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USE OF DIESEL TRANSPORTATION AND EXCAVATION EQUIPMENT IN THE NORTH RAMP OF THE ESF

A WHITE PAPER

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M&O ESF Senior Project Engineer

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WHITE PAPER
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EXECUTIVE SUMMARY

This white paper provides a basis for authorizing the use of diesel systems for transportation and excavation in the North Ramp of the ESF. This issue was precipitated by REECo's request to consider the use of surplus diesel locomotives which are available through NTS surplus. In addition to cost considerations, the project lacked a technical decision basis for the selection of excavation and transportation systems for use in the ESF. As a result of these two issues, DOE requested the M&O's evaluation of cost and waste isolation impacts associated with diesel use. This white paper addresses both issues as well as worker health/safety and ventilation considerations. This paper concludes that the potential impact to waste isolation by using diesel systems in the North Ramp is minimal and further summarizes that diesel is a cost effective alternative to electric trolley systems. The M&O recommends that diesel be permitted for use in the North Ramp and that Lawrence Livermore National Laboratories be commissioned to perform testing to enhance the database on impact of diesel emissions on the waste isolation characteristics of Yucca Mountain.

The Yucca Mountain Project faces an important decision concerning the type of power source for transportation and excavation support systems in the ESF. Mining technology limits systems to two primary types; electric and diesel. Both systems are in use today worldwide and are acceptable for use by all governing regulations imposed on YMP. Both systems have advantages and disadvantages that are key in the decision. For ease of discussion the major advantages and disadvantages are listed herein:

DIESEL SYSTEMS

Advantages:
1. Lower cost
2. Stand alone power source/not dependent on centralized distribution
3. Ease of support during excavation operations (Fueling on surface)

Disadvantages:
1. Emissions/Increased ventilation requirements
2. Risk of fluid leakage
3. Health implications

ELECTRIC SYSTEMS

Advantages:
1. No hydrocarbon emissions
2. No risk of diesel spillage

Disadvantages:
1. Higher cost/requires costly power infrastructure
2. Installation process required periodic system shutdowns. Battery systems can be used during shutdowns
3. System shutdown with power failure

In light of the fact that these tradeoffs exist the DOE requested that the M&O investigate the use of diesel systems in the ESF and prepare a recommendation for its use or non-use. A recommendation of non-use will, by default, require the use of electrical systems.

HISTORY

The transportation system in the ESF Technical Baseline (YMP/CM-0016) is a rubber - tired diesel concept. This system was initially selected because of the original ramp and drift grades established for the ESF exceeded 3% which makes a conventional rail systems infeasible. For grades in excess of 3% either specialized rail or rubber tired systems are required. The M&O perceived that specialized rail or rubber tired systems could present a potential problem in the ESF due to cost of acquisition and operations. A concomitant issue concerns the potential use of the rubber tired or specialized rail for transport of waste in large and heavy Multipurpose Canisters (MPCs) in a potential repository. As a result of these issues a revised ESF layout has been proposed in which ramp gradients do not exceed 2.6%. This revised layout concept allows for the use of conventional rail throughout the ESF excluding the Calico Hills (CH) Level, CH ramps and the Main Test Area (MTA).

Design package 2, ESF North Ramp, assumes that the ramp gradient is 2.6% or less and therefore incorporates a rail haulage system for transportation. A transportation study commissioned as part of package 2 recommends the use of electric rail. This recommendation was developed due to the fact that test data and studies which evaluate the impacts of diesel emissions on long-term waste isolation capability of the proposed repository do not exist. The use of electric haulage reduces the risk of altering the rock properties in a potential repository.

CURRENT SITUATION

The Yucca Mountain Project has been made aware that an abundance of Nevada Test Site (NTS) surplus equipment is available for use. On the list of items are four 20 ton diesel locomotives that are reported to be in good condition. The units would meet the needs for rail transport and could potentially save the project approximately $619K in capital procurements in FY94. At REECo's request the ESF Project Engineering group undertook the initiative to explore the use of diesel equipment in the ESF North Ramp. This was done to take advantage of the potential cost savings in FY94 and additional savings in future years. A preliminary estimate indicates that the incremental cost of using electric rail is on the order of $3M to $5M for all work in the ramps, main drift and ramp extensions. The estimate indicates that the per meter cost of electric trolley system is in the order of $560 more than diesel for trolley materials and installation. The material and labor cost for the loop and ramp extensions would be on the order of $5M based on 10,000 meters of drifting. In addition construction time for the loop will be extended on the order of 30 days to blast rectifier alcoves along the drifts and ramps.

