Kern Fan Groundwater Storage Project

RESPONSE TO DEC REVIEW FINDINGS

Addendum No. 4: Addressing Feasibility Study Comments

July 1, 2020

Irvine Ranch WATER DISTRICT

Rosedale-Rio Bravo WATER STORAGE DISTRICT

Addendum No. 4 – Addressing Feasibility Study Comments

Design Estimating and Construction (DEC) Review

Finding #4:

Feasibility Study:

a. *Concrete lining expensive; others should be considered. Hydraulics weren't considered in the selection. Need to revise and include info on the hydraulics.*
b. *Basis for cut and fill quantities unclear. Should include regular intervals full length of conveyance.*
c. *Lifespan of facilities may be reduced due to intermittent usage – need to address. O&M as it relates to wells and pumps unclear.*
d. *Recharge basin O&M unclear. How are fines and algal mats addressed?*

Response to Finding #4

Summary

- Conveyance Lining: A total of four lining alternatives have been considered herein; 1) Earth Lined Canal, 2) HDPE Lined Canal, 3) Shotcrete Lined Canal, and 4) Concrete Lined Canal. The material quantities, the constructability, the capital costs, the hydraulic impacts, and any issues or concerns have been discussed for each alternative. It appears that the HDPE Lined Canal is the most economical, however depending on the actual useful life of the HDPE lining it may be about the same cost or even more expensive than the concrete lining alternative over a sixty year period. The cost difference between the shotcrete lining and the concrete lining also is not very significant. Both of these lining systems are quality canal linings and result in a long useful life, however the shotcrete lining requires greater skill and quality control during application. Therefore, the concrete lining is the preferred alternative, although the project may bid other alternatives and consider the HDPE lining or shotcrete as value engineering options.
- Canal Cut and Fill Quantities: Cross-sections have been prepared for each reach of the canal at approximate 1,000-ft intervals and illustrate the estimated "neat-line" cut and fill area for the conveyance canal. The earthwork volume calculations utilizing the average end area method are attached. The calculations demonstrate the estimated cut and fill volumes for each reach of the canal resulting in a total of 244,227 cubic yards of cut and 716,381 cubic yards of fill for the entire conveyance canal. In addition, calculations for the subgrade preparation (over-excavation and re-compaction beneath the canal and embankments) have been prepared and estimate a "neat-line" volume of 226,189 cubic yards for the entire conveyance canal. Borrow material is anticipated to be obtained from areas in close proximity to the canal including, but not limited to, the Buena Vista Water Storage District recharge basins, the West Kern Water District recharge basins, the Phase II recharge basins, and the West Basins. Costs associated with the borrow material have been included in the unit prices utilized for the earthwork cut, fill, and subgrade preparation.

- Lifespan of Facilities: The lifespans for critical components of the project have been outlined. These lifespan estimates are based upon the significant experience of Rosedale-Rio Bravo Water Storage District with similar facilities and account for the typical intermittent usage that is associated with these types of recharge and recovery projects.
- O&M Project Costs: The O&M costs for the project has been defined in greater detail for wet periods when water is being recharged, for dry periods when water is being recovered from the groundwater basin, and for idle periods when water is neither being recharged or recovered. The O&M costs related to wells and pumps as well as for recharge basins are included.
  Well O&M costs include the following:
    - Pump Maintenance (Annual Pump Tests, Cleaning, Oil Testing, etc.)
    - Oil Lubrication
    - Weed Control around Well Sites
    - Rodent Control around Well Sites
    - Electricity
    - Remote Monitoring (Mission Unit Costs)
    - Office Staff and Overhead Costs

  Recharge basin O&M costs include the following:
    - Pond Maintenance (Weir board replacement, cleaning, etc.)
    - Weed Control along levee embankments
    - Rodent Control along levee embankments
    - Raptor box repairs/maintenance
    - Seeding and Plantings in basin bottoms
    - Occasional removal of fines from basin bottoms (scraping)
    - Office Staff and Overhead Costs

a. Concrete lining expensive; others should be considered. Hydraulics weren't considered in the selection. Need to revise and include info on the hydraulics.

I. Conveyance Canal Lining

This addendum serves to consider the following potential canal lining alternatives:

1. Earth Lined Canal
2. HDPE Lined Canal
3. Shotcrete Lined Canal
4. Concrete Lined Canal

The conveyance canal is approximately 8.80 miles long or 46,400-ft. The canal cross-section is approximately 8-ft deep with a 20-ft wide bottom and 1.5:1 side slopes. This equates to a cross-sectional area of approximately 51 sq. feet per lineal ft when including a 1-ft lip. The lip is the portion of the concrete lining that is outside of the canal prism at the top hinge point of the canal on both sides of the conveyance canal. The cross-sectional area for an earth lined canal with 3:1 side slopes is approximately 73 sq. feet per lineal ft when including a 1-ft lip on both sides of the conveyance canal.

1. Earth Lined Canal

Quantities:
The earthwork for the conveyance canal has been considered separately and will be roughly the same for any of the above lining alternatives. The earth lined canal is planned to have 3:1 side slopes to reduce velocities and minimize erosion and sediment transport. Typically, seepage in the earth lined canal for this project would not be a concern since the seepage can be accounted for as groundwater recharge under the project. However, seepage is a concern when operating the canal in the reverse direction for recovery of water and the return of water to the Aqueduct. Therefore, a return pipeline would need to be constructed parallel to the canal or a special earth liner such as a clay liner or bentonite liner constructed.

Constructability:
The earth lined canal will be constructed to the lines and grades shown on the project drawings. The side slopes of an earth lined canal shall be revised to be 3:1 in order to alleviate erosion and provide for canal maintenance. The material for the canal shall not be expansive or dispersive. Expansive soils could result in swelling, drying, and shrinkage that results in cracking and problems with seepage or a levee breach. Dispersive soils can pose a threat as they move away from water and could result in piping or a levee breach. The soils should have less than 15% finer than a 5 micron sieve so that there is not too much clay but also greater than 20% material finer than a 75 micron sieve so that there are fine sands and silts that provide good cohesion. The canal and levee material shall be compacted to a minimum 90% relative compaction.

