Gorge 2nd Tunnel

Appendix A: Notes from Decision Workshop, June 9, 2009

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Gorge 2nd Tunnel Project
Review and Decision Workshop
Tunnel Diameter Optimization and Layout / Water Transient Study

Workshop Minutes
9:00 AM to 1:00 PM, Tuesday June 9, 2009
Location: SCL, 700 Fifth Ave, Suite 3200, Seattle, WA 98124

Introductions	Gregg Davidson, JA, Project Manager (GWD) Mark Havekost, JA, Design Lead (MDH) Jeff Kerschner, SCL, Operator Powerhouse (JK) Dave Rowan, SCL, Project Engineer (DR) Stephen Spain ,HDR | DTA, Hydraulic Lead (SS) David Elwood, HDR | DTA, Load Rejection Modeling (DE) John Owen, SCL, Project Manager (JO) Tej Mathurs, SCL, Dam Safety Engineer (TM) Mary Yoder-Williams, SCL, Environmental Lead (MYW) Dee Smiley, SCL, Civil Engineering Manager (DAS) David Summers, HDR | DTA, Hydraulic Transients (DNS) Walt Davis, SCL, Safety Superintendent (WD) Wing Chen, SCL, Hydraulics(WC) Bob Fuchs, SCL, Mech. Engineer (BF) Scott McLean, SCL, Civil Supervisor (SMc) LE McCutcheon, JA (LEM) Mike Haynes, SCL, Program Director (MH) Roger Culleton, SCL (via video teleconference) (RC)
Goals and Objectives of Workshop	GWD outlined the goals and objectives of today's meeting: to identify a preferred link (downstream connection) and learn more about dispatch logic. Meeting will be interactive with questions as we go to facilitate discussion. GWD reviewed agenda for the meeting.
Project Update Phase 1 – Preliminary Design Phase 2 – Geotechnical Investigation	4 elements to Phase 1: Tunnel Diameter Optimization and Layout (TDOL), Water Transient Study, Water Quality Report (has been submitted), Water Management Plan (also complete). Emphasis now is water transient study and TDOL. Water transient study started development in Feb, followed by field investigation, culminating in report. Tunnel has looked at aspects of rock tunnel, roughness, potential TBM needs, connections, developed groundwater inflow modeling (fed into water management plan). Phase 2 geotech: program of 6 borings, majority of them are horizontal (access is conducive to this) with one near vertical boring. Deepest is 800 feet (by the surge tank). Horizontal holes are 400-70O ft long. End of July likely start

	drilling. FERC boundary affecting only 1-2 borings. Will finish boring program by end of Sept. With lab testing for another month and development of GBR strategy memo by the end of the year/beginning of next. Question from JK on geotech: Is National Parks Service (NPS) questioning authority to drill? Would that hold up the schedule? Owen clarified: We received a letter from NPS. This is to establish a paper trail to demonstrate that SCL does have the authority to proceed with the project. Working with Tom Marks the Attorney that specializes in FERC. Notify FERC Portland office and let them respond (Marks expects they will without issue) then we take that back to NPS to demonstrate our authority to drill in the wilderness area. FERC wants NPS to OK the work. Conference call with FERC tomorrow to discuss On June 16 Colin McShane and Mary Yoder-Williams are going to DC to debrief FERC on the project. Geotech should be good to go by the end of July, will only affect schedule in a worst-case scenario. GWD: Drilling should go smoothly during summer with all work done by end of September. Driller is being accommodating in flexible schedule. JK: Do we need to carry out earthworks to create a loading platform at the Devil's Elbow Adit portal? DR: No, the drillers will have a temporary platform that they can bring in. GWD: Initially they thought they needed one, but upon site recon, they thought the portable one would work.
Water Transient Study Hydraulic Modeling (Baseline and Preliminary Arrangements) Water Transient Analysis Partial Load Rejection Testing	DNS: Connection alternatives presented: with 4 options, referred to as "Links 1-4". These alternatives were developed by JA's initial analysis. The model DTA generated friction factors, head loss factors, yielding steady state flow. This helps address how bends and bifurcations introduce additional losses into the system. The model uses these physical inputs along with modeling of the turbines (hydraulic devices) to show the steady state solution of the flows. Looking at tunnel pressures, surge chamber levels as a result of load rejections. The initial effort was aimed at looking at flows, surge chamber levels in a worst case scenario (max flows with simultaneous load rejections, which is a rare worst-case event). The Links shown in the diagram are simplified for scoping only and would be optimized once a selected alternative is chosen. DNS reviewed all the parameters that went into the model, including tunnel physical characteristics, and hydraulic model inputs such as water surface levels, generating flow, and discharge characteristics. Flow testing was from 1999 before the powerhouse was upgraded. Can assign flow by assigning gate positions to see what the maximum flow would be in different operating scenarios. Turbine characteristics are from the manufacturer guaranteed performance data. All these inputs go into DTA's computer model to analyze altering different parameters and to see the impacts.

