HVAC OVERVIEW and
VALUE ENGINEERING ITEMS

August 13, 2008

<u>**CLIC Working Group CES**</u>

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RDR - Air treatment Design Basis

- **Tunnel Ventilation** – Conditioned dehumidified air from surface mounted equipment is ducted into the service tunnel at each shaft. A volume of 15000cfm (425meter^3/min) flows at approximately 88fpm (1.6km/hr) to the midpoint between shafts where it is routed into the beam tunnel and returned to the shaft area. Fresh air at a rate of 20% (air change/16hr) is mixed into the air then conditioned and it is recirculated back to the service tunnel. Air volumes for the DR and BDS are similar.

- **Hazardous Conditions** - The air direction is reversible and capable of being doubled (unconditioned) during hazardous situations.

- **Design temperature ML** - The design temperature for the ML service and beam tunnels is 80-90F (27-32C). ML electronics' heat rejection is mainly to CHW direct cooling and FCUs with small amounts of heat to the ventilation air. AHU and FCUs are used at alcoves and shaft areas.

- **Design temperature DR** - The design temperature for the DR tunnel is 104F (40C), using process water fan coil units, and the tunnel wall as a heat rejection source.

RDR - Air treatment Design Basis

- **Design temperature BDS** - The design temperature for the BDS is 85-90F (29-32C). The low "heat to air" load is mainly absorbed by the tunnel wall. Air mixing fans will be used for temperature stability as required by the BDS.

- Used the basis that airflow could pass from the service tunnel to the beam tunnel through fire/smoke/ODH/radiation protected passages between the tunnels. This assumes that radiation/oxygen deficiency hazards (ODH) do not exist or can be mitigated between the tunnels from the standpoint of air mixing. This item needs concurrence from rad/ODH groups.

- AHU and FCU sizes in the alcoves and tunnels did not consider heat absorption by the rock wall. These units use chilled water from the surface as the heat rejection source.