A 1-ft thick liner of the earthen canal prism shall have a minimum clay content of 12% to 15%. Fill material that has a clay content less than this will require some form of soil amendment or importation of a soil with adequate clay content. Powdered bentonite could be used as a soil amendment. The percentage of bentonite added would be the difference between the natural site clay content and the required minimum clay content. The minimum pounds of bentonite per square foot of amended area will be the percentage bentonite times the compacted dry density of the site soil times the liner thickness. Bentonite shall be evenly spread by a computerized spreading truck which is directly fed by the bulk delivery truck. Spread rate shall be confirmed by a pan test. The amended area shall be uniformly mixed and moisture conditioned by a cross-shafted mixer directly connected to the water truck. This equipment is standard for a specialty soil stabilization contractor. Stabilization contractors typically only spread the amendment, moisture condition, and compact the amended soil. They do not move material to achieve rough grade or fine grade, therefore they generally subcontract to a general earthwork contractor. However, in some instances soil amendment can be performed in-place for a liner thickness up to 1.5 feet with the typical cross-shafted mixer and open-hub compactors and this may be an option.

For an earth lined canal there are concerns with rodent holes, piping, and levee breaches particularly in areas of levee embankment fill. In order to mitigate these concerns, synthetic sheet piling is included. Sheet piling would be installed along both sides of the canal in areas of levee embankment fill and extend down to approximately 5-ft below the invert of the canal (sheetpile depth of 15-ft).

Capital Cost:

The capital cost estimates compare the costs of different lining materials. However, the earth lined canal will require a different canal cross-section in order to mitigate soil erosion and prevent seepage. Therefore, capital costs for the canal earthwork are also included.

The capital cost estimate for the canal earthwork is $7,148,566. This adds approximately $1,551,360 ($7,148,566 - $5,597,206) to the cost of the earthwork over and above the cost for the canal earthwork on the other three alternatives because of the wider canal cross-section.

The option to install a return water pipeline and not line the earthen canal involves installing approximately 45,000 feet of 48” pipe which at $280/lf equates to approximately $12,600,000. However, this does eliminate the need for the Return Water Pump Station in turn saving approximately $2,081,000. This results in an additional cost of $10,519,000 or $12,600,000 - $2,081,000.

The soil amendment cost to treat/amend, mix, and compact the soil for a 1-ft thick liner is estimated at $3.93 per square foot. There are approximately 73 sf/lf x 46,400 lf or 3,387,200 square feet.

The earth lining alternative also includes the installation of synthetic sheet piling to mitigate rodent holes. There is approximately 53,550-ft of sheet piling and 15-ft deep which equates to approximately 803,250 square feet. A unit cost of $35/sf has been used. This equates to a capital cost of $28,113,750 which effectively makes the earth lined canal relatively expensive and not practical.

As presented below and summarized in Table 1 of Section II - Summary of Canal Lining Alternatives, the cost of an earth lined canal liner is about $43,000,000 with a clay liner and $40,000,000 with a return water pipeline.

• Additional Earthwork	$1,551,360
• 1-ft Thick Clay Liner at $3.93/sf	$13,311,696
• Sheet Piling to Mitigate Rodent Holes	$28,113,750
Total Earth Lined Canal with Bentonite:	$42,976,806

Or

• Additional Earthwork	$1,551,360
• Return Water Pipeline	$10,519,000
• Sheet Piling to Mitigate Rodent Holes	$28,113,750
Total Earth Lined Canal with Return Pipeline:	$40,184,110

Canal Hydraulics:

The earth lined canal has a 20-ft wide bottom with 3:1 side slopes. A Manning's coefficient of 0.035 was utilized which is for an earth lined canal with light brush on the levee slopes. The velocities of an earth lined canal are less than that of a lined canal and have been maintained in the range of 1.0 to 2.5 fps to minimize erosion and sediment transport. The water depth varies from approximately 6-ft to 8.22-ft. This increases the canal depth from 8-ft to approximately 10-ft as a result of the higher Manning's coefficient.

Issues/Concerns:

An earth lined canal is not the most desirable alternative. There are significant portions of the canal that will be elevated above the natural ground surface. In addition, there may be long periods of time where this canal is not being utilized and is in a dry condition thus providing suitable habitat for rodents. The major concern is with rodent holes over time that could lead to piping and a levee breach and the potential for property damage to adjacent agricultural crops, homes, equipment, etc.

In order to mitigate the above concerns, synthetic sheet piling was considered in an effort to provide a barrier from rodent holes and potential piping. However, this appears to be cost prohibitive.

In addition, an earth lined canal will require greater maintenance. The maintenance includes:

- Levee monitoring for rodent holes and areas of significant erosion that require earthwork maintenance
- Weed control on levee slopes and the canal bottom
- Removal of sediment and debris potentially at siphon crossings, turnouts, and lift stations

2. Geosynthetic (HDPE) Lined Canal

Quantities:
A 60 mil thick membrane HDPE lining is recommended for canal conveyance. The HDPE lining material will be approximately 2,830,400 sf based upon a canal length of 46,400 ft and a cross sectional area of 61 sf/ft which includes an anchor trench on each side of the canal.

Constructability:

The HDPE lined canal will be constructed to the lines and grades shown on the project drawings. The side slopes of a HDPE lined canal shall be 1.5:1 as originally outlined above. The subgrade material for the canal shall not be expansive or dispersive. The soils should have less than 15% finer than a 5 micron sieve so that there is not too much clay but also greater than 20% material finer than a 75 micron sieve so that there are fine sands and silts that provide good cohesion. The canal and levee material shall be compacted to a minimum 90% relative compaction and graded to provide a smooth and uniform surface for the installation of the HDPE lining.

