Date	November 30, 2014
To:	Craig Garric, Kate Akyuz, King County Department of Natural Resources and Parks
From :	Merri Martz, Mark Hopkinson, Tetra Tech
Project Name::	Willowmoor Floodplain Restoration Project
Subject:	Draft Addendum #2 to Willowmoor Cold-Water Supplementation Concept Memo (June 2014)

INTRODUCTION

This memorandum is provided as the second addendum to the Willowmoor Cold-Water Supplementation Concepts Memo finalized in June 2014 (King County 2014). Based upon the project team design charrette held at the end of September 2014, two channel alternatives are being evaluated further:

- Split-flow with habitat channel (Alternative 4)
- Modified/widened existing Transition Zone channel (Alternative 5)

Associated with each of these channel alternatives are cold-water supplementation concepts that are the most promising and cost-effective:

4. Pumped groundwater to discharge into habitat channel (3 cfs)

5. Pumped and piped heat exchange to discharge into pools in the Transition Zone (10 cfs)

The estimated conceptual level implementation and life-cycle costs of anticipated operation and maintenance (net present value over 50 years) of these two options are summarized below in Table 1.

Table 1. Estimated conceptual level implementation and life cycle costs for the two remaining cold-water concept alternatives.

Concept Alternative	Implementation Cost ($)	Life-Cycle Cost (50 years; $)	Cfs Supplied[1]	$/cfs[1]
Concept 4-Pumped Groundwater	$1,600,000	$103,000	3	$568,000
Concept 5-Pump Lake Outlet Water to Heat Exchange System	$4,200,000	$435,000	10	$463,500

[1] – Cost per cfs based on sum of implementation cost plus life-cycle cost.