STRATEGY

In order to comply with DOE's request to investigate the use of diesel in the ESF, several meetings were held in November 1993 between ESF Project Engineering, M&O Surface Based Testing, M&O Regulatory, Lawrence Livermore National Laboratory (LLNL) and Peter Kiewit/Parsons Brinckerhoff (K/PB). At the first meeting it was determined that the window of opportunity to perform the LLNL study was inadequate. The necessary work to support a procurement decision would have had to have been completed in October 1993 in order to support a one year procurement lead time for equipment to be on site by October 1994, a point at which rail haulage would commence in the North Ramp. The team then set the goal of determining the feasibility of using diesel in a section of the ESF in order to provide an expanded window of opportunity in which LLNL could perform testing to improve the database on the impact of diesel emissions on the performance of the repository. The testing would combine geochemical computer modeling using EQ3/6 and analyses of field samples which have been exposed to diesel emissions for an extended period of time. Attachment 1 contains the text of LLNL proposed activity. The cost to perform said investigations are on the order of $160K.

The team then selected the North Ramp as an element of the ESF in which diesel systems would be considered for rail haulage and excavation operations. By allowing the use of diesel in the ramp, the procurement decision of diesel vs. electric for the loop could be deferred to August of 1994 (See Attachment 2). The team's assessment was that the span of time for testing would be extended sufficiently to accommodate the LLNL scope of work. The M&O then commissioned the team to develop a waste isolation analysis for the North Ramp (Attachment 3 - Part 3). The analysis assumed the use of clean burning diesel engines <u>without</u> the use of scrubber technology. The analysis further chose a conservative surrogate indicator for impact to potential waste emplacement locations. This indicator was set at perturbations in excess of 10% of the natural background concentrations of nitrate and organic carbons. Based on the operational usage calculation developed by K-PB (Attachment 3 - Part 1) and the volume of emissions expected during North Ramp excavation operations (Attachment 3 - Part 2) the analysis indicates that the majority of potential waste emplacement areas would experience less than a 10% increase in background ambient conditions. Two locations would experience an 11.6% increase. Nitrate emissions can be further reduced by retarding diesel engines by 2-3%. It is conservatively estimated that this action will reduce nitrate emissions by 30%. Based on this analysis and additional emissions control measures, the M&O concludes that the use of diesel in the North Ramp poses minimal risk to waste isolation.

By providing LLNL a window of opportunity to conduct a diesel emissions study, the project would be able to forecast the penetration of diesel fuel exhaust and resulting rock-water interactions in drift walls. This empirical data would then be used to improve our understanding of potential adverse impacts of the continued use of diesel in the ESF. If the decision is made in August 1994 to continue to use diesel systems, the project would realize the projected savings cited in page 1 of this white paper. If, on the other hand, the decision is made to remain with the electric rail system the project will only realize the savings of $619K realized in FY94. In either case there is a net cost avoidance to the project with minimal risk.

OTHER CONSIDERATIONS

An additional factor concerns the ventilation requirement to support diesel operations in the ESF. The current ventilation design will support the use of two operating diesel locomotives rated at 150 HP each and 200 working personnel in the ramp at any one time while the TBM is in operation. This design will support the proposed diesel operations plan developed by K/PB in support of this white paper. Should diesel be approved for use in the remainder of the ESF, there is a probability that additional ventilation would be required sooner than with the electric option. Current thinking is that additional ventilation will not be required until work in the MTA is initiated.