	To get some baseline information for calibration, load rejection tests were conducted on Unit 24 on May 12 & 13 (24 was chosen since it has the greatest hydraulic capacity and since there hadn't been testing on it since the upgrade in 2006). Summary of the inputs into the model they got from these field tests were presented and showed difference between the model and the field test data. BF: Wouldn't it be more accurate on the surge tank to look at the delta instead of correlating the difference. Shouldn't we look at gross head of the plant instead of the elevation? The comparison might be skewed. DNS: We were just looking for peak elevation. SS: Just wanted to predict the high elevation and see if that is where it went for a peak. BF: How accurate is the correlation to the model with this method? SS: We can provide the information on how it correlates. We think it correlates well. DNS: Yes we can correlate, but we took a steady state of the highest level and the delta. BF: A better model would be according to the elevation, not the highest elevation. SS: We can do that. We can make it a percentage change. DR: What is the elevation? DNS: 960 ft at the top SS: That is a good point to make the accuracy of the delta. We just wanted to make sure it didn't go over the top as a worst case scenario to put that to rest. DNS: We had heard anecdotally that there was evidence of it going over the top and we wanted the data to check that. BF: Your data right now is the best we have. DNS: For a given time you will get a certain set of results, but if you change the gate times from slow to rapid, for example, you will see a significant change in pressure rise and surge tank elevations. The point here is that once we have the field data, we could adjust the model and compare the two. DR: Where is the total plant rejection and predicted surge tank elevation? DNS: The cases considered were for all 4 units at 100%, except the last one, which is just 3 of the units at 100%. All show total plant rejections (except the last one). Compared to the max elevation of the surge tank of 960 ft, we have over ten feet of free board. DNS: Each one of these shows the maximum flow, which is right around 8,000 for each test. We used this to baseline the frictional factors for the existing tunnel. Once that is set, it will become part of the next model for the new tunnel and the additional nodes, frictional characteristics, etc.

	BF: What differences do we see between the older data and this? I'd be interested in seeing what degradation took place over that time. DNS: We didn't see that much. DNS: The next step will be to add the second tunnel to this model, which will affect the flows. SS: Adding the second tunnel doesn't increase flow if you want to manage that with your wicket gates so that your FERC license upper limit isn't affected. We need to know what that is, so we can model for that. DNS: We were looking at maximum flows without limitations, just what would actually pass. SS: Just keep in mind that if you decrease the flow (with wicket gates) from the maximum, you would still have the steady state head optimized. JO & JK: Wickets gates are not always 100% open, however. Would like to see the chart showing how we usually have the gates operating. DNS: All the cases presented have the gates at 100%. A follow-up could be to limit the flows to what your limit is and modeling from that. BF: Yes we'd like to see the actual operational limits used (instead of just the maximum). DNS: Again we just looked at the maximum as an upper-bounding case. We can run other scenarios with your lower actual operating cases. BF: Yes that would be useful for the economic modeling. DNS & GWD: This shows that the 2nd tunnel does give an improvement, which was the goal with this modeling. SS: What is the flow you are allowed by FERC. DR: FERC doesn't limit the flows. They give us a generation limit. Our agreement is for 207MW. WC: 7440 cfs is traditionally the flow limit (for old timers). SS: Has that changed since the turbine was upgraded? BF: Yes we did tell FERC when we upgraded Unit 24. SS: We should have a constant flow for the table instead of maximum to really determine what your reduction in head for the 2nd tunnel will be. We need to know what that is. DR: 7700 cfs is the number in the RFP. We need to revisit that and come to consensus. The FERC License is for 207MW MYW: The water rights might be involved with this flow issue. **JO: Action item: SCL has homework to do to provide the maximum flow value.** DR: A single number won't tell the whole story. We need an operating curve to show how we evaluate the energy. Maximum operating flow is almost academic, but rather how we actually operate it. BF: When we did 55 and 56 Harza told us to not change the flow regime and do the economics on that. Just look at worst case for the reports, then optimize for operation. JO: Getting improvements from the second tunnel and not having water squirt out the top of the surge tank is what we've shown here.