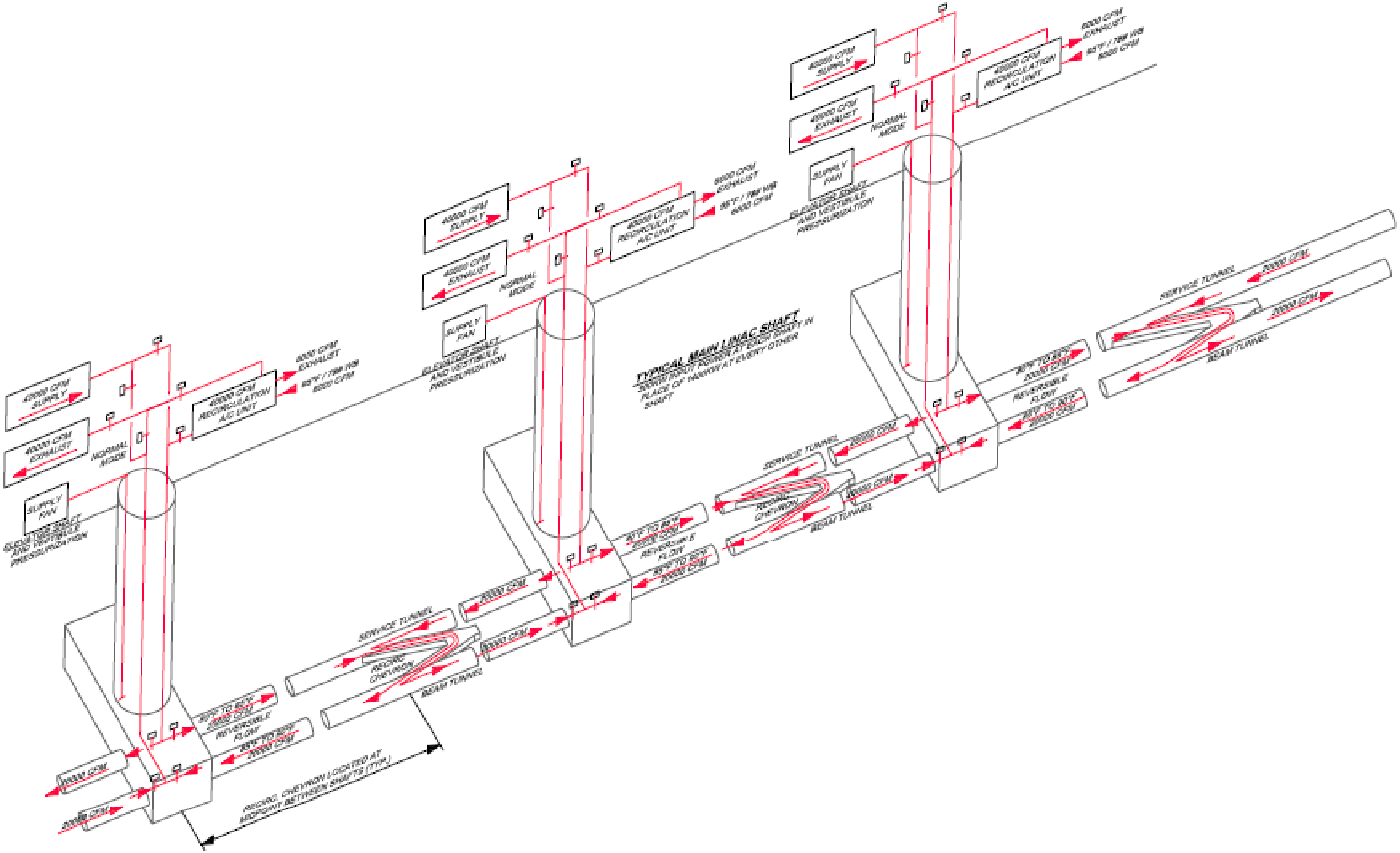
Air Treatment WBS

- Air Treatment Cost is about 1% of CFS