The use of diesel underground also raises the issue of worker health. As recently as August 1993 articles in "Mining Engineer" discussed concerns over the use of diesel underground. Primary were concerns over the release of; soot, polycyclic aromatic hydrocarbons and nitro polycyclic. It is believed that these items cause lung cancer. In order to mitigate this risk several steps are required:

- Engines should be derated
- Very clean diesel should be used
- Good maintenance program
- Scrubbers on diesel equipment
- High level of ventilation

If diesel is permitted in the North Ramp all of the above steps will be in effect throughout the phase of operations. The following actions are planned:

1. Engines will be derated by retardation (2-3%) to reduce nitrate emissions.
2. YMP will use NTS supplied low sulphur No. 2 diesel fuel which contains 0.05% sulphur and eliminates 30% of particulates.
3. K-PB will develop and maintain an aggressive maintenance program for all diesel equipment in use underground. Emission tests will be performed regularly to determine equipment performance.
4. All equipment will be equipped with scrubbers which decrease unburnt hydrocarbons by 80%, particulates by 33%, converts Carbon Monoxide to Carbon Dioxide and reduces odors. If deemed prudent the operator will purchase and install Dry System Technology (DST) which is certified by MSHA. DST reduces particulates by 98%, unburnt hydrocarbons by 96%, Carbon Monoxide by 96% and eliminates odors. The cost of installing DST is estimated at $20K per unit.
5. California ventilation codes require ventilation velocities of 60 feet per minute (fpm), OSHA requires 30 fpm and the Department of the Interior requires 100 fpm. The design value for ventilation velocity in the ESF varies from 120 to 180 fpm. The average is 150 fpm.

If the decision were made to switch to electric rail the net cost to the project for having used diesel in the North Ramp is minimal. The locomotives would be returned to surplus possibly with an investment of $40K in DST technology. The rail system installed for the diesel option is compatible with the new electric locomotives. REECo would have ample time to procure those materials necessary for a retrofit and perform the installation in time to catch up with the TBM prior to starting excavation of the main cross drift.

Attachment 4 contains a paper developed by Jeff McCleary of the M&O which discusses the position of the testing community on the proposed LLNL emissions tests. The conclusion of McCleary and his team was that the project should have a quantitative evaluation of the effects of diesel emissions and that the LLNL studies should be commissioned. The tests would provide the project with
predictive capability and confidence to make informed decisions. Valuable information would be gained for subsequent test interference analyses.

RECOMMENDATION

Based on the waste isolation evaluation, the M&O recommends that DOE consider the use of diesel rail haulage and diesel support equipment in the North Ramp. The decision will set in motion the required actions for REECo to plan for the use of diesel, acquire equipment and authorize LLNL to conduct hydrocarbon emissions tests. The strategy for implementing the decision proposes that the electric rail haulage concept, as described in the transportation study contained in design package 2B, continue through the baselining process. The M&O should proceed with designing the electric haulage system on the assumption that the final decision will be to go with electric rail. A management hold should be placed on the procurement of any electric system components until 30 August 1994 when the final decision is made. If the decision is made to go electric the hold can be lifted. If the decision is to go with diesel then a baseline change proposal will be developed and processed. The decision to permit the use of diesel in the North Ramp is required as soon as possible in order to afford LLNL the maximum amount of time to perform their test. Should DOE decide to not use diesel in the North Ramp and proceed with electric rail procurements there will be a delay in the time between initiation of excavation and arrival of electric rail components. The underground subcontractor K/PB is prepared to supply battery operated locomotives until such time that procured electric rail components arrive and are installed. If the DOE decides to not use diesel for the rail system, the underground contractor still requests the use of diesel for support operations and for emergencies. The diesel emissions volume under this stipulation falls to 25% of the basis for the North Ramp presented in this paper.

ATTACHMENT 1

LLNL DIESEL EMISSIONS TEST

Assessment of Diesel Fuel Emissions on Yucca Mountain Repository

The objective of the proposed work is to assess the impact of diesel fuel exhaust, introduced during construction and emplacement of the radioactive waste packages, on the long-term stability of the repository . We will combine geochemical computer modeling using EQ3/6 and analyses of field samples which have been exposed to diesel fuel emissions for an extended period of time. EQ3/6 will allow us to simulate rock-water interactions over a range of geochemical environments likely to occur during construction. Analyses of tunnel rock and surfaces from N-tunnel will provide valuable information on the penetration of the diesel fuel exhaust and resulting rock-water interactions in the repository walls.