An anchor trench will need to be excavated parallel to the canal on each side of the conveyance canal, the HDPE liner installed in the trench, and the trench backfilled and compacted. In addition, the HDPE liner will need to be connected to the concrete at all structures, turnouts, and lift stations.

Capital Cost:

The capital cost estimates compare the costs of different lining materials. The HDPE lined canal is estimated to utilize approximately 2,830,400 sf of material. In addition, there will be locations where the lining must be connected to the concrete structures in the canal such as the transition structures, turnouts, and lift stations. This is estimated to be approximately 1,500 lineal feet. There will also be the need for underdrains where the canal is in cut adjacent to recharge basins.

The capital cost estimate for the canal earthwork is $5,597,206. The cost of adding an HDPE lining adds $5,291,400 as presented below and summarized in Table 1 of Section II - Summary of Canal Lining Alternatives.

• HDPE Lining at $1/sf	$2,830,400
• HDPE Anchor Trench Installation	$928,000
• Connection to Structures at $23/lf	$34,500
• Underdrain System	$1,498,500
Total HDPE Lining:	$5,291,400

Canal Hydraulics:

The Manning's coefficient utilized for a HDPE lined canal is 0.011. The velocities of the HDPE lined canal range from approximately 2.0 fps to 3.5 fps. The water depth varies from approximately 6-ft to 6.76-ft. This maintains a minimum of 1-ft of freeboard from the top of canal lining.

Issues/Concerns:

A HDPE lined canal is an economical alternative and worth considering. The HDPE lining can be prone to surface deterioration and tearing from UV damage and wind. The canal will have long periods of time when it is not in operation and is empty thus subject to sun exposure and damage. The anticipated useful life of a typical HDPE liner that is exposed to the elements is 10 to 20 years.

3. Shotcrete Lined Canal

Quantities:
Shotcrete is a pneumatically applied Portland cement mortar lining. The shotcrete lining is recommended to have a minimum 3" thickness. The shotcrete lining material would be approximately 2,366,400 sf based upon a canal length of 46,400 ft and a cross sectional area of 51 sf/ft. (Approximately 21,911 cubic yards).

Constructability:
The shotcrete lined canal will be constructed to the lines and grades shown on the project drawings. The side slopes of a shotcrete lined canal shall be 1.5:1 as originally outlined above. The subgrade material for the canal shall not be expansive or dispersive. The soils should have less than 15% finer than a 5 micron sieve so that there is not too much clay but also greater than 20% material finer than a 75 micron sieve so that there are fine sands and silts that provide good cohesion. The canal and levee material shall be compacted to a minimum 90% relative compaction and graded to provide a smooth and uniform surface for the installation of the shotcrete lining.

The application of shotcrete is highly specialized and requires a certified nozzleman in order to ensure against rebound which results from a portion of the mortar bouncing away from the surface to which it is applied. It is recommended that the shotcrete lining have a smooth trowel surface in order to improve the hydraulic characteristics.

Capital Cost:

The capital cost estimates compare the costs of different lining materials only. The shotcrete lined canal is estimated to utilize approximately 2,366,400 sf of material. There will also be the need for underdrains where the canal is in cut adjacent to recharge basins.

The capital cost estimate for the canal earthwork is $5,597,206. The cost of adding a shotcrete lining adds $13,330,500 as presented below and summarized in Table 1 of Section II- Summary of Canal Lining Alternatives.

- Shotcrete Lining at $5/sf $11,832,00
- Underdrain System $1,498,500

Total Shotcrete Lining: $13,330,500

Canal Hydraulics:

The Manning's coefficient utilized for a shotcrete lined canal is 0.017. The Manning's coefficient assumes that the shotcrete surface will not be as smooth as conventional concrete placement and finishing. The velocities of the shotcrete lined canal range from approximately 2.0 fps to 3.0 fps. The water depth varies from approximately 6-ft to 7.33-ft. This would require the canal depth to be increased by approximately 0.5-ft in some locations to an 8.5-ft depth in order to maintain the minimum of 1-ft of freeboard to the top of canal lining.

Issues/Concerns:

A shotcrete lined canal is an economical alternative and worth considering. However, in general this type of lining is only slightly more economical than formed in place concrete when considering long, un-impacted stretches of canal. The shotcrete lining requires skilled operating personnel, additional quality control measures to ensure against excessive rebound and to ensure application at the proper thickness. If a concrete lined canal is the selected alternative, it is recommended that the concrete lining be allowed to be constructed by shotcrete application, slip-form placed, or formed in place.

4. Concrete Lined Canal

Quantities:
Concrete lining can be placed by slip-lining, using a rolling screed, or by cast in place methods. The concrete lining is recommended to have a minimum 3" thickness and crack control spacing at approximate 10'-0" spacing. The concrete lining material would be approximately 2,366,400 sf based upon a canal length of 46,400 ft and a cross sectional area of 51 sf/ft. (Approximately 21,911 cubic yards).

Constructability:

The concrete lined canal will be constructed to the lines and grades shown on the project drawings. The side slopes of a concrete lined canal shall be 1.5:1 as originally outlined above. The subgrade material for the canal shall not be expansive or dispersive. The soils should have less than 15% finer than a 5 micron sieve so that there is not too much clay but also greater than 20% material finer than a 75 micron sieve so that there are fine sands and silts that provide good cohesion. The canal and levee material shall be compacted to a minimum 90% relative compaction and graded to provide a smooth and uniform surface for the installation of the concrete lining.

Capital Cost:

The capital cost estimates compare the costs of different lining materials only. The concrete lined canal is estimated to utilize approximately 2,366,400 sf of material. There will also be the need for underdrains where the canal is in cut adjacent to recharge basins.