TABLE 2. Alternative Matrix

TETRA TECH

	Hypolimnetic Withdrawal	Pump Groundwater to Side Channel	Shallow Groundwater Trench Consolidat	Purchase Potable Water	Heat Pump Exchange	Hyporheic Flow	Transition Zone Hyporheic	Hypolimnetic Cooling
Key Features	Withdraw water from 35 to 49 foot depth in Lake Sammamish	One 40-60 foot deep well south of transition zone	Pipe trench to intercept shallow groundwater	Connect to existing City water line at W Lake Sammamish Pkwy	Pump near rowing club to buried heat exchange mechanical system, plus passive gravity infiltration terminal section	Pump near rowing club to discharge to gravel trenches near Transition Zone	Replace existing Transition Zone channel with coarse gravel backfill for hyporheic exchange	Pump Lake Sammamish surface water through heat exchange piping on bottom of lake
	~16,000 LF submerged pipeline -- discharge at weir	~2,000 LF of pipeline -- discharge to new side channel	~3,000 LF of pipeline -- discharge to Transition Zone or new channel	~3,000 LF of pipeline -- discharge to Transition Zone or new channel	~1,600 LF of pipeline & ~2 EA 1,500 LF heat exchanger-- discharge to Transition Zone or new channel	~2,800 LF of pipeline -- discharge to Transition Zone or new channel(s)	7 acres of excavation and backfill with new channel reconstruction	~16,000 LF of pipeline -- discharge at weir
Planning Level Construction Costs	$7.0 million total cost	$1.6 million total cost	$800k total cost	$900k total cost	$4.2 million total cost	$2.0 million total cost	$5.6 million total cost	$7.4 million total cost
Net Present Value, Operation and Maintenance Over 50 Years	$197k NPV for O&M (over 50 years)	$103k NPV for O&M (over 50 years)	$23k NPV for O&M (over 50 years)	$4.5 million NPV for O&M (over 50 years)	$435k NPV for O&M (over 50 years)	$62k NPV for O&M (over 50 years)	$117k NPV for O&M (over 50 years)	$197k NPV for O&M (over 50 years)
Water Quality of Source	Temperature average = 13C	Temperature average = 10C	Temperature average = 10C	Temperature average = 10C	Temperature average = 13C (after cooling)	Temperature average = 18C (after cooling)	Temperature average = existing river temps	Temperature typical = 13C (after cooling)
	DO average = 5 mg/l	DO average = <1 mg/l; requires aeration	DO average = <1 mg/l; requires aeration	DO average = <1 mg/l; requires aeration	DO average = 8 to 9 mg/l	DO average = <1 mg/l; requires aeration	DO average = <1 mg/l when upwelling	DO average = 8 to 9 mg/l
	Phosphorus = <0.01 mg/l; however may want to consider treatment for phosphorus	Phosphorus = no data	Phosphorus = no data	Phosphorus = no data	Phosphorus = <0.01 mg/l	Phosphorus = <0.01 mg/l	Phosphorus = <0.01 mg/l	Phosphorus = <0.01 mg/l
	Need to identify aeration options prior to discharge below weir in river.	Need to identify aeration options prior to discharge to pools	Need to identify aeration options prior to discharge to pools	Need to identify aeration and chlorine removal options prior to discharge to pools	Cooling to 10C may be possible	Need to identify aeration options prior to discharge to pools and if further cooling is feasible		
Water Quantity	10 or 20 cfs is feasible; 10 cfs is cooled more easily at approximately 23% less cost	3 cfs based on estimated yield from City of Redmond wells.	Less than 1 cfs; no data available	1 cfs assumed since City water supply would be limited	10 cfs scaled up using two 5 cfs heat exchange systems in parallel	5 cfs (may be possible to scale up to 10, or 20 cfs)	<1 cfs likely to exchange in hyporheic zone	10 or 20 cfs is feasible; 10 cfs is cooled more easily at approximately 20% less cost
	Costs assume 60 days of pumping (July 15-Sept 15)	Costs assume 60 days of pumping (July 15-Sept 15)	Need further information on water availability during summer	Costs assume 60 days of purchase (July 15-Sept 15)	Costs assume 60 days of pumping (July 15-Sept 15)	Costs assume 60 days of pumping (July 15-Sept 15)	No costs for water source	Costs assume 60 days of pumping (July 15-Sept15)
Temperature Cooling Effect and Distance Downstream	Cooling to 17.5C for 5,000 to 25,000 square feet when lake temperature is 24 or 20C (for 20 cfs)	As added to ~5 cfs habitat channel, along with 1 cfs from Tosh Creek; likely cooling of entire flow to 19C when lake temp is 24C; or to 16C when lake temp is 20C	Cooling by 0.5C or less within pool	Cooling by 0.5C or less within pool	Cooling to 17.5C for 2,000 to 13,000 square feet when lake temperature is 24 or 20C (10 cfs)	Create thermal refuge(s) in Transition Zone at less than 21C lethal limit	Cooling by 0.5C or less within pools	Cooling to 21C when river temperature is 24C; cooling to 18C when river temperature is 21C
	Cooling of river to 17.5C for ~800 feet downstream of weir or 2000 feet remaining less than 21C (for 20 cfs)	Provides entire length of habitat channel below lethal limit or to 16C criteria when lake levels are cooler; will also provide refuge where channel re-enters river, but not substantially cool the river (i.e. by ~1C to Bear Creek	Provides small area of refuge	Provides small area of refuge	Cold refuge pools and cooling of river to 17.5C for 400 feet downstream of discharge and remaining below 21C to Bear Creek.		Provides small area of refuge	
Change in Index of Thermal Stress	20 cfs reduces thermal stress by 88% and 100% for 16 and 21C thresholds; 10 cfs by 61% and 95%, respectively	Not yet known	Negligible	Negligible	Reduces thermal stress by 12% and 85% for 16 and 21C thresholds, above Bear Creek	Reduces thermal stress by 12% and 85% for 16 and 21C thresholds, upper river only	Negligible	tbd
Habitat and Water Quantity Effects of Construction Activities	Wetlands = less than 1/2 acre impact	Wetlands = 1 acre impact	Wetlands = 1 acre impact	Wetlands = 1 acre impact	Wetlands = 1 acre impact for trench-scale	Wetlands = 1 acre impact for short trench, could be 5-10 acres or more for larger channel system	Requires complete excavation of existing transition zone; wetlands = 5 acres impact and river channel	Wetlands = <1/2 acre impacts
	Tree Removal = ~16-20 (pump and discharge locations)	Tree Removal = ~15 (pipe trenching)	Tree Removal = ~25 (install pipe trench)	Tree Removal = ~6-8 (pipe trenching)	Tree Removal = ~6-8 (pipe trenching)	Tree Removal = ~6-8 (trenching)	Removal of existing willow buffer	Tree Removal = ~16-20 (pump and discharge locations)
	Fish screen required for intake	N/A	N/A	N/A	Fish screen required for intake	Fish screen required for intake		Fish screen required for intake
	No effects to groundwater table (replaces existing volume of surface outflow from lake)	Need to evaluate effects to groundwater table	Need to evaluate effects to wetlands from draining (up to 9 acres)	Need to evaluate effects on City water supply	Likely no effect to groundwater table	Need to evaluate potential effects (raising and/or lowering) on groundwater table and residence time	Need to evaluate potential loss of surface water to groundwater table and residence time	Avoids issues of potential effects on hypolimnion temperature and other constituents
Constructability	Easy to moderate -- sink pipeline to bed of lake/river	Easy to moderate -- trenching in wetland soils	Moderate -- large trench in wetland soils	Easy to moderate -- trenching in wetland soils	Moderate to difficult -- Much larger scale than normal heat pump systems; unproven to work at this scale	Moderate -- trenching in wetland soils	Moderate -- excvation in river channel, requires dewatering and removal of wet soils	Easy to moderate -- sink pipeline to bed of lake/river
Operation and Maintenance	Moderate -- annual pump maintenance and 60 days of electricity	Limited -- infrequent well pump maintenance and 60 days of electricity	Essentially none	Extensive -- high potable water purchase costs	Moderate to extensive -- Piping may need periodic clean-out; annual pump maintenance and electricity	Moderate -- annual pump maintenance and electricity; infrequent clean-out of gravel trenches	Low -- likely reduced annual maintenance to maintain channel capacity	Moderate -- annual pump maintenance and 60 days of electricity
Additional-Qualitative Disadvantages	Need for navigation buoys and signage		Likely not a reliable water source	Water rights or other City approval	Unproven as to feasibility on this large of a scale	Potentially too short residence time to cool water	Likely low volume of hyporheic flow does not appreciably cool the river	Need for navigation buoys and signage
Additional-Qualitative Advantages	Highest volume for maximum temperature reduction	Water right likely not required	Only "natural"-type solution, no mechanical/electrical required		Could potentially cool as low as 10C (similar to natural groundwater)	Gravel trenches will also passively convey cooler ambient groundwater to resting pools	Suitable for combination with any other restoration alternatives	Highest volume for maximum temperature reduction
	High reliability for source water	High reliability for source water		If confirmed with City, reliable water source	High reliability for source water	High reliability for source water	Limited engineering and limited O&M requirements	High reliability for source water
Bottom Line	Highly effective, high cost	Moderate effectiveness, moderate cost	Limited effectiveness, low cost	Limited effectiveness, high cost	Moderate-high effectiveness, moderate-high cost	Moderate effectiveness, moderate cost	Limited effectiveness, moderate cost	Highly effective, high cost