An immediate concern is the effect of the diesel fuel exhaust on geochemical monitoring at sample sites during construction of the repository. A potential impact of diesel exhaust on the repository is that the component inorganic gases (carbon monoxide, carbon dioxide, nitric oxide, nitrogen dioxide, and sulfur dioxide) could increase the acidity of any water present. The ability of the rock-water system at Yucca Mountain to neutralize an increase in acidity from the diesel fuel exhaust is limited. Generally, the durability of silicate minerals decreases with increasing acidity, which may create porosity in the repository horizon rock. The buffering capacity of waters present during the construction of the repository will be affected by other man-made materials, such as cement. As another example, water samples collected along a fracture zone could be contaminated by products of diesel fuel exhaust interacting with rock and water. Also, diesel fuel exhaust particulate matter are a potential source of organic nutrients which may result in a micro-biological plume.

Proposed Work

A. Geochemical Simulations using EQ3/6 (60K)

The geochemical simulations will determine the aqueous and solid products due to diesel fuel emissions. In order to bracket the potential impact of diesel fuel exhaust on the repository, three diesel fuel emission levels will be tested: (1) an ideal scrubbed emission composition provided by J. Houseworth, (2) an unscrubbed conventional emission composition, and (3) an intermediate composition which reflects scrubbed emissions from non-ideally tuned engines. The rock-water ratios and geochemical parameters reflecting other man-made materials will be varied to provide boundary conditions for each of the diesel fuel compositions.

B. Geochemical Analyses of Field Samples from N-tunnel (100K)

Geochemical analyses of block samples, acetate replicas, and waters collected from N-tunnel walls at Yucca Mountain will be compared with geochemical simulations described above.

1) Several acetate replicas, which remove the surface products, will be collected from the walls of the N-tunnel. The replicas will be analyzed with SEM and EDS to determine the mineralogy and chemical compositions of the solid phases. Some replicas will be digested in acid solutions and analyzed with ICP to determine the chemical composition of the soluble fraction of the diesel fuel accumulation.

2) Samples from blocks taken from N-tunnel walls will be analyzed with SEM and EDS to determine the mineralogy and chemical

compositions resulting from ~~to~~ diesel fuel exposure during tunnel excavation. Primarily, we are interested in determining the extent of diesel fuel exhaust penetration into the rock. It is imperative that the samples from the tunnel walls not be contaminated in the sampling process. Coring requires fluids to cool the drill bit, which may alter soluble products in the rock. For this reason, small blocks will be chiseled out of the wall. Initially two blocks will be thoroughly analyzed in this study; other blocks will be used in future studies if needed. As a function of wall depth, chips will be taken from a freshly cleaved block and prepared for SEM and EDS analyses. Additional thin sections will be made if more detailed analyses are necessary. Sample analyses will concentrate on alterations occurring along fractures and between fractures. Diesel fuel exhaust penetration into the tunnel walls should be greatest along fractures.

3) If waters are present in N-tunnel, samples will be taken, filtered and analyzed with ICP and HPLC to determine the inorganic and organic compositions.

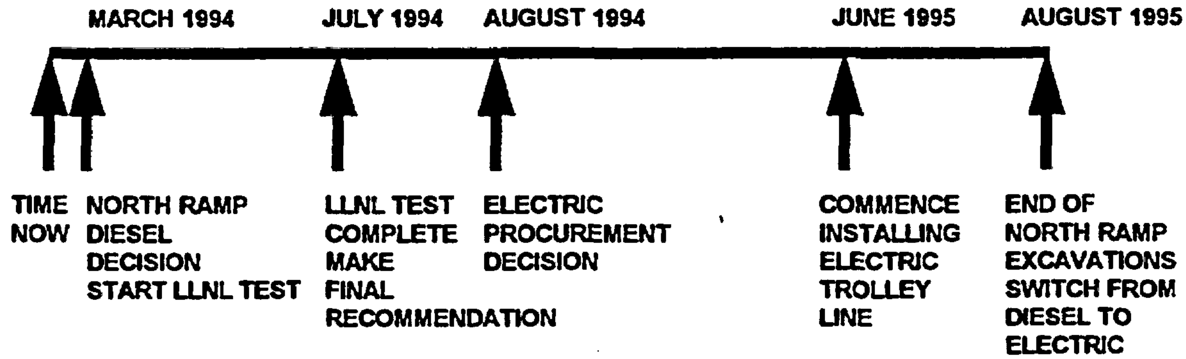
C. The results of the geochemical simulations and the field sample analyses will be integrated to assess the effect of diesel fuel exhaust on the repository stability.