The capital cost estimate for the canal earthwork is $5,597,206. The cost of adding a concrete lining adds $15,696,900 as presented below and summarized in Table 1 of Section II.

• Concrete Lining at $6/sf	$14,198,400
• Underdrain System	$1,498,500
Total Concrete Lining:	$15,696,900

Canal Hydraulics:

The Manning's coefficient utilized for the concrete lined canal is 0.014. The velocities of the concrete lined canal range from approximately 2.0 fps to 3.2 fps. The water depth varies from approximately 6-ft to 7-ft. This maintains a minimum of 1-ft of freeboard from the top of canal lining and has slightly better hydraulic characteristics than the shotcrete lining.

Issues/Concerns:

A concrete lined canal is an expensive alternative, but also has the longest useful life. Concrete lining has a typical useful life of beyond 60 years if well maintained and protected. The concrete lined canal will also require the smallest amount of

maintenance and has better hydraulic characteristics than the shotcrete lining. Typical maintenance is the cleaning and removal of sediment and mud, if applicable, and then the replacement of cracked panels if it occurs.

II. Summary of Canal Lining Alternatives

Four lining options for the conveyance canal were evaluated as summarized in Table 1.

Table 1
Canal Lining Alternatives

Lining Alternative	Estimated Unit Cost	Estimated Total Cost
HDPE Lined	$1.87/SF	$5,291,400
Shotcrete Lined	$5.63/SF	$13,330,500
Concrete Lined	$6.63/SF	$15,696,900
Earth Lined	$11.86/SF	$40,184,110

The earth lined canal is not considered a good alternative due to concerns with rodent holes and piping failures, liability due to adjacent landowners, and overall increased canal maintenance with weed control, sedimentation, and rodent hole control. In order to mitigate these concerns, a clay liner has been included to mitigate canal seepage when returning water to the Aqueduct along with geosynthetic sheet piling to mitigate concerns with rodent holes and piping or levee failures. This in turn drives the cost up significantly thereby making this alternative cost prohibitive.

The HDPE canal lining is an economical alternative, has the best hydraulic properties, and is easier to maintain than an earth lined canal. The drawback to the HDPE canal lining is the estimated useful life of 10 to 20 years.

The cost difference between the shotcrete lining and the concrete lining is also not very significant. Both of these lining systems are quality canal linings and result in a long useful life, however the shotcrete lining requires greater skill and quality control during application. It is recommended that the conventional concrete lining be selected between these two options, however the contract documents could allow for both application methods and the most economical alternative could be selected at bid time.

The choice of canal lining appears to be a decision between a HDPE liner and concrete lining. The concrete lined canal has a useful life that is approximately three times greater than the HDPE lining (60 yrs versus 20 yrs). Assuming a 2% inflation rate at approximately the consumer price index (CPI) to replace the HDPE lining in 20 years would result in a future replacement cost of $7,862,742. To replace the HDPE lining in 40 years would result in a future replacement cost of $11,683,621. Assuming the future replacement costs in year 20 and 40 are invested at 2% interest, the present value the HDPE lining over 60 years is approximately $$15,874,200 (3 * $5,291,400) which is slightly greater than the cost of a concrete lined canal over that same period of time. A concrete lined canal is the recommended alternative at this time, although both the HDPE lining and the concrete lining may be bid as a value engineering consideration.

b. Basis for cut and fill quantities unclear. Should include regular intervals full length of conveyance.

I. Canal Cut and Fill Quantities

Canal cross-sections have been prepared for the canal conveyance alignment and are included in Exhibit J.

Cross-sections have been prepared for each reach of the canal at approximate 1,000-ft intervals and illustrate the estimated "neat-line" cut and fill area for the conveyance canal. The earthwork volume calculations utilizing the average end area method are attached in Exhibit K. The calculations demonstrate the estimated cut and fill volumes for each reach of the canal resulting in a total of 244,227 cubic yards of cut and 716,381 cubic yards of fill for the entire conveyance canal. In addition, calculations for the subgrade preparation (over-excavation and re-compaction beneath the canal and embankments) have been prepared and estimate a "neat-line" volume of 226,189 cubic yards for the entire conveyance canal. Borrow material is anticipated to be obtained from areas in close proximity to the canal including, but not limited to, the Buena Vista Water Storage District recharge basins, the West Kern Water District recharge basins, the Phase II recharge basins, and the West Basins. Costs associated with the borrow material have been included in the unit prices utilized for the earthwork cut, fill, and subgrade preparation.

c. Lifespan of facilities may be reduced due to intermittent usage – need to address. O&M as it relates to wells and pumps unclear.

I. Lifespan of Facilities

The Rosedale-Rio Bravo Water Storage District and Irvine Ranch Water District have similar facilities installed including, but not limited to, well pumps and motors, well piping and appurtenances, flow meters, slide gates and actuators, electrical equipment, VFD's, and earth levees. The lifespans listed below are based upon their significant experience operating and maintaining these facilities, and already account for the typical intermittent usage that is associated with these types of recharge and recovery projects.

The lifespan of concrete structures such as transition structures, siphon crossings, turnouts, and lift stations are estimated to be 50 years.

Lift Station pumps and motors have an estimated useful life of approximately 10 to 15 years and will require regular maintenance to keep them in good operating order given the intermittent usage.

Lift Station valves, electrical, and appurtenances are estimated to have a useful life of approximately 20 to 25 years.

Turnout slide gates, actuators, meters, and electrical are estimated to have a useful life of approximately 25 years.

Well pump and motors have an estimated useful life of approximately 10 to 15 years and will require regular maintenance to keep them in good operating order given the intermittent usage. The District performs annual maintenance on the well pumps and motors including, but not limited to, the cleaning of electrical equipment and the replacement of filter screens, the manual turning of lineshafts, replacement of motor oil and grease, and preventative maintenance on motor starter panels and VFD's.