Updated Conceptual Alternatives

Pumped Groundwater to Habitat Channel

Overview: This Alternative 4 is a revision of the previous Concept 2, Pumped Groundwater to Pools. The alternative now pumps to the upstream limits of a proposed split-flow habitat channel that provides additional habitat features of pools, riffles, and meanders. The pumped groundwater system is modeled, based on estimated Redmond well site yields across the river in Marymoor Park. The proposed habitat channel will receive an assumed minimum of 5 cfs of warm surface water from a diversion structure upstream of the Sammamish Weir, which will be augmented and cooled by 3 cfs of cold water from the proposed pumped groundwater system, and an estimated 1 cfs of cooler flows from Tosh Creek (~18C). The constructed habitat channel will return downstream of the Transition Zone, discharging colder temperature water than the existing Lake discharge during a 60-day critical time period (generally July 15 to September 15).

Primary Features:

- A 40-60 foot deep well located southwest of the transition zone, generally between NE 51st Street and NE 50th Street. Power to the proposed well house is from a new service connection from the overhead electric on the southwest side of West Lake Sammamish Parkway NE, extending overhead across the road, and then trenching underground electric to the well house.
- Trenched upland well pump discharge piping to the upstream end of the constructed side channel as a constant dedicated source of cooler water during the summer months.
- Three Transition Zone resting pools, with bench habit on both sides of the river.
- A habitat channel, constructed from upstream of the Sammamish Weir, across the wetlands with meander benches and pools, to return back to the river at the downstream end of the Transition Zone. The habitat channel will passively receive summer flows from the Lake Sammamish outlet channel, mixed with cold pumped groundwater flows and cool Tosh Creek flows.