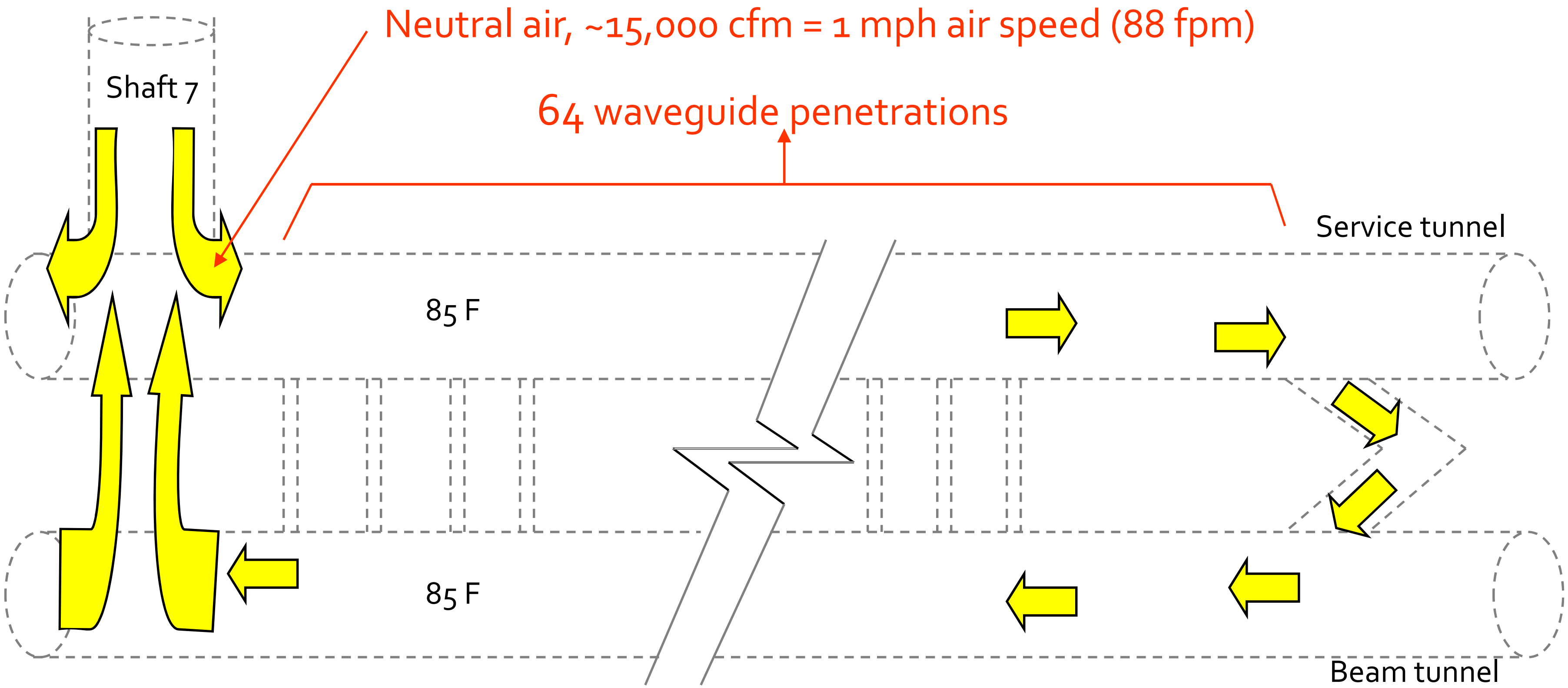
(or 5.5% *when CHW system is moved to the air treatment WBS*)