	DE: Load Rejection testing. May 12 and 13th we did 2 load rejections at partial load on Unit 24 with 21 and 22 (23 was out for servicing) running at low loads. Steady state conditions are presented in the table in the WTS report. There were pressure taps on each unit to measure transient pressure and a lower, long pressure wave. DE described timing that was put into the model and noted that the numbers might be slightly skewed since we had to trip a breaker during the shutdown. The unit stop button wasn't pressed until a minute after start, which can be seen on the graphs. This is not a normal occurrence and only shows on the 38MW graphs. In the second test for 60MW we hit the unit breaker right after the stop button and didn't have this issue. DE: The testing showed that the time it takes for that wave to fully decay was like 3 hours out, which seemed uncharacteristically long. JK: Isn't some of that going to be restarting units? DE: We didn't keep track of when that restarting took place. JK: Looks like at 4,000 cfs they are turning back on (1/2 hour later?) There was general agreement that this explains it. DE: The instrument we used was not recovered and should still be in the surge tank. It is designed for oceanographic use, so it could last in there for a long time and can be recovered if the tank is ever dewatered, even next year when it is dewatered for inspection. Luckily it worked great until May 14th, which all tracked, so we feel confident in the results. We think the second rejection test moved it so the lanyard is hung up. We feel it is there safe and sound just didn't want to dive in after it. We can get it when we do the tunnel inspection. It is plastic and about 10 inches long, shouldn't cause any problems. SS: The bottom line is that these tests have verified we are within parameters for the existing surge tank. DR: Question on mechanical engineering. The speed goes up when the water is cut off? All mechanical engineers jump in to answer - Yes that is right. You can balance that with governor timing though. More mechanical engineering explanation of pressures and loads when they shut the system. SS: Running the system at 100% with load rejection at that point is the worst case scenario, but we couldn't do that as a field test. DE: These test calibrated the model very well. SS: It was a good calibration. Within a few %.
Link alternatives review	DNS: Provided summary of the links being considered: Link 1, closest to Unit 24, ties in almost directly to the Unit 24 penstock. Gives maximum benefit when running Unit 24 by itself or if it is on. The flow path to the other three units is very convoluted. Link 2 is mid span between the Unit 24 tunnel and the tunnel to the other three units. This and Link 3 provide the best operational flow for all four units.