The well site valves, electrical, and appurtenances are estimated to have a useful life of approximately 20 to 25 years.

The canal useful life will depend on the canal lining as discussed under item 4.a above. The useful life of a concrete lined canal is estimated to be 60 years and should not be impacted by the intermittent usage. However, a HDPE liner is estimated to have a useful life of 10 to 20 years given the intermittent usage and the exposure to UV and wind.

II. O&M for Wells and Pumps

See item 4.d below in which all of the O&M costs are discussed in detail.

d. Recharge basin O&M unclear. How are fines and algal mats addressed?

I. O&M Project Costs

Operation, maintenance and replacement costs were prepared for the Project and are presented in Section 4 of the 30% Design Report for three types of operating years: Idle, Recharge and Recovery. Idle year conditions are expected to occur 5 times every 10 years, include no recharge or recovery operations, and cost about $227,000 per year. Dry year conditions are expected to occur 3 times every 10 years, include recovery operations and cost on average approximately $3,966,000 per year. Wet year conditions are expected to occur 2 times every 10 years, include recharge operations and cost about $3,040,000 per year. In addition to the year type, the operations and maintenance (O&M) costs have been estimated for the canal conveyance facilities, groundwater recharge operations, and water recovery operations. The estimated O&M costs are based on RRBWSD's extensive experience operating and maintaining recharge basins, recovery wells and facilities, pump stations and canals.

Well O&M costs primarily occur during idle periods and recovery operations and include the following:

- Pump Maintenance (Annual Pump Tests, Inspection, Cleaning, Oil Testing, Calibration, Water Quality Testing)
- Oil Lubrication
- Weed Control around Well Sites
- Rodent Control around Well Sites
- Electricity
- Remote Monitoring (Mission Unit Costs)
- Office Staff and Overhead Costs

Recharge basin O&M costs primarily occur during idle periods and recharge operations and include the following:

- Pond Maintenance (Weir board replacement, inspection, cleaning, etc.)
- Weed Control along levee embankments
- Rodent Control along levee embankments
- Raptor box repair/maintenance
- Seeding and Planting in basin bottoms
- Mowing in basin bottoms
- Occasional removal of fines or algal mats from basin bottoms (scraping)
- Office Staff and Overhead Costs

Managing sediments, fines and algal mats: It has been RRBWSD's experience that the existing recharge basins have not been significantly affected by the settlement of fine sediments or bacterial fowling. Sediment is typically settled prior to reaching this portion of the service area. To the extent that this may occasionally occur, these materials would be

scraped and placed on islands during idle periods as needed. The estimated costs for basin maintenance associated with occasional fine sediment accumulation or potential algae mat growth are included in the staff time under the idle operating periods and are based on actual operating experience for similar facilities.

Idle Periods

Idle periods are months in which there is no groundwater recharge activities taking place and no water recovery activities taking place. However, there are still on-going O&M costs that must be taken into consideration. Idle periods are estimated to occur an average of 5 years out of every 10 years.

The canal O&M costs during an idle period (idle year) are outlined below:

- RRBWSD Operation Cost: $4,100 per month
  This cost includes field staff time for canal maintenance (cleaning, repair of floats, etc.), weed control around roads and embankments, rodent control, equipment maintenance, office staff, and overhead cost.
- Electricity Cost: $1,500 per month
  This cost is a standby charge for three lift stations along the canal.
- Mission Unit Cost: $158.33 per month
  This is the average monthly cost for cellular service to three (3) mission units based upon what is currently being paid.
- Total Monthly Cost: $5,758.33 per month
- Total Conveyance O&M Cost: $69,100 per year in an idle year

The conveyance O&M costs for the Goose Lake Lift Station during an idle period (idle year) are outlined below:

- RRBWSD Operation Cost: $1,000 per month
  This cost includes field staff time for lift station maintenance (cleaning, repairs, etc.), weed control around lift station, rodent control, equipment maintenance, office staff, and overhead cost.
- Electricity Cost: $300 per month
  This cost is a standby charge for the lift station.
- Mission Unit Cost: $52.78 per month
  This is the average monthly cost for cellular service to one (1) mission unit based upon what is currently being paid.
- Total Monthly Cost: $1,352.78 per month
- Total Annual Conveyance Cost: $16,233.33 per year in an idle year

The Phase I recharge basin and well equipment O&M costs during an idle period (idle year) are outlined below:

- RRBWSD Operation Cost: $4,100 per month
  This cost includes field staff time for pond maintenance (inspection, cleaning, repairs to berms and levees as needed), weed control around levees, rodent

control, seeding and plantings in basin bottoms, mowing basin bottoms as needed, occasional scraping of basin bottoms as needed, well equipment maintenance (inspection, cleaning, testing, calibration of meters), scheduled water quality testing, cattle or sheep grazing to control weed growth, repair and gravel roads as needed, raptor box maintenance as needed, office staff, and overhead cost.

- Electricity Cost: $1,500 per month
  This cost is the estimated monthly standby charges for six recovery wells.
- Mission Unit Cost: $316.67 per month
  This is the average monthly cost for cellular service to six (6) mission units based upon what is currently being paid.
- Total Monthly Cost: $5,916.67 per month
- Total Annual Recharge Facility Cost: $71,000 per year in an idle year

The Phase II recharge basin and well equipment O&M costs during an idle period (idle year) are outlined below:

- RRBWSD Operation Cost: $4,100 per month
  This cost includes field staff time for pond maintenance (inspection, cleaning, repairs to berms and levees as needed), weed control around levees, rodent control, seeding and planting in basin bottoms, mowing basin bottoms as needed, occasional scraping of basin bottoms as needed, well equipment maintenance (inspection, cleaning, testing, calibration of meters), scheduled water quality testing, cattle or sheep grazing to control weed growth, repair and gravel roads as needed, raptor box maintenance as needed, office staff, and overhead cost.
- Electricity Cost: $1,500 per month
  This cost is the estimated monthly standby charges for six recovery wells.
- Mission Unit Cost: $316.67 per month
  This is the average monthly cost for cellular service to six (6) mission units based upon what is currently being paid.
- Total Monthly Cost: $5,916.67 per month
- Total Annual Recharge Facility Cost: $71,000 per year in an idle year

