Use of Existing Pipes for Water Storage for 50-kW Energy Storage Demonstration

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Summary

Water is needed to provide 10 hours of energy storage for the Aquifer Pumped Hydro 50-kW demonstration (EPC-19-058). The volume of water needed for injection is 1.8 acre-feet (AF) based on a flow of 2.1 cfs. Several options for surface storage of water were investigated. Building a surface storage pond ran into regulatory issues with the local water quality board that could not be resolved within the project timelines. The installation of four bladder bags was about one-half a million dollars and would bust the project budget. An option to store water using the volume of existing pipes in the ground to store the water at the surface is feasible. The existing volumes of the available pipes totals 4.1 AF. This is enough volume to provide injection flow for 23 hours.

Volume Calculation

The 50-kW Aquifer Pumped Hydro (APH) demonstration will utilize the irrigation well at the southwest corner of Gaskell and 160th. This well is expected to produce about 800 gallons per minute (1.8 cfs) when pumping based on the 2021 SCE well flow testing (Table 1). When injecting, it is expected to inject about 20% more flow, or about 960 gpm. This is a 2.1 cubic feet per second (cfs) flow. 10-hours of flow for injection is 1.8 acre-feet (AF) of storage needed. The existing pipes have a volume of 4.1 AF (Table 2). This is over twice the amount needed to provide 10 hours of injection flow for APH. This means the existing piping can provide the required 10 hours of storage for the injection flow.

Table 1: APH Well for EPC19-058

Well No.	Well Location	cfs	AFD	Ft. above MSL	Comments
APH Well	Gaskell and 160th	2.1	4.2	~2635’	Injection flow (pumping is less)

Table 2: Volume calculation for existing pipes

Pipe Length	Diam.	Miles	Feet of pipe	Area, Sq. Ft.	Cubic Feet Vol.	Million Gallons	Acre-feet
1. Gaskell from 140th to 150th	54”	1.0	5,280	15.9	84,000	0.63	1.93
2. Gaskell from 150th to 155th	54”	0.5	2,640	15.9	42,000	0.31	0.96
3. 155th from Gaskell to Willow	48”	0.5	2,640	12.6	33,300	0.25	0.76
4. 155th from Willow to Holiday	36”	0.5	2,640	7.1	18,700	0.14	0.43
Total	-	2.5	13,200	-	178,000	1.33	4.1

Figure 1 provides a schematic of the pipeline facilities in question.