RDR		RDR Cost (America)		RDR with CHW adjustment	
1.7.1	Civil Engineering	64.3%		64.3%	
1.7.2	ELECTRICAL	13.2%		13.2%	
1.7.3	AIR TREATMENT EQUIPMENT	**1.0%**		**5.5%**	Moved CHW to Air Treatment
1.7.4	PIPED UTILITIES	0.1%		0.1%	
1.7.5	PROCESS (COOLING) WATER	**14.9%**	Includes CHW	**10.3%**	
1.7.6	Handling Equipment	1.6%		1.6%	
1.7.7	Safety Equipment	1.3%		1.3%	
1.7.8	Survey and Alignment	3.7%		3.7%	
		100.0%		100.0%	Same Totals

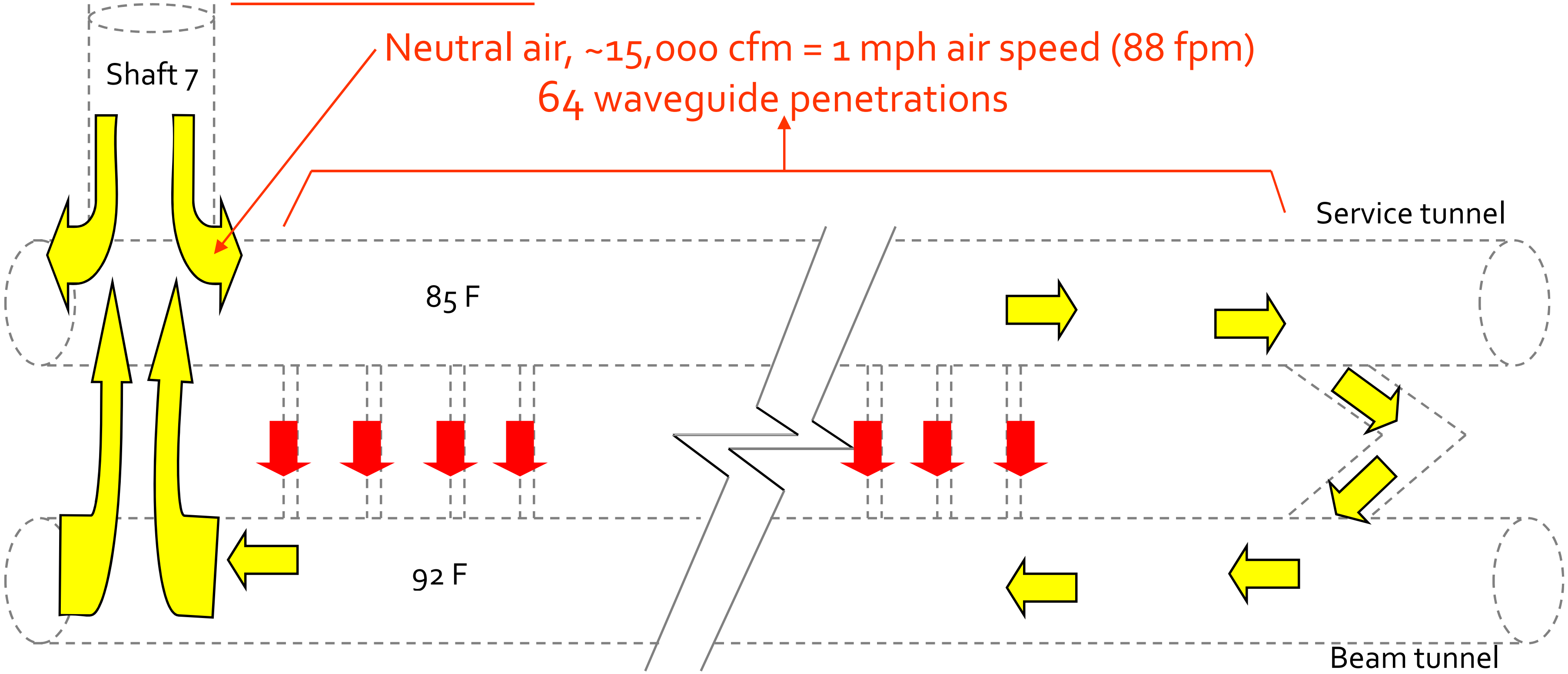
CFS Air Treatment Layout



AIR SYSTEM CONCEPT (assume no issues with mixing airflow between service and beam tunnel)



Possible waveguide cooling - IF "Waveguide at Penetration" is aircooled and no issues with mixing airflow between service and beam tunnel



0.676 KW per waveguide pene ~300cfm @ 7 air delta T X 64 = additional 19,200 cfm air

- Waveguide load in the beam tunnel will **still** need be picked up by fancoils
- Means of air balancing at each penetration needed
- Some part of tunnel will have ~200 fpm air speed

POST RDR

	Heat Load KW per RF		
	RDR	Post RDR **as of** Dec 07	Post RDR **after** Dec 07
Service Tunnel (ML RF)			
to water	100	104	
to air	26	21.4	
racks	11.5	11.5	
beam tunnel (ML RF)			
to water	included	included	
to air (wvguide)	0	5.9	
Load to air, servc tunnel, w /m	~ 684		
Servc tunnel temp F	85	104	> 104???
DR tunnel temperature F	104	85 (cooler LCW)	
Metrology reqmnt (GDE Oct 2007)		< 90F	
Air Stability		+ - 0.1 C	
Water Supply stability		+ - 0.2 C	