<u>The total O&M costs during an idle period (idle year) are outlined below:</u>

- Canal Conveyance O&M Costs: $5,758.33 per month
- Goose Lake Lift Station O&M Costs: $1,352.78 per month
- Phase I Recharge Basin O&M Costs: $5,916.67 per month
- Phase II Recharge Basin O&M Costs: <u>$5,916.67 per month</u>
  Total Monthly O&M Costs (idle year): $18,944.45 per month
  Total Annual O&M Costs (12 months): $227,333.40 per idle year

Water Recharge Periods

A water recharge period is anticipated to occur for a total of approximately 2 years out of every 10 years, however these events are oftentimes during a short period of time while Article 21 water is available. Therefore, the objective of the project is to convey the maximum amount of water to the recharge facilities that can be recharged into the groundwater basin while the water is available. Based on RRBWSD's long term experience in maintaining basins, sediments are typically settled prior to reaching this portion of the service area. Existing recharge basins are very seldomly affected by fine sediments or bacterial fowling. The maintenance costs estimated during idle periods includes the occasional scraping of these materials which would be deposited on islands.

The canal O&M costs during a recharge event (wet year) are outlined below:

- RRBWSD Operation Cost: $9,000 per month
  This cost includes field staff time for canal maintenance (cleaning, repair of floats, etc.), weed control around roads and embankments, rodent control, equipment maintenance, office staff, and overhead cost.
- Electricity Cost: $230,400 per month
  This cost is predicated on moving 460 cfs at a 40-ft TDH to get the water from the Aqueduct to the Phase II property and West Basins property. It is estimated that a total of 56,250 ac-ft would be recharged into the Phase II property and 56,250 ac-ft would be recharged to the West Basins. The power cost is estimated at an average of $0.13/kwh. This total cost has been divided by 4 to account for recharging this volume of water over a four-month period.
- Mission Unit Cost: $158.33 per month
  This is the average monthly cost for cellular service to three (3) mission units based upon what is currently being paid.
- DWR Conveyance Cost: $404,296.88 per month
  The cost of Article 21 water is approximately $23.00 per acre-foot for 112,500 ac-ft, however the IRWD share, which is 37.5%, is paid through an agreement with the Metropolitan Water District (MWD). Therefore, the estimated monthly water costs include $23 per ac-ft for 70,312.5 ac-ft or 62.5% of 112,500 ac-ft. The recharge event is estimated to be a four-month period therefore the total cost of $23/ac-ft x 70,312.5 ac-ft has been divided by 4 to obtain a monthly cost.
- Total Monthly Cost: $643,855.21 per month
  This cost is the estimated monthly cost to recharge approximately 112,500 ac-ft of water over a four-month period.
- Total Annual Conveyance Cost: $2,621,487.50 per year or $46.60/ac-ft

The conveyance O&M costs to lift water up to the Phase I recharge property (Goose Lake Lift Station) during a recharge event (wet year) are outlined below:

- RRBWSD Operation Cost: $4,000 per month
  This cost includes field staff time for lift station maintenance (cleaning, repairs, etc.), weed control around lift station, rodent control, equipment maintenance, office staff, and overhead cost.
- Electricity Cost: $52,500 per month
  This cost is predicated on moving 240 cfs at an 18-ft TDH through the lift station to get the water from the Goose Lake Channel to the Phase I property. It is estimated that a total of 56,250 ac-ft would be recharged into the Phase I property. The power cost is estimated at an average of $0.13/kwh. This total cost has been divided by 4 to account for recharging this volume of water over a four-month period.
- Mission Unit Cost: $52.78 per month
  This is the average monthly cost for cellular service to one (1) mission unit based upon what is currently being paid.
- Total Monthly Cost: $56,552.78 per month
  This cost is the estimated monthly cost to recharge approximately 56,250 ac-ft of water over a four-month period.
- Total Annual Conveyance Cost: $237,033.33 per year or $4.21/ac-ft

The Phase I recharge basin O&M costs during a recharge event (wet year) are outlined below:

- RRBWSD Operation Cost: $9,000 per month
  This cost includes field staff time for pond and basin control structure maintenance (inspection, cleaning, repairs as needed), weed control around levees, rodent control, limit mowing to allow for bank vegetation growth, control of algal mats as needed, raptor box maintenance as needed, office staff, and overhead cost.
- Electricity Cost: $1,500 per month
  This cost is the estimated monthly standby charges for six recovery wells.
- Mission Unit Cost: $316.67 per month
  This is the average monthly cost for cellular service to six (6) mission units based upon what is currently being paid.
- Total Monthly Cost: $10,816.67 per month
  This cost is the estimated monthly cost to recharge approximately 56,250 ac-ft of water over a four-month period.
- Total Annual Recharge Facility Cost: $90,600 per year or $1.61/ac-ft

The Phase II recharge basin O&M costs during a recharge event (wet year) are outlined below:

- RRBWSD Operation Cost: $9,000 per month
  This cost includes field staff time for pond and basin control structure maintenance (inspection, cleaning, repairs as needed), weed control around levees, rodent

control, limit mowing to allow for bank vegetation growth, control of algal mats as needed, raptor box maintenance as needed, office staff, and overhead cost.