Benefits:

- High level of habitat improvement from large-scale excavation through the floodplain and existing degraded wetlands.
- Moderate environmental impacts to construct well pump site adjacent to Lake Sammamish Parkway NE, with small footprint and short gravel maintenance driveway.
- Habitat channel temperature estimated to generally range from 16-19°C (61-66°F), based on contributing flows:
    - 5 cfs Lake outlet water, July to September, generally ranging from 20- 24°C (68-75°F)
    - 3 cfs well pump groundwater discharge at 10-13°C (50-55°F)
    - 1 cfs Tosh Creek flows at 18°C (64°F)
- Return of cool flow to Transition Zone may reduce the overall river temperature by ~1C down to Bear Creek

Risks:

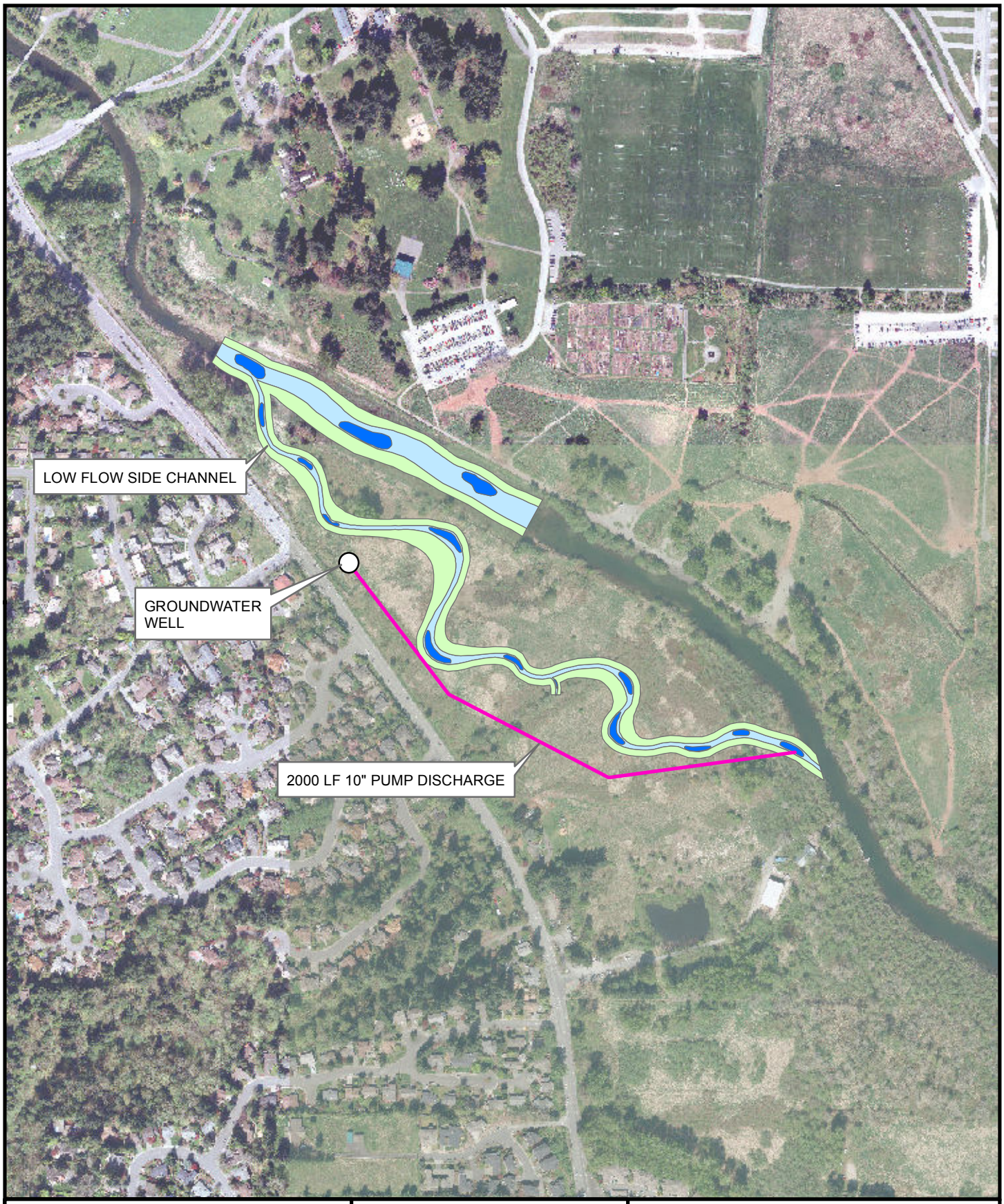
- Combined habitat channel and well/pipe system over 10 acres of impacts to wetlands.
- High potential for archaeological disturbance.
- Access off of Lake Sammamish Parkway NE to gravel driveway assumed as right in-right out, due to maintenance access safety concerns.
- May lower groundwater elevation in wetland, within vicinity of the pump drawdown curve.