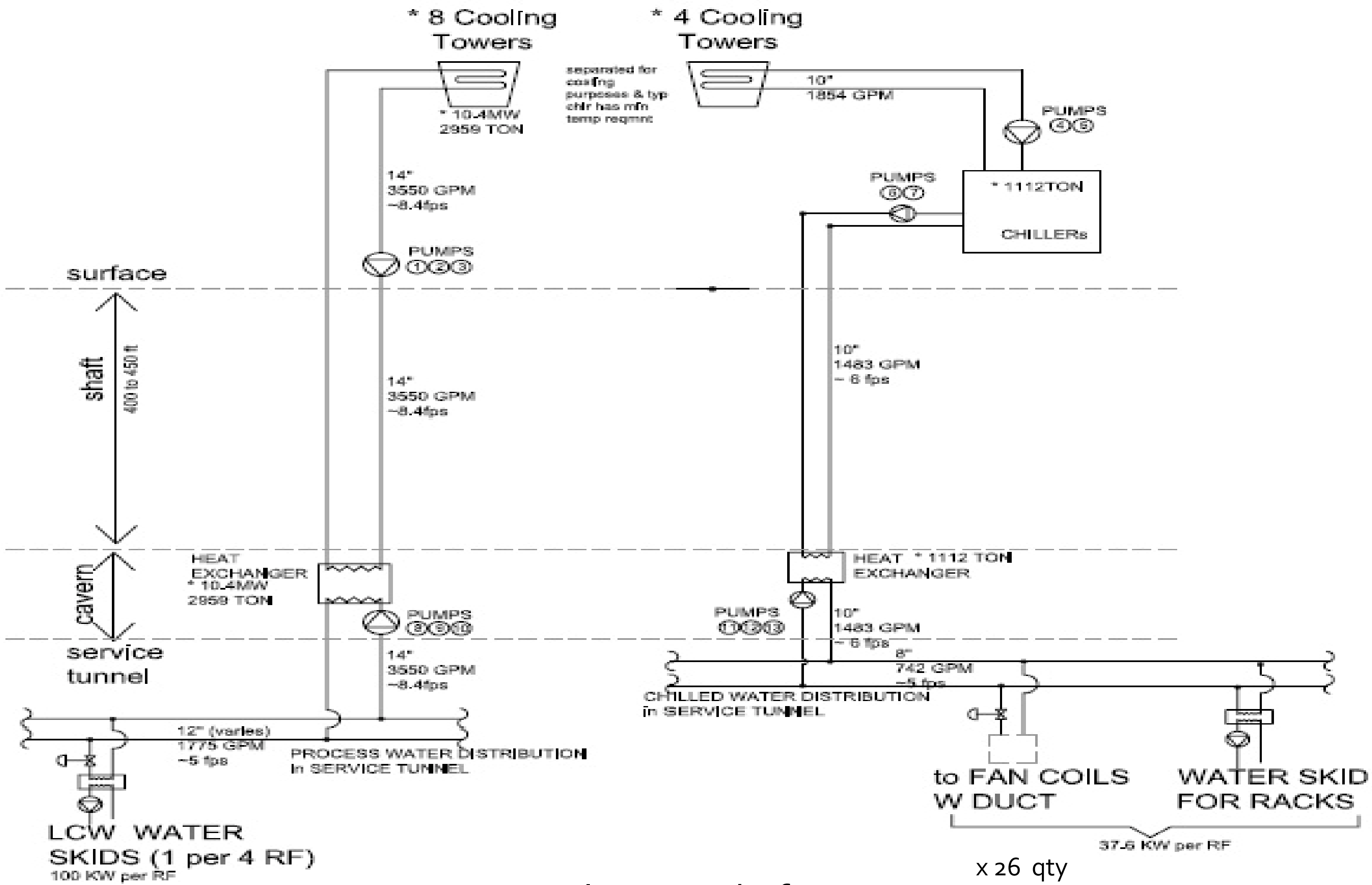
Rock Contribution?

Analysis by	W/M	KW in 36m RF	Material (K in W/m-K)	Temp in (F)	Tunnel Dia-m	Temp up to what radius
Ztang - Sep 2006	130	*-4.68*	Rock (4.6)	86	5	55F (25m)
Gbowden -Jul 2003	73	*-2.63*	Earth, Sandstone, Conc (varies)	113	3	77F (10m)
SSC TP/JT - Feb 1985	29	*-1.04*	Dolomite (3.5)	65	2.5?	55F (30m)
A Enomoto - June 2008	100	*-3.60*				

Some discussions and preliminary investigation, but not considered

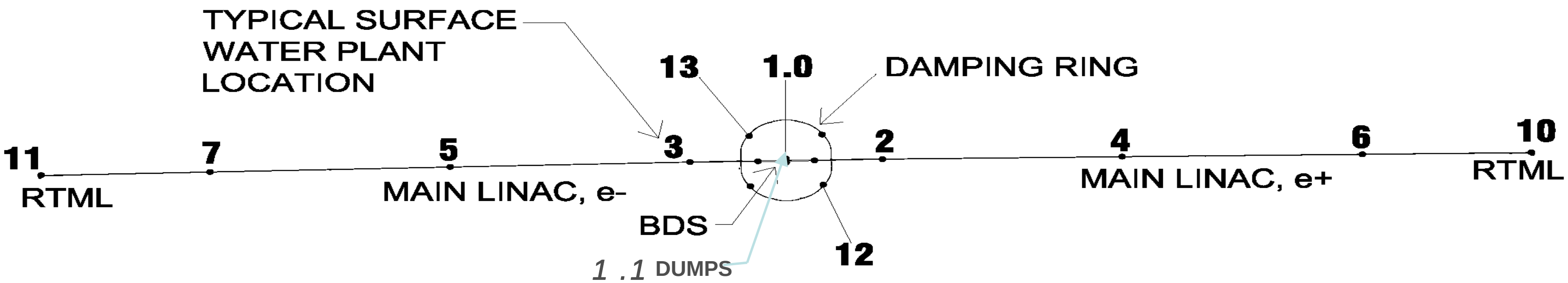
There still is considerable KW load to the air per RF - chilled fancoils are needed to maintain temperatures