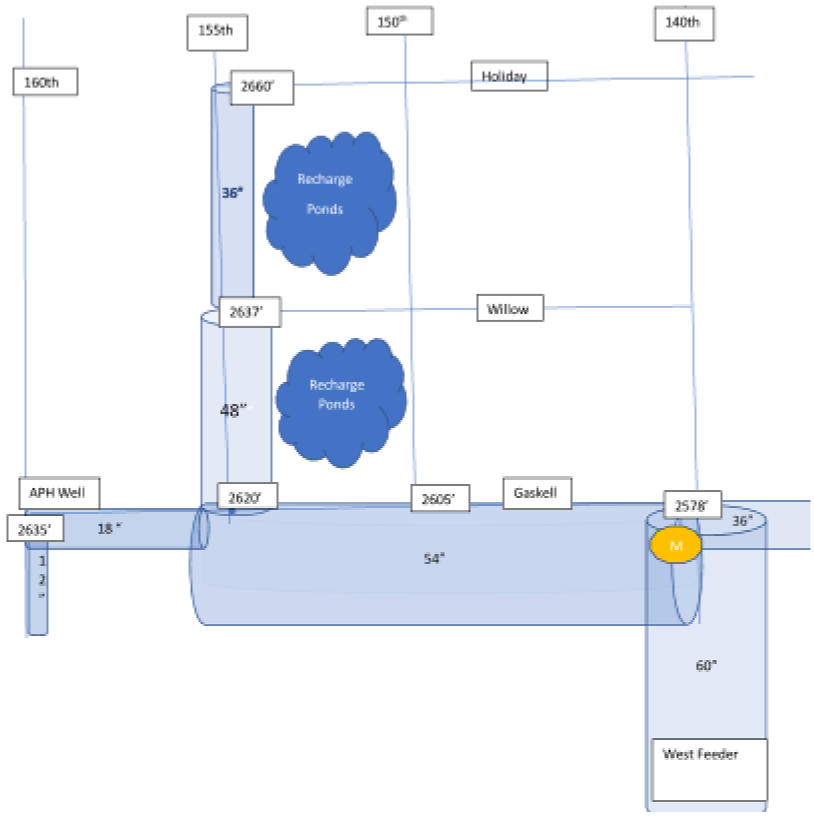

Figure 1: Facilities Layout

Elevations and Pressures

The APH well at Gaskell and 160th is at an elevation of ~2,635' above mean sea level (MSL). There are pipes connecting the higher elevation wells at 155th and Willow and 155th and Holiday that would provide a positive pressure for flows to the APH well, particularly if a 10 ft standpipe is added at 155th and Holiday. These pipes contain 1.19 acre-ft of water storage, enough for 6-7 hours of operation of the APH generation.

Figure 2 provides a schematic of the hydraulic grade line of these facilities. The water in the large 54" pipeline will not flow by gravity into the APH well – it is lower elevation than the APH well. There are two available options. First is to the use pressure from the West Feeder facilities to push the water in this pipeline into the well. The second is to use a siphon at the APH well to suck the water into the well.

A siphon was considered as an alternative to using the pressure from the West Feeder but was rejected as being impractical and too dangerous. As the siphon worked the water would be drained out of the 54" pipe into the APH well. This would create a significant vacuum in the 54" pipe. The pipes were not designed to tolerate an internal vacuum. If anything goes wrong, it could result in a vacuum in the piping, risking collapse of the pipe and a tremendously expensive repair. Using existing pressure in the West Feeder is a safer and simpler solution.