Construction Cost:

- Planning level cost estimate with contingency, tax, engineering and administrative = $1,594,000.

Operation/Life-Cycle Costs:

- Life cycle costs include electricity for 60 days of pumping, annual start-up/maintenance/shut-down of the well, plus 5 year maintenance of well pump. Net present value of $103,000 over fifty years of operation.



Bench
Stream
Pool

King County

N
0
500
Feet

WILLOWMOOR PARK
ALTERNATIVE 4
PUMP GW TO SIDE CHANNEL

T32971 King County - Willowmoor
Task 420 Alternative 4 (Previously Concept 2) - Pump Groundwater to Side Channel
Subject: Concept Alternative Cost Estimate Details
Alternative 4 - Pump Groundwater to Side Channel
Date : 25-Nov-14

TETRA TECH

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$50,000	**$**	**50,000**
2	**Sitework**					
	Well Site					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$5,000	$	5,000
	Clear & grub	1	ls	$5,000	$	5,000
	Trench shoring	1	ls	$1,000	$	1,000
	Construction entrance & well site access driveway	100	cy	$30	$	3,000
	Excavation - Electrical Conduits	640	cy	$15	$	10,000
	Haul waste to disposal	1,200	ton	$10	$	12,000
	Imported concrete fill - Electrical Conduits	640	ton	$111	$	71,000
	New well	1	ls	$30,000	$	30,000
	Discharge Pipeline					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Trench shoring	1	ls	$5,000	$	5,000
	Excavation - Discharge Pipeline	5,680	cy	$15	$	85,000
	Haul waste to disposal	10,500	ton	$10	$	105,000
	Imported fill - Discharge Pipeline	5,680	ton	$15	$	85,000
	Side Channel Discharge					
	Side Channel Discharge - sitework by others during channel reconfiguration project				$	-
					$	**437,000**
3	**Piping**					
	10" HDPE pipe	3,500	lf	$33	$	115,500
	Pipe valves and appertenances	1	ea	$1,325	$	2,000
	Fittings	4	ea	$300	$	1,200
	Subtotal, Piping				**$**	**118,700**

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
4	**Structural and Architectural**				
	Well House				
	Slab on grade (10'x20'x8")	5	cy	$420	$ 3,000
	Pump building (timber frame, 8'x16')	128	sf	$200	$ 26,000
	Subtotal, Structural and Architectural				**$ 29,000**
5	**Mechanical**				
	Pump 25 hp w/ controls, electric hook up, plumb, & mech	1	ls	$40,000	$ 40,000
	Subtotal, Mechanical				**$ 40,000**
6	**Electrical**				
	Wood electrical service pole at W Lake Sammish Pkwy	1	ea	$2,000	$ 2,000
	Trench 3 phase service connection from W Lk Sammamish Pkwy	300	lf	$17	$ 6,000
	Pump station power and control panel	1	allow	$75,000	$ 75,000
	Electrical contingency allowance	1	ls	$5,000	$ 5,000
	Subtotal, Electrical and Control				**$ 88,000**
7	**Intrumentation and Control**				
	Included in electrical in section 6				**$ -**
	Subtotal, Intrumentation and Control				**$ -**
8	**Site Restoration**				
	Well Site				
	Site landscaping	1	ls	$2,000	$ 2,000
	Upland Piping				
	Surface restoration & landscaping	200	msf	$67	$ 13,400
	Discharge Site				
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$ -
	Subtotal, Site Restoration				**$ 15,400**
	Total Estimated Direct Costs (Rounded)				$ 778,000
	General Contractor Overhead and Profit	15.0%			$ 117,000
	Subtotal				**$ 895,000**
	Contingency	30.0%			$ 269,000
	Sales Tax (City of Redmond)	9.5%			$ 111,000
	Subtotal				**$1,275,000**
	Engineering (Design and Construction)	15.0%			$ 191,000
	Administration	10.0%			$ 128,000
	Alternative 2 - Total Estimated Project Costs				**$1,594,000**

Heat Pump Exchange System

Overview: This revised concept updates the previous 5 cfs system to a 10 cfs heat exchange system. The water is withdrawn from the outlet channel of Lake Sammamish (upstream of the Sammamish Weir) and pumped into two parallel heat exchange systems for cooling and then discharged downstream of the Sammamish Weir to two constructed resting pools. An additional passive infiltration trench is extended from the drain gravel surrounding the southerly heat exchange trench to discharge to a third resting pool, downstream of the first two. The cold water discharge would generally replace 10 cfs of passive outflow from the Lake during a 60-day critical time period (generally July 15 to September 15).