RDR Chilled Water Schematic



CHW Plant at Shaft 7

Surface Air/CHW Plant locations



Air Treatment Summary

- Air Treatment Components in RDR:
  - Large air handling systems providing heating, cooling, dehumidification, humidification.
  - Fans for air purge, tunnel and shaft pressurization
  - Miscellaneous ducting and accessories, dampers, insulation, etc

- Chilled water systems including chillers, cooling towers, piping and accessories will be moved to the Air Treatment WBS

- Air treatment design is dependent on the ventilation requirements and the heat load criteria received from the area systems

- Air treatment and purge systems have not been fully investigated for radiation and ODH issues. Need further input on air flow configuration concerning radiation and ODH issues

- Air treatment and purge systems configuration were not developed with consensus of any AHJ (authority having jurisdiction, even who this is may not be identified for some time). Need fire protection consultant.

POST RDR

Specific V.E. List

DESCRIPTIONs & "color" legend (DRAFT Dec 18 2007)	Who to develop short desc/option
(Gut-Feel) may not result in large savings	
(Gut-Feel) may result in savings. Will be evaluated? (potential cost savings TBD)	
MARC ROSS DEC 04, 2007 DIRECTION (LAST TO BE EVALUATED)	
Will be evaluated by [illegible] not CFS, whether high cost savings impact or not	
(not shaded) = Items that I'm Not Sure	
Provide one high efficiency cogen power / cooling plant on site and distribute power and 33 degree F chilled water throughout the facility, remove the power generation and chilling cost from the project cost	Steve
Eliminate one piping system by using process water as primary rejection for chilled water system w#1 (using refrigerated heat pump as fancoils and standalone chillers for racks)	Emil
Eliminate one piping system by using process water as primary rejection for chilled water system w#1 (using process cooled fancoils), warmer tunnel (item 8_15)	
Increase the delta T in the LCW and chilled water systems to 30 degrees, reduce flow, pipe size w#1	Emil
Add a chiller on the process water side w#1	Steve
Lower the temperature in the tunnel to 65 or 70 degrees to increase operating efficiency, extend equipment life, and improve operating environment w#1	Steve
Consider use of renewable energy source for use with cogen system w#1	Steve
Provide a cost analysis for reducing the overall cooling load by 5% and 10% w#1	Steve
Centralize the cooling system	Steve
Provide distributed cogen power / cryo (similar to #1 &2)	Steve
Decentralize the 345 KV substation function w/ 18, 20, 38, & 39	Tracy
Electrically engineer the distribution system to optimize and reduce cost w#9	Tracy
Provide connection to electrical utility sytem at all shafts (w/ #9)	Tracy
Optimize substation spacing w#9	Tracy
Let the electrical utility construct substations and don't include that cost in the project construction cost w#9	Tracy
Centralize the HVAC and reconfigure air flow from the ends	Lee
Pipe two chilled water coils in series, chilled water reclaim, size one for 30 degree delta T w#10	Larry
Let the temperature in the tunnel go to 104 degrees F during normal operation and local cool to 85 degrees where people are (consider increased cost for more frequent replacement)	Keith
Raise tunnel temperature to 103 degrees at all times (meets OSHA requirements) w#13	Keith
Provide air conditioned suits for personnel working in tunnel and let the temp go higher than OSHA requirements w#13	Keith
Consider oversizing electrical cables and transformers to reduce heat	Keith
Redesign the RF loads for more optimal process water flow	Mike
Modify top shaft HVAC to only process make up air, add blowers down shaft for recirculation	Lee
Reduce lighting level to egress limits	Tom
Reduce water pressure drop across components, minimize head pressure	Mike