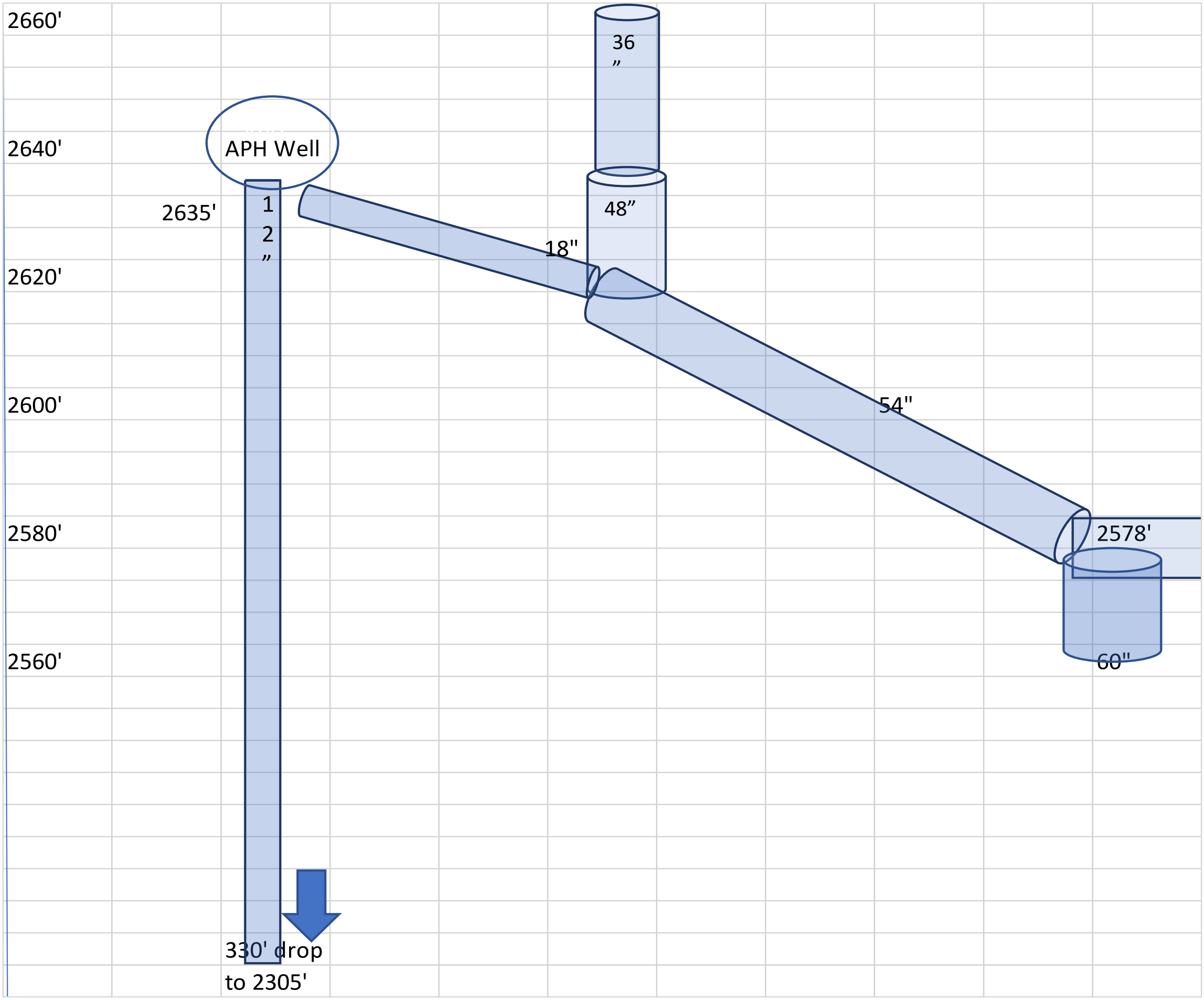

Figure 2. Hydraulic Grade Line of Pipeline Facilities.

Testing the Pipeline Integrity

To begin the test, the existing pipes will be drained of any water. The low point of the 54" pipe is the flow meter at the corner of Gaskell and 140th. It has an elevation of 2,578'. It is 57 feet below the elevation of the irrigation well used for the 50-kW test.

The pipes will then be refilled with groundwater that contains embedded energy. To push the water out of the 54" pipe and into the well, the flow control valve to the AVEK West Feeder will then be opened slowly. The existing pressure in the West Feeder will push the groundwater into the irrigation well. As the pipes empty of groundwater, they will be backfilled by surface water from AVEK, avoiding the creation of a vacuum and collapse of the pipeline. The West Feeder's pressure at that location is estimated to be 100 pounds per square inch, or 231' of hydraulic energy. With the known ground elevation of 2,578', the total West Feeder hydraulic gradeline will be 2,578 + 231 = 2,809'. This is adequate to push the groundwater into the APH well at Gaskell and 160th. The hydraulic gradeline will be controlled at 2667' with the addition of a 10' standpipe at the corner of Holiday and 155th (see Fig. 1).

This will provide 2667 – 2632 = 35’ of HGL or 15 psi of positive pressure in the pipe. To maintain this pressure, the flow meter at the West Feeder will be adjusted to match the flow being injected into the irrigation well.

Verification of Groundwater Injection

Verification that only groundwater was injected will result from the addition of a small amount of chlorine to the groundwater (2-4 parts per million). If the water maintains a residual, it can be verified that it is groundwater. Surface water from AVEK is raw water with zero chlorine in it. With 4.1 AF of storage volume in the pipes and only 1.8 AF needed for injection flow, the stored groundwater should be over twice the amount needed for 10 hours of injection.

APH Testing Protocol

The demonstration of 50-kW of energy storage will require a series of operational steps. They are summarized in Table 3.

Table 3: APH Testing Protocol

1. Use other wells to provide water in initial APH evaluation test.
2. Use stored water in pipes along 155th to run APH for 5 hours
3. Use west feeder to provide pressure for 54” pipe and run APH for 10 hours

The facilities involved are shown in Figure 1. Table 4 provides a summary of the testing protocol for the entire APH system

Table 4: APH System Testing Protocol

1. Purge existing irrigation wells at Gaskell and 160th, Kingbird and 160^{th,} and Gaskell and 152nd of sand and other material and pump water to recharge or waste
2. Verify that the 18” pipe along Gaskell connects to the irrigation well at Gaskell and 160th. If it does not connect, lay 18” pipe along the surface to connect the irrigation well to the 54” pipe on Gaskell & 155th .
3. Pressure test the 18” piping from 54” pipe along Gaskell to determine if it leaks. If so, plug leaks.
4. Add a new combination air and vacuum valve at the irrigation well at Gaskell and 160th. Add a standpipe to the 36” pipe at Holiday and 155th and place pipes to drain to the percolation ponds.
5. Use flow from wells at Kingbird and 160th and Gaskell and 152nd to test APH power generation equipment. Maximize flow to provide ~50 kW of power for 5 hours.
6. After 5 hours of injection shut off supporting wells, depressurize pipes, and terminate test.
7. Keep the flow control valve at Gaskell and 140th closed and drain water from all existing WSWB piping
8. Refill existing pipes full of chlorinated groundwater from APH well and use standpipe at the Holiday and 155th high spot to control pressures. Blowoff excess flows to percolation ponds.
9. Close the connection to the 54” pipeline and use the water in the pipes along 155th to run APH generation for 5 hours by opening the valve to the APH well.
10. After 5 hours of injection, depressurize pipes, and terminate test.
11. Close the turnout at Gaskell and 155th and slowly open the flow control valve at Gaskell and 140th to connect to the West Feeder.