	Link 3 is by the bifurcation to Unit 24 and the other three units. It also provides good operational flexibility. Link 4 is located by the surge tank. It is so far back, it doesn't provide as much head loss. It doesn't provide much benefit in terms of load rejection. Link 4 is the least recommended option. DNS: If you don't want to give operational bias to Unit 24, the preferred choice is Link 2 or 3. Which is better depends on operational characteristics (dispatch logic). Link 3 seems preferential without that information. WC: Is there a shutout valve considered for this connection? DNS: It can certainly be modeled but was not in our scope. JO: Not in favor of any arrangement that gives "preferential treatment" to any of the units. I'd like to keep the operation flexible. But how does the plant usually operate? JK: Do you have experience with this exact thing? Adding a second tunnel and how it affects operations? I am wondering if it changes anything. MH: We are not changing the configuration. So the settings wouldn't move that much. BF: The only difference will be head. JK: I'm just asking if this would affect where rough zones are - that would affect which machines we run when and how much water would be needed to just run a machine at speed. Since we got the new wheel on Unit 24, we start and stop it all lot more than we used to. We have a lot more efficiency gains to play around with and shift the loads around. We've changed a lot within the last two years how dispatch has been running Gorge. Also we have machines that are operator started, and those have problems that might get fixed in the future which would change how operators run the plant. (One will be fixed later this year when the voltage thing is fixed.) JO: All the more reason to not prefer Unit 24—it isn't always the first on, etc. BF: Just last week 24 was down and we used the other three. WC: We usually try to balance. JO: We've had a lot of discussion about this with JA regarding the flow path of Link 2. The flow path seems convoluted and not something you would want to do unless there were other advantages. BF: When you run the optimization power studies you are going top pick a flow regime and come up with a number. JO: There isn't a huge difference in head loss between Link 2 and the others, so what are the other disadvantages to that flow path? DNS: For Link 3, it is preferred with regard to flow path without preferring Unit 24. Although when you have two tunnels, the head loss will decrease anyway. Unit 24 has such large hydraulic capacity, Link 2 and 1 look a little better—direct feed into Unit 24. JO: If you select Link 2 and Unit 24 is off, you have two 180 degree turns to get to the other three units. DNS: Those other links would have to be optimized in terms of connection angles, etc.

	JO: Are we going to see cavitation with those angles? Is that a problem since the head loss isn't as big a deal? The changes are only incremental. DNS: Correct - the changes in head loss are only incremental with the two large tunnels and since the velocities are lower. We'd have to do a lot of design in these curves here to optimize flow around these corners, especially the counter path. Link 3 is a more standard connection without these "u-turns" and hard angles. I would prefer Link 3 for this reason. JO: So since we don't see much difference in head loss between these links, What are the other implications of each link? Are there tunnel or construction issues? DR: We're going to cover that next. Plus we're going to model other options; we have a lot more hydraulic analysis to do for this. This is just showing the maximum flows at this point. SS: This is only one part of the story. There are 4 parts to the story: hydraulics, energy, cost, and economics. This is just the first part. BF: If you use Link 3 instead of Link 4, since it connects to the surge tank, what kind of rejection will you see in the other tunnel? Will you get a surge in the gate house because the second tunnel isn't part of the surge tank? DNS: We want to do those plots to model the pressure wave over time in the other tunnel. We can plot those pressures so you can see the wave. Yes we can do that for you if you need a visual. BF: We need to know that we're not going to have a surge in the gate house. SS: You have increased the tunnel cross section so much and decreased the velocity by half, so it isn't as critical as it is now. With everything else the same, but with more room to go and with the velocity so much slower with the additional tunnel. BF: It is a question of momentum and velocity. SS: Yes we have twice the surface area resisting that momentum. At this conceptual level we are comfortable it isn't necessary. We will model that for final design and chase that down. At this point we just need to choose an alternative. GWD: From a construction standpoint Links 1 and 2 are slightly better because they are shorter connections and there is a good amount of drill and blast before the TBM is launched. Link 2, however, has a lot of work however to get all the curves right, etc. We need to combine the construction benefits with the hydraulic perspective. MDH: Links 1 to 3 will all have form work. Link 3 might need to come in slightly upstream to avoid the bifurcation. JO: Link 3 might be too far away from the portal. MDH: Yes that is true, you can do Link 1 or 2 as part of the starter tunnel while waiting for the TBM to arrive and it could potentially shorten the connection start-up schedule. DR: Link 3: if you do that right by the tunnel bifurcation. We can get really good as-builts of that area during the outage next year. GWD: We want to be able to do as much work as possible to decrease connection downtime to the plant. For Link 3, we could blast it after the TBM