Examine possibility of going to 2 condenser water loops instead of 3 as presently planned	Emil
Consider using low mineral content water instead of LCW w/28 (design water system for low mineral water)	Keith
Allow different types of pipe materials: PVC, CPVC, HDPE, carbon fiber wrapped PE, etc in lieu of stainless steel	Rick
Consider replacing the fan coil units with a chilled water beam (radiant cooling)	Kumar
Put the water piping in the concrete slab, eliminate pipe supports	Tom
Use water cooled waveguide in the accelerator tunnel in lieu of air cooling	Mike
Provide passive convection tunnel using cooling shafts during colder months	Lee
Provide multiple modes of operation dependent on outdoor temperature	Lee
Develop loads that do not require low conductivity water	Fukuda
Use the waveguide pressurization system for cooling the waveguide (flow cooled gas inside the waveguide)	Mike
Pulse the power source for selected loads when not being used	Tom / controls
Use pressure regulators to control the hydrostatic pressure in the collectors	John Mathis
Define the maximum hydrostatic pressure for the collectors	Mike
Consider expandability of systems - modular vs centralized	Tom
Reexamine the hot changeout of modulator power supplies	Keith
Plan for a 4 month downtime during the summer	Rick
Limit the operation of the system to 72 degree wet bulb	Rick
Use CO2/radon monitoring and limit the intake of outside air to what is necessary to maintain a safe environment	Lee
Use a dessicant to dehumidify ventilation air	Lee
Evaluate each load individually to determine requirements	Keith / Mike
Establish power budgets for the relay racks (400 W / RF + 10% of power supplies)	Keith
Provide power supply that will work with warm water if necessary (quasi militarized)	Keith
Use on site ponds for make up water	
Consider using cooling ponds in lieu of cooling towers	
Give or sell heat from chillers to neighboring communities	
Increase the number of RF stations per LCW skids	
Use vapor phase cooling on the collector and generate electricity from excess energy	
Use the lowest KVA transformer to reduce heat load	
Consider use of geothermal cooling	
Use the Fox river for once thru primary cooling, eliminate the cooling towers	
Use modular systems for all equipment	
Eliminate Rack Skid and replace with just pump	Tom/Emil
Eliminate one piping system by using chilled water only as primary rejection, eliminate process water distribution	Tom/Emil

- About 50+ list from V.E. in Nov 2007, List from value engineering sessions in Nov 2007. Some appear to have very good cost reduction potential.
- No pros/cons and cost impact evaluation done yet
- Color coded

  Red=Marc selected on Dec 4 2007

  Yellow=potential VE but not necessarily cost reduction?

  Green= by others (HLRF), not CFS

  Gray=ignore

  White=not sure

- Most VE work effort stopped on Dec 18 07

HVAC/CHW Value Engineering Studies

- Provide one hi-efficiency cogen power/cooling plant on site and distribute power and 33°F (0.6°C) CHW throughout the facility,
  - Removes power/CHW production systems costs from the project cost.
  - Removes one piping system from project.
  - 33°F CHW = smaller pipes, lower HP pumps, smaller HXs, very HI delta T (90°F/50°C+)
  - Cogen plant builder/operator finances, builds, operates, and maintains power plant then sells utility power and CHW to ILC.
  - Allows cooling of tunnel and electronics mitigating high temperature disadvantages.
  - Centralize plant reduces shaft/support area footprints.
- Centralize the HVAC and reconfigure airflow from tunnel ends or center.
- Modify top-of-shaft HVAC to only process make up air, add blowers at tunnel level for recirculation.
- Investigate use of desiccants to dehumidify make up air. Could use heat recovery from cogen plant.
- Investigate alternate piping materials, PVC, copper, HDPE, etc.