12. Open the valve to the APH well and begin to generate power. Flow from West Feeder to match the measured injection flow at the well. HGL controlled at 2667’ by standpipe. This is energy discharging from storage.
13. Verify that only groundwater is being injected by measuring chlorine residual.
14. After 10 hours of injection, slowly close isolation valve at Gaskell and 140th, depressurize pipes, and terminate test.

Attachment: AVWS Facilities

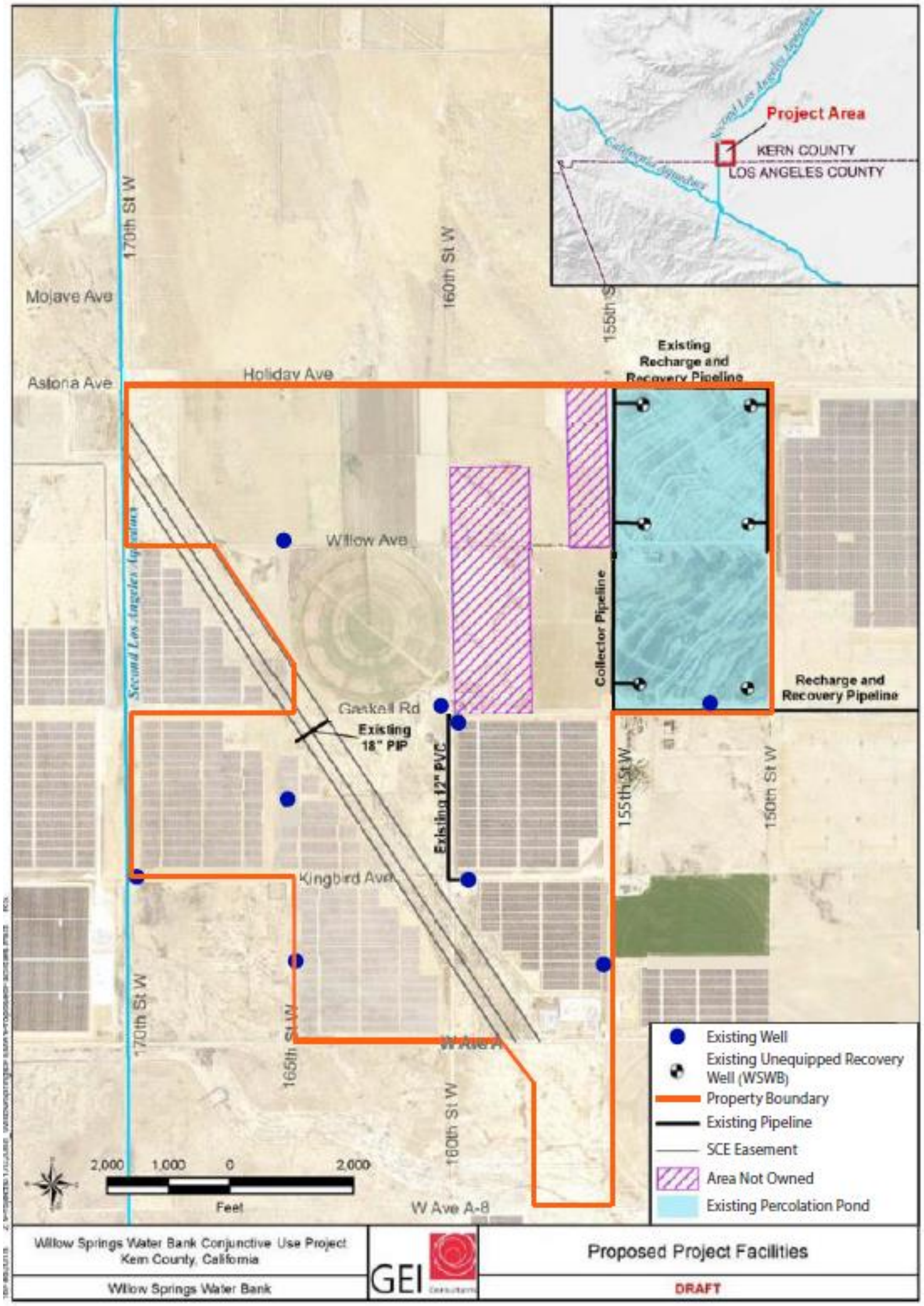

Figure 1: Map of WSWB Facilities as of June, 2021

Table 1: Existing WSWB Tangible Facilities

1,000,000 Acre-Feet (TAF) Bank	Est. Quantity	Data Room Location
1. 320 acres of existing percolation ponds (Fig. 1)	67 TAFY*	Land mapping & info/facility inventory/as built drawings
2. 663 acres of vacant land for future ponds	163 TAFY	Land mapping & info/site master plan/2016 MP update
Recharge	230 TAFY	
3. 6 production wells (unequipped, have equipment for 4)	17.9 TAFY	Land mapping & info/facility inventory/new well logs & drilling
4. 8 operational irrigation wells (see Table 2)	12.9 TAFY	Geotechnical/well database/ag well logs
Extraction	30.8 TAFY	
5. 54", 48", 36" & 18" pipe from West Feeder. along Gaskell to production wells	2.5 miles	Land mapping & info/facility inventory/as built drawings
6. 12" pipe connecting 2 irrigation wells along 160th Street	0.5 miles	Figure 1 (no design drawing)
7. 54" flow meter at West Feeder (140th and Gaskell)	-	Land mapping & info/facility inventory/as built drawings
8. Solar Exclusion Zones around solar, 80'-105' wide	88.7 acres	Land mapping & info/facility inventory/easements acquired
9. Easements from Sempra for wells east of 150th (Fig. 2)	4.5 miles	Land mapping & info/facility inventory/easements acquired
