of a full scale reservoir project is recommended to reduce that risk. This additional data would also be used to protect the underlying clay layer of the reservoir floor from over-excavation during construction.



Applegate Group, Inc.
WATER RESOURCE ADVISORS FOR THE WEST

Figure 1

Engineers Opinion of Probable Construction Cost

Applegate Group, Inc.

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Elm Creek Complex Slurry Wall Pilot Project

Job No. : 16-116
By: CMA
Date: 2/1/2017
Client: PRRIP

Description of Work	Item	Units	Quantity	Unit Cost	Total Cost
Slurry Wall to approximate 24 foot depth	***Slurry Wall Construciton***				
	Slurry Wall Construction to 24 feet in depth	SF	72,000	$ 5	$ 360,000
	Dewatering trench to well sump	LF	1,000	$ 10.00	$ 10,000
	Dewatering Sump Pump	LS	1	$ 20,000	$ 20,000
	Power source for dewatering well	LS	1	$ 25,000	$ 25,000
	Monitoring Wells	EA	9	$ 1,200	$ 10,800
	Construction Subtotal				**$ 425,800**
	Mobilization	%		12%	$ 51,096
	Construction Contengency	%		30%	$ 127,740
	Construction Total				**$ 604,636**
	Final Engineering Design	%		6%	$ 40,000
	Survey	LS	1	$ 2,000	$ 2,000
	Geotechnical Testing	LS	1	$ 5,000	$ 5,000
	Construction Management	LS	1	$ 20,000	$ 20,000
	Total				**$ 671,636**

Note: These costs are based upon conceptual design assumptions and are subject to change upon obtaining survey and geotechnical information and completing final design. This estimate does not account for the cost of property or easement acquisition which may be required. Power costs are assuming a nearby 3 phase power line can be routed to the property.

Engineers Opinion of Probable Construction Cost

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Elm Creek Complex Slurry Wall Excavated Pit

Job No. :	16-116
By:	CMA
Date:	2/1/2017
Client:	PRRIP

Description of Work	Item	Units	Quantity	Unit Cost	Total Cost
Slurry Wall to approximate 24 foot depth with gravel alluvium excavated	***Slurry Wall Construction***				
	Slurry Wall Construction to 24 feet in depth	SF	0	$ 5.00	$ -
	Floating Barge Pump and Discharge line to shore	LS	1	$ 40,000	$ 40,000
	Power source for barge pump	LS	1	$ 25,000	$ 25,000
	Excavation and stockpile gravel alluvium inside slurry wall	CY	200,000	$ 2.00	$ 400,000
	Inlet structure from Kearney Canal	LS	1	$ 30,000	$ 30,000
	Discharge line to Platte River	LS	1	$ 10,000	$ 10,000
	Monitoring wells outside slurry wall	EA	5	$ 1,200.00	$ 6,000
	Construction Subtotal				**$ 511,000**
	Mobilization	%		12%	$ 61,320
	Construction Contengency	%		30%	$ 153,300
	Construction Total				**$ 725,620**
	Final Engineering Design	%		6%	$ 50,000
	Survey	LS	1	$ 4,000	$ 4,000
	Geotechnical Testing	LS	1	$ 7,000	$ 7,000
	Construction Management	LS	1	$ 40,000	$ 40,000
	Total				**$ 826,620**

Note: These costs are based upon conceptual design assumptions and are subject to change upon obtaining survey and geotechnical information and completing final design. This estimate does not account for the cost of property or easement acquisition which may be required. Power costs are assuming a nearby 3 phase power line can be routed to the property.

Attachment B:

Preliminary cost estimates developed by the EDO for full-scale slurry wall storage facilities

Slurry Wall Aquifer Storage Facility - Preliminary Cost Estimate

Land Costs	Quantity	Cost	Units	Total Cost	Notes
Land Acquisition	0	$ 7,000.00	acre	$ -	
Administration/Permits	1	$ -	LS	$ -	Assumed 2.5% of land (Oamek memo).
Total Land Costs				***$ -***	

Construction Costs	Quantity	Cost	Units	Total Cost	Notes
Mobilization	1	$100,000.00	LS	$ 100,000.00	
Clearing and Grubbing	13.2	$ 2,000.00	acre	$ 26,328.74	Assume double the berm footprint
Berm Construction	19,911.1	$ 5.00	cy	$ 99,555.56	
Slurry Wall Construction	322,560.0	$ 5.00	ft2	$ 1,612,800.00	
Inlet Structure	1	$ 70,000.00	LS	$ 70,000.00	Scaled up from Applegate memo (based on vol)
Pump Station	1	$420,000.00	LS	$ 420,000.00	Scaled up from Applegate memo (based on vol)
Pump Station Earthwork	200000	$ 3.00	cy	$ 600,000.00	Open Pit Excavation
Electrical Connections	1	$ 87,500.00	LS	$ 87,500.00	Scaled up from Applegate memo (based on vol)
Outlet Structure	1	$ 70,000.00	LS	$ 70,000.00	Scaled up from Applegate memo (based on vol)
Excavation to Grade	-	$ 2.00	cy	$ -	Assume $0 because pit already exists.
Delivery Pipeline	1	$200,000.00	LS	$ 200,000.00	Assume $200,000 for delivery pipeline.
Subtotal Construction Costs				*$ 3,286,184.30*	
Total Construction Costs w/ 40% Contingency				***$ 4,600,658.02***	
Annual O&M Costs				***$ 57,508.23***	1.25% of Construction