Primary Features:

- Submerged intake with upland pump station proposed near Sammamish Rowing Association river access for existing power and access purposes.
- Trenched upland discharge piping including two heat exchange transition structures that split flow into two 1500 LF heat exchange systems, mixing with colder ambient groundwater.
- Heat exchange systems constructed in excavated trenches with twelve 6-inch pipelines to collection transition structures before continuing as single trenched pipe construction downstream.
- Construct three Transition Zone resting pools, two to receive up to 5 cfs flows from heat exchange pipe discharges, and a third to receive a passive infiltration trench gravity flow.

Benefits:

- Reduced environmental impacts by small project footprint adjacent to existing Sammamish Rowing Association facilities.
- Modeling of each of the two 5 cfs heat exchangers is estimated to produce the following cooling (based on ASHRAE 2009):
    - The first 500 feet temperature cools from 24°C (75°F) to 17.5°C (63.5°F) = 6.5°C (11.5°F) drop
    - The second 500 feet temperature cools from 17.5°C (63.5°F)to 15°C (58.7°F) = 2.5°C (4.8°F) drop
    - The third 500 feet temperatures from 15°C (58.7°F)to 13.7°C (56.7°F) = 1.3°C (2.0°F) drop

Risks:

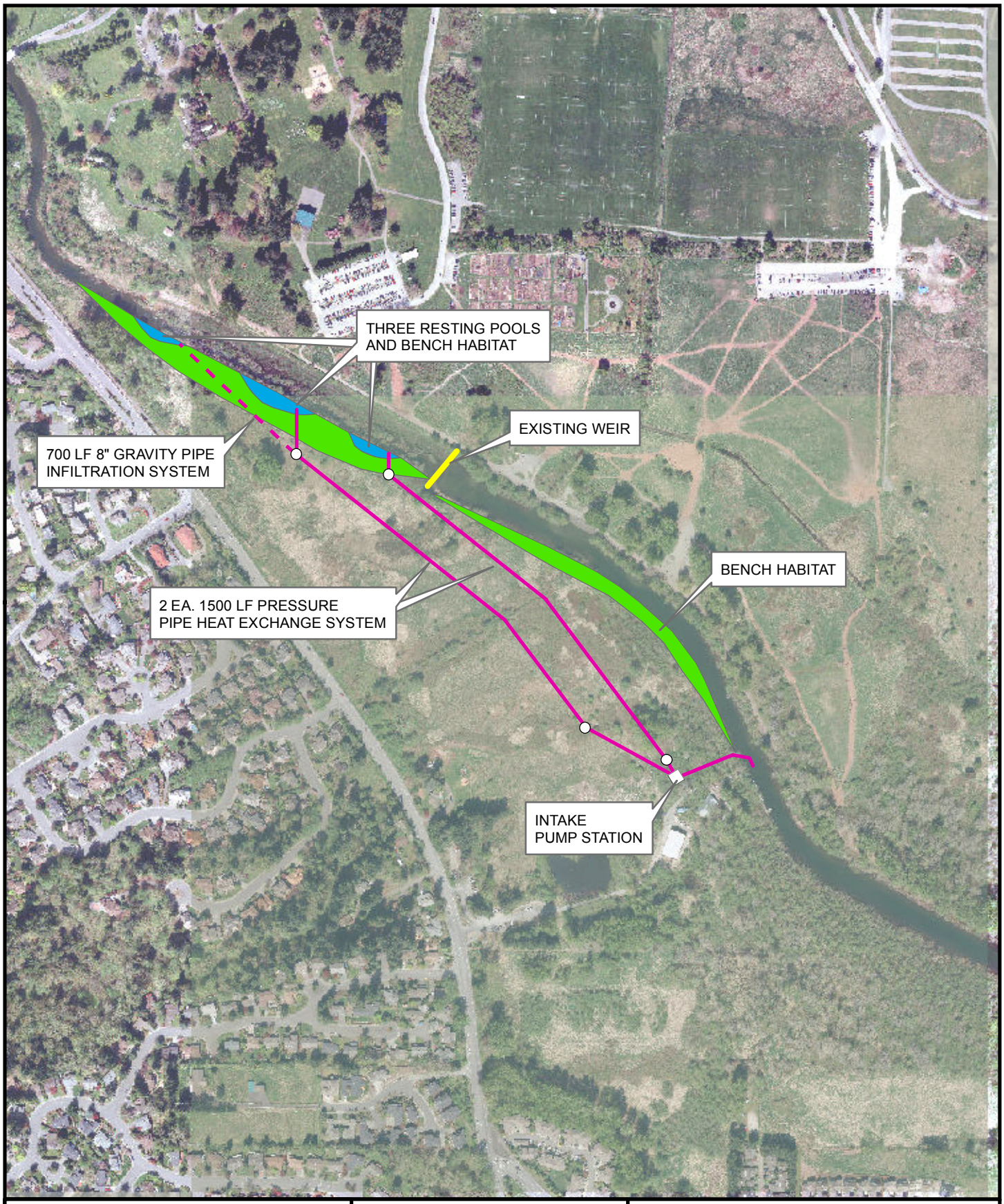
- Sammamish Rowing Association temporary construction disturbances and power needs need to be negotiated.
- Risk of archaeological resources in 3,000 LF trench footprint.
- Requires more operation and maintenance than more passive pump/pipe/discharge systems, given higher pressures than other alternatives.