- Electricity Cost: $1,500 per month
  This cost is the estimated monthly standby charges for six recovery wells.
- Mission Unit Cost: $316.67 per month
  This is the average monthly cost for cellular service to six (6) mission units based upon what is currently being paid.
- Total Monthly Cost: $10,816.67 per month
  This cost is the estimated monthly cost to recharge approximately 56,250 ac-ft of water over a four-month period.
- Total Annual Recharge Facility Cost: $90,600 per year or $1.61/ac-ft

The total O&M costs during a recharge event (wet year) are outlined below:

- Canal Conveyance O&M Costs: $643,855.21 per month
- Goose Lake Lift Station O&M Costs: $56,552.78 per month
- Phase I Recharge Basin O&M Costs: $10,816.67 per month
- Phase II Recharge Basin O&M Costs: $10,816.67 per month

Total Monthly O&M Costs (wet year): $722,041.33 per month
Total Annual O&M Costs (4 months): $2,888,165.32 per year
Total Idle Year O&M Costs (8 months): $151,555.52 per year
Total Annual O&M Costs (12 months): $3,039,720.84 per year
Average Cost per acre-foot: $27.02 per ac-ft for 112,500 ac-ft/year

Water Recovery Periods

A water recovery period is anticipated to occur for a total of approximately 3 years out of every 10 years. The wells are operated to recover stored groundwater during drought type conditions for agricultural use within the Rosedale-Rio Bravo Water Storage District, conveyance to IRWD, or to exchange with water in the Delta for ecosystem benefits.

The canal O&M costs during a recovery event (dry year) are outlined below:

- RRBWSD Operation Cost: $8,000 per month
  This cost includes field staff time for canal maintenance (cleaning, repair of floats, etc.), weed control around roads and embankments, rodent control, equipment maintenance, office staff, and overhead cost.
- Electricity Cost: $14,040 per month
  This cost is predicated on moving 70 cfs at a 33-ft TDH through the return water lift station to convey the water from the conveyance canal to the Aqueduct. It is estimated that a total of 25,000 ac-ft would be returned to the California Aqueduct. The power cost is estimated at an average of $0.13/kwh. This total cost has been

divided by 12 to account for recharging this volume of water over a twelve-month period.

- Mission Unit Cost: $158.33 per month
  This is the average monthly cost for cellular service to three (3) mission units based upon what is currently being paid.
- Total Monthly Cost: $22,198.33 per month
  This cost is the estimated monthly cost to recover approximately 25,000 ac-ft of water over a twelve-month period.
- Total Annual Conveyance Cost: $266,380 per year or $10.66/ac-ft

The O&M costs for the Goose Lake Lift Station during a recovery event (dry year) are outlined below:

- RRBWSD Operation Cost: $1,500 per month
  This cost includes field staff time for lift station maintenance (cleaning, repairs, etc.), weed control around lift station, rodent control, equipment maintenance, office staff, and overhead cost.
- Electricity Cost: $300 per month
  This cost is the estimated monthly standby charge for the lift station.
- Mission Unit Cost: $52.78 per month
  This is the average monthly cost for cellular service to one (1) mission unit based upon what is currently being paid.
- Total Monthly Cost: $1,852.78 per month
- Total Annual Lift Station Cost: $22,233.33 per year or $0.89/ac-ft

The Phase I recovery well O&M costs during a recovery event (dry year) are outlined below:

- RRBWSD Operation Cost: $8,000 per month
  This cost includes field staff time for pump maintenance, oil for pumps, weed control around well sites, rodent control, scheduled water quality testing, office staff, and overhead cost.
- Electricity Cost: $144,900 per month
  This cost is predicated on moving 35 cfs (6 wells at 6 cfs each and an approximate TDH of 340-ft) for a 30 day period for a total of approximately 2,083 ac-ft of water recovered per month or 25,000 ac-ft per year. The power cost is estimated at an average of $0.13/kwh. This total cost has been divided by 12 to account for recovering this volume of water over a twelve-month period. This is approximately $24,150 per well per month.
- Mission Unit Cost: $316.67 per month
  This is the average monthly cost for cellular service to six (6) mission units based upon what is currently being paid.
- Total Monthly Cost: $153,216.67 per month
  This cost is the estimated monthly cost to recover approximately 25,000 ac-ft of water over a twelve-month period.
- Total Annual Recovery Facility Cost: $1,838,600 per year or $73.54/ac-ft

The Phase II recovery well O&M costs during a recovery event (dry year) are outlined below:

- RRBWSD Operation Cost: $8,000 per month
  This cost includes field staff time for pump maintenance, oil for pumps, weed control around well sites, rodent control, scheduled water quality testing, office staff, and overhead cost.
- Electricity Cost: $144,900 per month
  This cost is predicated on moving 35 cfs (6 wells at 6 cfs each and an approximate TDH of 340-ft) for a 30 day period for a total of approximately 2,083 ac-ft of water recovered per month or 25,000 ac-ft per year. The power cost is estimated at an average of $0.13/kwh. This total cost has been divided by 12 to account for recovering this volume of water over a twelve-month period. This is approximately $24,150 per well per month.
- Mission Unit Cost: $316.67 per month
  This is the average monthly cost for cellular service to six (6) mission units based upon what is currently being paid.
- Total Monthly Cost: $153,216.67 per month
  This cost is the estimated monthly cost to recover approximately 25,000 ac-ft of water over a twelve-month period.
- Total Annual Recovery Facility Cost: $1,838,600 per year or $73.54/ac-ft

The total O&M costs during a recovery event (dry year) are outlined below:

- Canal Reverse Flow O&M Costs: $22,198.33 per month
- Goose Lake Lift Station O&M Costs: $1,852.78 per month
- Phase I Recovery Well O&M Costs: $153,216.67 per month
- Phase II Recovery Well O&M Costs: $153,216.67 per month

Total Monthly O&M Costs (dry year): $330,484.45 per month

Total Annual O&M Costs (12 months): $3,965,813.33 per year
Average Cost per acre-foot: $79.32 per ac-ft for 50,000 ac-ft/year

Figure 1 below shows a summary of all project O&M costs by facility and by operating year type.