	has gone by and be working on that while the rest of the tunnel is being constructed. GWD: Is there a preference between Link 2 and 3 from an operations standpoint? JO: There isn't much headloss difference, so it isn't as easy a decision to make. MDH: Another thought is that between Link 2 and 3, there is a way to make another connection - we could get some constructability benefits because we could have more of a 90-degree angle and avoid the bifurcation. So there are marginal benefits to something between there. BF: Do we need to choose one now? GWD: That would be best, but we could do models on two. SS: Walked through the hydraulics of Link 2 and 3. If Link 2 "doesn't look right" that is because it just isn't. Far too convoluted a path for the water… too complex. And the connection angles and impact therefore in the modeling is probably not fully understood with the model. DNS: We're not running a CFD model at this point. We would need to optimize the design and how the edges are rounded and things like that. At this point it is assumptions; they are not detailed out. SS: Link 4 doesn't gain much and doesn't give as much head benefit. Link 1 is just great if you're going to run Unit 24 all the time. Link 3 is the best if you want the operation flexibility. We need to know how you operate Unit 24 and how to start/dispatch them. JK Things have changed so much recently. We used to run Unit 24 all the time and Link 1 would have looked the best for that, but lately we haven't. **MH: Having heard all of the discussion, advantages and disadvantages, etc let's stop further discussion and just say it is Link 3.** **JO: With the caveat that it needs to be optimized with regards to constructability and hydraulics.**
Tunnel Diameter Optimization and Layout	
Alignment Tunnel Separation Portal Location Portal Staging Area Connections to Existing Tunnel	MDH presented criteria used to optimize tunnel alignment: 1) To be kept within the existing FERC boundary as much as possible. 2) Need 1.75 to 2 tunnel diameters worth of tunnel separation distance for structural and interference needs, which means 50 feet from sidewall to sidewall was used to plan alignment. 3) Stability of the hillside at the portal and stabilization needed. Investigated by engineering geologist. Rock fall may need to be stabilized depending on where the portal is located. Portal site #2 is preferred. It avoids the fault and impacts the fewest trees, but may need some scaling of the rock beforehand. 4) Upstream connection: only one preferred candidate. We propose to bring the TBM as close to the connection as possible because this entire rock mass has been grouted and stabilized from the intake construction work in the

	1950's, the rock joints will be filled with grout and be stable enough to get close to the intake and get a nice smooth flow path. 5) Downstream connections: reviewed TBM launch sequence. The radius is 1,200 feet and gets slightly out of the FERC boundary (4,000 sf) before it gets to the straight portion. At the upstream end the alignment just nicks the FERC boundary (less than 100 sf). DR: What about vertical clearance? MDH: We looked at the cover criteria starting at 3-4% near the launch portal, then 2% the rest of the way, which is a good angle for tunnel boring and allows easy collection of any flows inside the tunnel during construction. DAS: Is that the only curve there at the start? MDH: There is another 1200 ft radius at the end where we park the TBM. 6) Connection Link Evaluation: Link 3 is preferable for a number of reasons, especially when we add in hydraulics. The table shown is preliminary and will be updated to add hydraulics and finalize it. JK: What does "risk of operation" refer to? MDH: Don't recall; I'll have to look it up. DR: Can we please take out "future plant expansion". FERC won't like it and it is the same across the board. That is the old plan we don't want to resurrect. GWD: We'll take it off. The preferred alignment in plan and profile was presented.
Tunnel Boring Machine Requirements	MDH: Described the type of machine that is preferred for this type of work. Walked through what each section does and where the operators work. DR: Where are the motors? MDH: There would probably be 6 or 7 motors turning on a big gear behind the cutterhead working with thrust cylinders to push them into the rock. This rock is well suited to machine boring. There won't be excessive wear on the cutterheads and 3-4 manufacturers can build a machine for this size job: Robbbins, and 1-2 German and Japanese manufacturers. The cost of the machine and advance rate will be incorporated in the cost estimate. Could utilize redundant gauge cutters to knock off the (high parts?) to improve hydraulic performance. The specification of the machine will incorporate this. The muck produced will be a uniform grade material coming out as "rock chips" with a maximum size up to 3-4 inch diameter. Good for gravel and fill.
Muck Disposal	MDH: There will be 190,000 cy (approximately) of muck material for a 14-foot tunnel. Our cost estimate will outline how many trucks will be required to move the spoils to the disposal site. We are lucky to have a disposal site so