10. Center pivot irrigation system for 160 acres	1	No data
11. Warehouse at 160th Street and Gaskell Avenue	1	No data

Table 2: Existing WSWB Wells

Location	Casing	Flow, TAFY	Motor HP	Data Room Location
1. Gaskell & 150th	18" PVC	3.2*	300	Land Mapping and Info/well database/new well logs, drilling
2. Gaskell & 155th	24" steel	4.4*	300	Land Mapping and Info/well database/new well logs, drilling
3. Willow & 155th	24" steel	2.4*	300	Land Mapping and Info/well database/new well logs, drilling
4. Holiday & 155th	24" steel	2.4*	300	Land Mapping and Info/well database/new well logs, drilling
5. Holiday & 150th	24" steel	2.1*	TBD	Land Mapping and Info/well database/new well logs, drilling
6. Willow & 150th	18" PVC	3.4*	TBD	Land Mapping and Info/well database/new well logs, drilling
7. Gaskell & 152nd	12" steel	1.3	250	Geotechnical/well database/ag well logs & ag well videos
8. Gaskell & 160th	14" steel	1.3	200	Geotechnical/well database/ag well logs & ag well videos
9. Kingbird & 160th	12" steel	1.1	150	Geotechnical/well database/ag well logs & ag well videos
10. Ave. A & 155th (1/4 mi. N.)	12" steel	1.5	200	Geotechnical/well database/ag well logs & ag well videos
11. Kingbird & 170th	12" steel	2.1	200	Geotechnical/well database/ag well logs & ag well videos
12. Kingbird & 165th (1/4 mi. N.)	10" steel	1.8	200	Geotechnical/well database/ag well logs & ag well videos
13. Ave. A & 165th (1/4 mi. N.)	14" steel	2.2	200	Geotechnical/well database/ag well logs & ag well videos
14. Willow & 165th	TBD	1.6	Diesel	Geotechnical/well database/ag well logs & ag well videos
Total	-	30.8	-	

* Flow estimate from well completion report. Other flows measured from SCE efficiency tests. Well depths, perforation areas, and video logs in data room.