Irvine Ranch Water District

Operation & Maintenance Cost Estimate

Phase I Well Field Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3,5]	Monthly Mission Unit Cost[4]	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost if Utilized for 12 Months[6]	Average Cost per Ac-Ft[7]
Dry Year (Pumping Wells)	$ 8,000.00	$ 144,900.00	$ 316.67	$ -	$ 153,216.67	$ 1,838,600.00	$ 73.54
Wet Year (Recharging Water)	$ 9,000.00	$ 1,500.00	$ 316.67	$ -	$ 10,816.67	$ 90,600.00	$ 1.61
Idle Year	$ 4,100.00	$ 1,500.00	$ 316.67	$ -	$ 5,916.67	$ 71,000.00	

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent control cost, office staff, overhead cost,
2. Cost includes one additional piece of equipment for property maintenance
3. Monthly PG&E cost to operate (6) 400 hp wells
4. Average monthly cost for cellular service to (6) Mission Units
5. Assumed 35 cfs flow rate for a 30 day month for a total of 2,083 ac-ft of water recovered per month or 25,000 ac-ft/yr
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 4 months of recharging water up to 56,250 ac-ft and 8 months at idle
7. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Canal Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	DWR Conveyance Cost[5]	Total Monthly Cost	Total Annual Cost[6]	Average Cost per Ac-Ft[7]
Dry Year (Pumping Wells)	$ 8,000.00	$ 14,040.00	$ 158.33	$ -	$ 22,198.33	$ 266,380.00	$ 10.66
Wet Year (Recharging Water)	$ 9,000.00	$ 230,400.00	$ 158.33	$ 404,296.88	$ 643,855.21	$ 2,621,487.50	$ 46.60
Idle Year	$ 4,100.00	$ 1,500.00	$ 158.33	$ -	$ 5,758.33	$ 69,100.00	

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent control cost, office staff, overhead cost,
2. Cost includes one additional piece of equipment for canal maintenance
3. Monthly PG&E cost to operate two lift stations moving 230 cfs at a 20-ft TDH each, Total 56,250 ac-ft / year for wet years. Monthly PG&E cost to operate Return Water Lift Station moving 35 cfs at a 25-ft TDH, total 25,000 ac-ft/yr.
4. Average monthly cost for cellular service to (3) Mission Units
5. Article 21 water cost estimated at $23.00/AF for 112,500 ac-ft, however IRWD's share (37.5%) is paid through agreement with Metropolitan Water District. Therefore the estimated monthly water costs include $23/AF for 70,312.5 ac-ft.
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 4 months of recharging water up to 56,250 ac-ft and 8 months at idle
7. Dry year conveying 25,000 ac-ft to aqueduct and a wet year recharging 112,500 ac-ft.

Goose Lake Channel Turnout Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1]	Monthly PG&E Cost[2]	Monthly Mission Unit Cost[3]	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost[4]	Average Cost per Ac-Ft[5]
Dry Year (Pumping Wells)	$ 1,500.00	$ 300.00	$ 52.78	$ -	$ 1,852.78	$ 22,233.33	$ 0.89
Wet Year (Recharging Water)	$ 4,000.00	$ 52,500.00	$ 52.78	$ -	$ 56,552.78	$ 237,033.33	$ 4.21
Idle Year	$ 1,000.00	$ 300.00	$ 52.78	$ -	$ 1,352.78	$ 16,233.33	

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent control cost, office staff, overhead cost,
2. Monthly PG&E cost to operate (4) 200 hp lift pumps moving 240 cfs, Total 56,250 ac-ft / year
3. Average monthly cost for cellular service to (1) Mission Units
4. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 4 months of recharging water up to 56,250 ac-ft and 8 months at idle
5. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Phase II Well Field Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost if Utilized for 12 Months[6]	Average Cost per Ac-Ft[7]
Dry Year (Pumping Wells)	$ 8,000.00	$ 144,900.00	$ 316.67	$ -	$ 153,216.67	$ 1,838,600.00	$ 73.54
Wet Year (Recharging Water)	$ 9,000.00	$ 1,500.00	$ 316.67	$ -	$ 10,816.67	$ 90,600.00	$ 1.61
Idle Year	$ 4,100.00	$ 1,500.00	$ 316.67	$ -	$ 5,916.67	$ 71,000.00	

1. Rosedale's operation cost includes pond maintenance, oil for reservoirs, field staff time, equipment cost, weed control cost, rodent control cost, office staff, overhead cost,
2. Cost includes one additional piece of equipment for property maintenance
3. Monthly PG&E cost to operate (6) wells
4. Average monthly cost for cellular service to (6) Mission Units
5. Assumed 35 cfs flow rate for a 30 day month for a total of 2,083 ac-ft of water recovered per month or 25,000 ac-ft/yr
6. Dry year annual cost based on operating 12 months out of the year. Wet year annual cost based on 4 months of recharging water up to 56,250 ac-ft and 8 months at idle
7. Dry year pumping 25,000 ac-ft and a wet year recharging 56,250 ac-ft.

Total Project Operation Costs

Type of Year	Monthly RRBWSD Operation Cost[1,2]	Monthly PG&E Cost[3]	Monthly Mission Unit Cost[4]	DWR Conveyance Cost	Total Monthly Cost	Total Annual Cost if Utilized for 12 Months[6]	Average Cost per Ac-Ft[7]
Dry Year (Pumping Wells and Returning Wate	$ 25,500.00	$ 304,140.00	$ 844.44	$ -	$ 330,484.44	$ 3,965,813.33	$ 79.32
Wet Year (Conveying and Recharging Water)	$ 31,000.00	$ 285,900.00	$ 844.44	$ 404,296.88	$ 722,041.32	$ 3,039,720.83	$ 27.02
Idle Year	$ 13,300.00	$ 4,800.00	$ 844.44	$ -	$ 18,944.44	$ 227,333.33	