	nearby. MYW: Should change “abandoned quarry” to a new term, since it is a nature preserve or something now. JA will check with JO on how best to describe this. Also “muck disposal” doesn’t sound right - reword to indicate that it is more akin to fill. MDH: The trucks will come into the yard gate and go through the compound, then exit through Riverside way to SR20. They wouldn’t go through Main St. It is a tight radius coming out of the compound, so we’ve estimated single trucks that could make it through the gate. With gate expansion, we might be able to use a “Truck and a Pup” if the gate is altered slightly.
Groundwater Inflows	MDH: The LiDAR image showed the rock surface and drainage features. These features might impact groundwater inflows. We are anticipating three large water-bearing features.
Tunnel Support and Lining	MDH: Presented friction calculations for the TBM tunnel. There is some optimization and room for improvement with the TBM specification to improve hydraulic performance. JO: Did they use redundant cutter gauges on Grizzly? MDH: They didn’t. They had them close, but didn’t have the redundant cutters to knock off the tips. DR: Are the Manning numbers from the friction calculation used in the hydraulic model? DNS: No that isn’t the number we used. We used a Darcy Equation numbers. DR: I’d like to see the same unit on this table used in the Darcy Equation for friction. **GWD: We’ll ensure the units are consistent.**
Construction Layouts	GWD: Showed the site layout if a conveyor is utilized for spoils movement. We are confident this site is conducive to conveyor operations. Muck cart option is also supported. MH: What water source will you use for process? The native water? GWD: Going to use the feed right by the powerhouse. Concurred by JK. BF: What about impacts from the conveyor and dust maintenance. GWD and MYW concurred that the conveyor must be covered. Noise walls and dust barriers also at the truck station. JK: Where does the conveyor go? GWD: Hopefully on the pedestrian portion of the rail bridge. JO: There is another pedestrian bridge downstream which may work. DAS: How are these muck cars propelled? GWD: Diesel rail cars. DAS: Are there issues with running diesel in the tunnel?

	MDH: No. We will manage the ventilation, but we'll need to have a diesel rail system even if we don't use muck cars, because those are needed for personnel transport. DR: Hatch Mott McDonald wanted to elevate the muck carts (or excavate below). GWD: That was if the trucks came across the bridge to the portal. We think it may end up being better for a conveyor to take the spoil material across the river.
Construction Power Requirements	GWD: Presented typical power requirements for an 18-foot diameter tunnel. No final conclusion yet for how to address this load. It is typically the contractor's responsibility to manage this within the site area, but the table is close enough to model the anticipated load and how to feed it. MH: Once we replace 10 and 27, we should think about providing it by tapping from there.
Next Steps Energy Analysis Information (SCL)	WC uses an algorithm for dispatch logic. DNS will provide the factors for the three options to WC to model those in SCL's operational system. SCL will provide the algorithm for DNS to model a composite curve of flows. DTA will provide WC with a loss curve for each tunnel diameter. DNS will rerun the model at lower flows for each unit for WC's analysis. DNS and WC to coordinate to get the information needed to advance the head loss model. This will yield a table of head loss for each flow scenario. WC has an equation that relates flow to head loss for each unit.
Update and Combination of Reports Development of Cost Estimate Schedule of Deliverables	GWD says we will update with the next draft due in a few weeks' time. He solicited comments and critique to incorporate into the report. We will start developing cost estimates now that we have a preferred Link selected. Next draft of combined report is targeted by the end of the month.
Other Action Items	JA - Robbins image of TBM; would it be all right to publish this on the FERC web site. Drawing package to support FERC meeting. DR to get us list of drawings needed. They need these drawings by Friday: LiDAR image with alignment superimposed would be a good one to have; Muck Disposal Location Slide with title changed; Only show Link 3 on all the drawings; Connections at both ends. Overall layout; Site layout with conveyor option; All 24 x 36 size drawings.