Associated Construction Costs -> Permits, Engineering, Administration, Etc.

Associate Construct Costs	Quantity	Cost	Units	Total Cost	Notes
Environmental Mitigation	0			$ -	
Permitting	1	$ 60,000.00	LS	$ 60,000.00	From Jason
Engineering Design	1	$131,447.37	LS	$ 131,447.37	Scaled up from Applegate memo (~4% of construction subtotal)
Construction Management	1	$ 72,296.05	LS	$ 72,296.05	Scaled up from Applegate memo (~2.2% of construction subtotal)
Construction Administration	1	$ 32,861.84	LS	$ 32,861.84	Scaled up from Applegate memo (~1% of construction subtotal)
Surveying	1	$ 16,430.92	LS	$ 16,430.92	Scaled up from Applegate memo (~0.5% of construction subtotal)
Total Other Costs				*$ 313,036.19*	
Total Other Costs w/ 40% Contingency				***$ 438,250.67***	
Total Costs to Build Slurry Wall Gravel Pit				***$ 5,038,908.68***	
Annual O&M and Water Delivery Cost				***$ 79,284.36***	

Slurry Wall Storage Facility - Existing Sandpit - Preliminary Cost Estimate

Land Costs	Quantity	Cost	Units	Total Cost	Notes
Land Acquisition	160	$ 10,000.00	acre	$ 1,600,000.00	
Administration/Permits	1	$ 40,000.00	LS	$ 40,000.00	Assumed 2.5% of land (Oamek memo).
Total Land Costs				***$ 1,640,000.00***	

Construction Costs	Quantity	Cost	Units	Total Cost	Notes
Mobilization	1	$ 100,000.00	LS	$ 100,000.00	
Clearing and Grubbing	9.9	$ 2,000.00	acre	$ 19,770.06	Assume double the berm footprint
Berm Construction	14,951.1	$ 5.00	cy	$ 74,755.56	
Slurry Wall Construction	242,208.0	$ 5.00	ft2	$ 1,211,040.00	
Inlet Structure	1	$ 70,000.00	LS	$ 70,000.00	Scaled up from Applegate memo (based on vol)
Pump Station	1	$ 420,000.00	LS	$ 420,000.00	Scaled up from Applegate memo (based on vol)
Electrical Connections	1	$ 87,500.00	LS	$ 87,500.00	Scaled up from Applegate memo (based on vol)
Outlet Structure	1	$ 70,000.00	LS	$ 70,000.00	Scaled up from Applegate memo (based on vol)
Excavation to Grade	0	$ -	cy	$ -	Assume $0 because pit already exists.
Delivery Pipeline	1	$ 500,000.00	LS	$ 500,000.00	
Subtotal Construction Costs				*$ 2,553,065.62*	
Total Construction Costs w/ 40% Contingency				***$ 3,574,291.87***	
Annual O&M Costs				***$ 44,678.65***	1.25% of Construction

Associated Construction Costs -> Permits, Engineering, Administration, Etc.

Associate Construct Costs	Quantity	Cost	Units	Total Cost	Notes
Environmental Mitigation	0			$ -	
Permitting	1	$ 60,000.00	LS	$ 60,000.00	From Jason
Engineering Design	1	$ 102,122.62	LS	$ 102,122.62	Scaled up from Applegate memo (~4% of construction subtotal)
Construction Management	1	$ 56,167.44	LS	$ 56,167.44	Scaled up from Applegate memo (~2.2% of construction subtotal)
Construction Administration	1	$ 25,530.66	LS	$ 25,530.66	Scaled up from Applegate memo (~1% of construction subtotal)
Surveying	1	$ 12,765.33	LS	$ 12,765.33	Scaled up from Applegate memo (~0.5% of construction subtotal)
Total Other Costs				*$ 256,586.05*	
Total Other Costs w/ 40% Contingency				***$ 359,220.47***	
Total Costs to Build Slurry Wall Gravel Pit				***$ 5,573,512.34***	
Annual O&M and Water Delivery Cost				***$ 91,893.96***	