Construction Cost:

- Planning level cost estimate with contingency, tax, engineering and administrative = $4,180,000.

Operation/Life-Cycle Costs:

- Life cycle costs include electricity for 60 days of pumping, annual start-up/maintenance/shut-down of the pump, plus 5 year maintenance of heat exchange pipe flushing, inspection and cleaning sediment at transitions. Net present value of $435,000 over fifty years of operation.



Bench

Pool

King County

N

0 500 Feet

WILLOWMOOR PARK
ALTERNATIVE 5
HEAT EXCHANGE SYSTEM

T32971 King County - Willowmoor
Task 420 Alternative 5 (Refined Concept 5) - Heat Exchange Water Cooling
Concept Alternative Cost Estimate Details
Alternative 5 - Pump River Water To Heat Exchange System
Date : **24-Nov-14**

TETRA TECH

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$141,600	**$**	**141,600**
2	**Sitework**					
	Pump Site					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$5,000	$	5,000
	Clear & grub	1	ls	$5,000	$	5,000
	Trench shoring	1	ls	$5,000	$	5,000
	Excavation - Pipelines	1,280	cy	$15	$	19,200
	Excavation - Pump station	40	cy	$20	$	800
	Turbidity Curtain	200	lf	$15	$	3,000
	Haul waste to disposal	2,400	ton	$10	$	24,000
	Imported fill - Pipeline & Pump Station	2,400	ton	$15	$	36,000
	Dewatering for pipeline and pump station	5	days	$200	$	1,000
	Crushed Surfacing Base Course	100	cy	$30	$	3,000
	Upland Pipe From Pump Station To Heat Exchange To Transition Zone Discharge					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$2,000	$	2,000
	Clear & grub	1	ls	$2,000	$	2,000
	Trench shoring	1	ls	$2,000	$	2,000
	Excavation - Conveyance & Discharge Pipelines	1,400	cy	$15	$	21,000
	Excavation - Heat Exchange Pipe Trench	6,400	cy	$15	$	96,000
	Excavation - Infiltration Pipelines	1,500	cy	$15	$	22,500
	Haul waste to disposal	17,200	ton	$10	$	172,000
	Imported free draining fill - Pipeline & Heat Exchange	17,200	ton	$15	$	258,000
	Dewatering for pipeline construction	15	days	$200	$	3,000
	Transition Zone Resting Pools					
	Transition Zone Resting Pools - sitework by others during channel reconfiguration work				$	-
	Subtotal, Sitework				**$**	**700,500**