ATTACHMENT 2

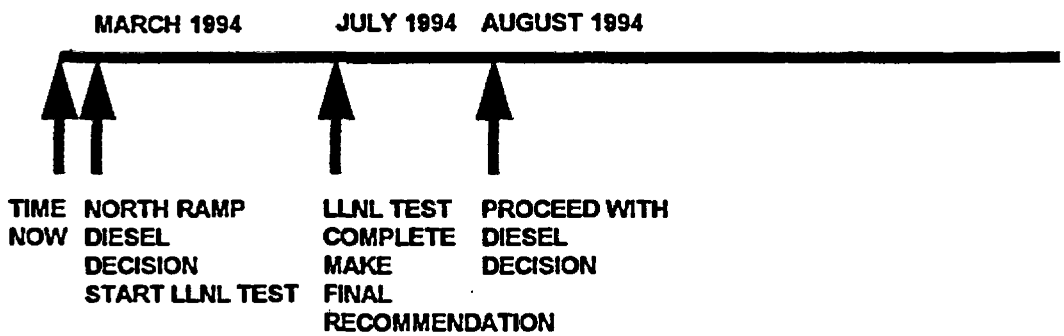
PROCUREMENT DECISION SCHEDULE

PROCUREMENT TIMING FOR NORTH RAMP HAULAGE SYSTEM

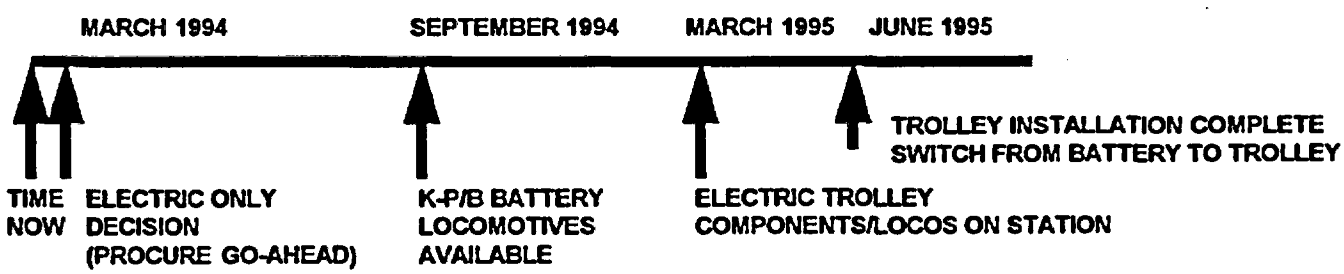
SCENARIO A: Authorize use of diesel in North Ramp, final decision - electric



SCENARIO B: Authorize use of diesel in North Ramp, final decision - diesel



SCENARIO C: No use of diesel in ESF



ATTACHMENT 3
WASTE ISOLATION ANALYSIS

PART 1 - DIESEL OPERATIONS ESTIMATE (K/PB)

PART 2 - VOLUME OF EMISSIONS EXPECTED DURING N. RAMP EXCAVATIONS

PART 3 - IMPACT ANALYSIS, WASTE ISOLATION

KIEWIT/PB
YUCCA MOUNTAIN PROJECT
4460 SO. ARVILLE ST., SUITE 6, LAS VEGAS, NV 89103 (702) 295-2101
FAX (702) 295-2319

February 1, 1994

WBS: 1.2.6
QA: N/A
SCP: N/A
K/PB Letter No. 184

Reynolds Electrical & Engineering Co., Inc.
P.O. Box 98521
Las Vegas, NV 89193-8521

Attn: R. F. Pritchett, M/S 408

RE: Subcontract No. 1-YUC-01-2

SUBJECT: DIESEL USE

An estimate of the diesel use for construction of the North Ramp of the ESF is herewith provided for use in the Performance Assessment Analysis by the M&O. This is our best estimate of the diesel use for the start of tunneling from the North Ramp to the base of the ramp at STA 91 + 85 feet. The durations of activities, including rate of tunneling, match our current construction schedule.