3	**Piping**					
	Intake To Pump Station					
	Fish Screen Assembly	1	allow	$5,000	$	5,000
	16" HDPE DIPS DR 21 Intake Assembly	1	ls	$3,000	$	3,000
	16" HDPE DIPS DR 21 Intake Pipe	280	lf	$69	$	19,300
	36" Precast Pipe Anchors	3	ea	$240	$	700
	Work boat for pipe intake positioning	3	day	$200	$	600
	16x12 Reducer	1	ea	$1,600	$	1,600
	12" HDPE DIPS DR 21 PS Transition Pipe	20	lf	$37	$	700
	12" Valve	1	ea	$5,400	$	5,400
	16" 45 Deg Bend	4	ea	$1,600	$	6,400
	Upland Pipe From Pump Station To Heat Exchange To Transition Zone					
	12" HDPE DIPS DR 21 PS Transition Pipe	20	lf	$37	$	700
	12" Valve	1	ea	$1,950	$	2,000
	16x12 Reducer	1	ea	$1,600	$	1,600
	16" HDPE DIPS DR 21 Discharge Pipe	400	lf	$69	$	27,600
	16" 45 Deg Bend	4	ea	$1,600	$	6,400
	16" Wye	1	ea	$1,950	$	2,000
	Heat Exchange Pipe Transition	4	ea	$5,000	$	20,000
	6" Aluminum Heat Exchange Pipe	36,000	lf	$18	$	648,000
	Transition Zone Pipe Discharge to Pools					
	16" HDPE DIPS DR 21 Discharge Pipe	250	lf	$69	$	17,300
	16" Discharge Tee Energy Dissipator	2	ea	$1,950	$	3,900
	6" Valve	4	ea	$1,300	$	5,200
	8" Perforated Aluminum Infiltration Pipe	700	lf	$14	$	9,800
	Subtotal, Piping				**$**	**787,200**
4	**Structural and Architectural**					
	Pump Station					
	Slab on grade (10'x20'x8")	5	cy	$420	$	2,100
	Pump building (timber frame, 8'x16')	128	sf	$200	$	25,600
	Subtotal, Structural and Architectural				**$**	**27,700**
5	**Mechanical**					
	Pump Station					
	Pump System	1	ea	$250,000	$	250,000
	Building space heater and passive ventilation	1	ls	$5,000	$	5,000
	Subtotal, Mechanical				**$**	**255,000**

6	**Electrical**					
	Pump Station					
	Pump station power and control panel	1	allow	$75,000	$	75,000
	2-3" PVC direct bury conduit	500	lf	$20	$	10,000
	Power extension to pump station	500	lf	$20	$	10,000
	Meter & shutoff	1	ls	$500	$	500
	Electrical contingency allowance	1	ls	$2,500	$	2,500
	Subtotal, Electrical and Control				**$**	**98,000**
7	**Intrumentation and Control**					
	Included in electrical in section 6				**$**	**-**
	Subtotal, Intrumentation and Control				**$**	**-**
8	**Site Restoration**					
	Pump Station					
	Site landscaping	1	ls	$2,000	$	2,000
	Upland Piping					
	Surface restoration & landscaping	460	msf	$67	$	30,800
	Discharge Site					
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$	-
	Subtotal, Site Restoration				**$**	**32,800**

Total Estimated Direct Costs (Rounded)		$	2,043,000
General Contractor Overhead and Profit	15.0%	$	306,000
Subtotal		**$**	**2,349,000**
Contingency	30.0%	$	705,000
Sales Tax (City of Redmond)	9.5%	$	290,000
Subtotal			**$3,344,000**
Engineering (Design and Construction)	15.0%	$	502,000
Administration	10.0%	$	334,000
Alternative 1 - Total Estimated Project Costs			**$4,180,000**

Summary

The pumped groundwater and pumped heat exchange systems could be implemented with either channel alternative; however, the groundwater volume is not sufficient to substantially cool the main channel flow as it is almost certain to be less than 5 cfs (3 cfs estimated herein). Both alternatives provide substantial cooling benefits. We recommend installing a 30-40 foot groundwater well in the vicinity of West Lake Sammamish Parkway to further identify the potential volume of water that may be available and to evaluate the potential effects on the groundwater table and wetland hydrology before determining the feasibility of this alternative.

References

American Society of Heating, Refrigerating, and Air-Conditioning Engineers. 2009. Fundamentals. 880 pages. On the web at: https://www.ashrae.org/resources--publications/handbook/description-of-the-2013-ashrae-handbook--fundamentals

King County. 2014. Willowmoor Cold-Water Supplementation Concepts. Prepared by Tetra Tech, Inc. Seattle, WA. Final June 2014.