This analysis was requested by the M&O and has been developed in close coordination with their staff. In December 1993, initial meetings were held to determine the scope of what was required. We made preliminary analyses and held informal discussions of the results. We have considered their input in these calculations. The calculations of diesel use have the date of January 31, 1994, which was our final adjustment of format and notes to the spreadsheet computations.

Very truly yours,

Lance deStwolinski
Project Manager

LWD:sr
Enclosure

cy w/encl.
C. J. Nesbitt, M&O, M/S 423
D. G. McKenzie, M&O, M/S 423
J. Steinhoff, M&O, M/S 423
R. D. Sunday, REECo, M/S 404
Job File

DIESEL LOCOMOTIVE OPERATION
EXPLORATORY STUDIES FACILITY -- TOPOPAH SPRINGS NORTH RAMP
KIEWIT/PB

Column 1		Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11
						DIESEL USE FOR MUCK HAULAGE					
						TBM Excavation		Alcove Excavation		Total Hours for Each Segment	
Segment Stations, ft from	to	Tunnel Advance, ft	Alcove Excavation, bcy	Mining Rate, ft/ day	Operating Days, days	Total Muck Trains, trains/day	Muck Train Load Time, min/day	Total Muck Trains, trains/day	Muck Train Load Time, min	Muck Train Load Time, hours	Muck Train Tram Time, hours
2+00	3+60	160		11	15	5	100			28.8	1.3
3+60	4+60	100		15	7	7	140			18.8	1.3
4+60	6+20	160		15	11	7	140			29.5	2.7
6+20	8+50	230		20	14	9	180			48.3	5.9
8+50	10+50	200		30	7	14	280			37.6	5.9
10+50	15+00	450		30	15	14	280			80.5	17.1
Test Alcove #2			400		15			10	1800	34.5	1.0
15+00	25+00	1000		30	44	14	280			236.1	78.7
Equipment Niche #1			107		10			3	480	9.2	0.5
25+00	43+00	1800		30	66	14	280			354.2	200.7
Conveyor Installation					35					0.0	0.0
Equipment Niche #2			107		10			3	480	9.2	0.8
43+00	57+00	1400		65	22					0.0	0.0
Refuge Chamber			160		20			4	720	13.8	1.5
57+00	61+00	400		65	7					0.0	0.0
Equipment Niche #3			107		10			3	480	9.2	1.2
61+00	79+00	1800		65	30					0.0	0.0
Equipment Niche #4			107		10			3	480	9.2	1.5
79+00	91+85	1285		65	20					0.0	0.0
TOTALS		8985 ft	987 bcy		368 days					918.9 hrs	320.1 hrs

Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20
DIESEL USE FOR PERSONNEL and MATERIAL [illegible]					COMBINED MUCK HAUL AND SERVICE TRAIN			
One-way Train Trips/day			Total Hours for Each Segment		Total Hours for Each Segment			
Crew	Science	Utility and Maintenance	Service Loci Idle Time, hours	Service Loci Tram Time, hours	Idle & Muck Load Total Time, hours	Tram Total Time, hours	Total Oper Time, hours	Comments
0	0	6	17.3	0.8	46.1	2.1	48.2	Start TBM tunneling at North Portal
0	0	6	8.1	0.6	26.9	1.9	28.8	
0	0	6	12.7	1.1	42.2	3.8	46.0	
0	0	6	16.1	2.0	64.4	7.9	72.3	Bow Ridge Fault area, includes 2 additional days for steel set erection
0	0	6	8.1	1.3	45.7	7.2	52.9	
7	10	6	66.1	14.1	146.6	31.2	177.8	
7	10	10	77.6	19.4	112.1	20.4	132.5	Drill and blast excavation, using diesel powered rubber tired equipment
7	10	6	194.0	64.7	430.1	143.4	573.5	5 fault zones, 10 additional days for steel set erection
7	6	10	44.1	18.4	53.3	18.9	72.2	Drill and blast excavation, using diesel powered rubber tired equipment
7	10	6	291.0	164.9	645.2	365.6	1010.8	3 fault zones, 6 additional days for steel set erection
7	6	12	167.7	120.2	167.7	120.2	287.9	Mining operation is shut down during the conveyor installation
7	6	10	44.1	31.6	53.3	32.4	85.7	Drill and blast excavation, using diesel powered rubber tired equipment
7	10	10	113.9	94.9	113.9	94.9	208.8	
7	10	10	103.5	98.3	117.3	99.8	217.1	Drill and blast excavation, using diesel powered rubber tired equipment
7	10	10	36.2	35.6	36.2	35.6	71.8	
7	6	10	44.1	44.8	53.3	46.0	99.3	Drill and blast excavation, using diesel powered rubber tired equipment
7	10	10	155.3	181.1	155.3	181.1	336.4	1 fault zone, 2 additional days for steel set erection
7	6	10	44.1	58.0	53.3	59.5	112.8	Drill and blast excavation, using diesel powered rubber tired equipment
7	10	10	103.5	147.4	103.5	147.4	250.9	Tunneling to end TS North Ramp
					2466 hrs	1419 hrs	3886 hrs	

Note: Column 1: Location of operation requiring diesel operation, either locomotives or LHDs.

Note: Column 2: Tunnel advance is the total feet of excavation for each segment as shown by the stationing in column 1.

Note: Column 3: Alcove excavation includes test alcoves and equipment niches. The excavation volume is in Bank Cubic Yards (bcy)
Test alcove size: 12 ft high, 12 ft wide, 75 ft deep
Equipment niche size: 30 ft long, 12 ft high, 8 ft deep
Refuge chamber size: 30 ft long, 12 ft high, 12 ft wide

Note: Column 4: Mining rate is the daily average advance for the TBM excavation.

Note: Column 5: Operating days are based on a five day mining operation. These durations are developed from current K/PB estimate of the work involved.

Note: Column 6: The number of muck trains is based on a three-car train. The capacity of each train is 60 cubic yards. The excavated volume per foot of tunnel is 18.2 Bank Cubic Yards.

Note: Column 7: Muck train loading time is based on a mining rate of 2 inches per minute, with mining a 30 inch stroke per train. An additional 5 minutes idle time is included for each train. Total muck train load time is 20 minutes per train.

Note: Column 8: The number of muck trains is based on a three-car train. The capacity of each train is 60 cubic yards.

Note: Column 9: Drill/Blast excavation muck loading time is based on an estimated 3 minutes of diesel operation per cubic yard and includes both locomotive and LHD.

Note: Column 10: Muck train load time is the daily load time (column 7) times the operating days (column 5), plus the alcove muck time (column 8). 15 % is added for programatic delays.

Note: Column11: Muck train tram time is the total tram time for the segment of tunnel. The tram time is based on an average tram speed of 600 feet per minute. The tram distance is from the portal to the mid-point of the segment, shown in column 1 for each increment of tunnel excavation. 15 % is added for programatic delays.

Note: Column 12: Crew mantrips are the number of one way trips required to transport mining crews to and from the heading. This represents the daily average for a five day mining operation and one maintenance shift on the sixth day.

Note: Column 13: Science mantrips are the one way trips required to transport science crews to and from the heading. This represents the daily average for a five day mining operation and one shift on the sixth day.

Note: Column 14: Utility and maintenance trips are the one way trips required to transport materials, including utilities, segments, maintenance supplies, etc. to and from the heading to support mining activities. This represents the daily average for a five day mining operation and one shift on the sixth day.

Note: Column 15: Idle time is based on 10 minutes of operation for each trip shown in columns 12, 13, 14 for each increment of tunnel excavation. 15 % is added for programatic delays.

Note: Column 16: Travel time is based on an average train speed of 600 feet per minute. The travel distance is from the portal to the mid-point of the section shown in column 1 for each increment of tunnel excavation. 15 % is added for programatic delays.

Note: Column 17: Combined muck loading and service idle time for each segment of tunnel.

Note: Column 18: Combined mucktrain and service train tram time for each segment of tunnel.

Note: Column 19: Total operating time is the sum of the combined idle time (column 17) and combined tram time (column 18).

DIESEL LOCOMOTIVE O
EXPLORATORY STUDIE
KIEWIT/PB

1		=1+A8	=1+B8	=1+C8	=1+D8	=1+E8	=1+F8	=1+G8	=1+H8
						DIESEL USE			
						TBM Excavatio		Alcove Excavatio	
Segment Stations, ft from	to	Tunnel Advance, ft	Alcove Excavation, bcy	Mining Rate, ft/ day	Operating Days, days	Total Muck Trains, trains/day	Muck Train Load Time, min/day	Total Muck Trains, trains/day	Muck Train Load Time, min
2+00	3+60	160		11	15	5	=+F17*20		
3+60	4+60	100		15	7	7	=+F18*20		
4+60	6+20	160		15	11	7	=+F19*20		
6+20	8+50	230		20	14	9	=+F20*20		
8+50	10+50	200		30	7	14	=+F21*20		
10+50	15+00	450		30	15	14	=+F22*20		
Test Alcove #2			400		15			=+C23*1.5/60	=+C23*1.5*3
15+00	25+00	1000		30	44	14	=+F24*20		
Equipment Niche #1			=30*8*12/27		10			3	=+C25*1.5*3
25+00	43+00	1800		30	66	14	=+F26*20		
Conveyor Installation					35				
Equipment Niche #2			=30*8*12/27		10			3	=+C28*1.5*3
43+00	57+00	1400		65	22				
Refuge Chamber			=30*12*12/27		20			=+C30*1.5/60	=+C30*1.5*3
57+00	61+00	400		65	7				
Equipment Niche #3			=30*8*12/27		10			3	=+C32*1.5*3
61+00	79+00	1800		65	30				
Equipment Niche #4			=30*8*12/27		10			3	=+C34*1.5*3
79+00	91+85	=9185-7900		65	20				
TOTALS		=SUM(B17:B35)	=SUM(C17:C35)		=SUM(E17:E35)				

1/31/94

=1+I8	=1+J8
Total Hours for Each Segment	
Muck Train Load Time, hours	Muck Train Tram Time, hours
=ROUND((E17*G17+I17)/60*1.15,1)	=ROUND(E17*(+F17*(SUM(B$17:B17)-B17/2+200)*2/600)/60*1.15+(+H17*(SUM(B$17:B17)-B17/2+200)*2/600)/60*1.15,1)
=ROUND((E18*G18+I18)/60*1.15,1)	=ROUND(E18*(+F18*(SUM(B$17:B18)-B18/2+200)*2/600)/60*1.15+(+H18*(SUM(B$17:B18)-B18/2+200)*2/600)/60*1.15,1)
=ROUND((E19*G19+I19)/60*1.15,1)	=ROUND(E19*(+F19*(SUM(B$17:B19)-B19/2+200)*2/600)/60*1.15+(+H19*(SUM(B$17:B19)-B19/2+200)*2/600)/60*1.15,1)
=ROUND((E20*G20+I20)/60*1.15,1)	=ROUND(E20*(+F20*(SUM(B$17:B20)-B20/2+200)*2/600)/60*1.15+(+H20*(SUM(B$17:B20)-B20/2+200)*2/600)/60*1.15,1)
=ROUND((E21*G21+I21)/60*1.15,1)	=ROUND(E21*(+F21*(SUM(B$17:B21)-B21/2+200)*2/600)/60*1.15+(+H21*(SUM(B$17:B21)-B21/2+200)*2/600)/60*1.15,1)
=ROUND((E22*G22+I22)/60*1.15,1)	=ROUND(E22*(+F22*(SUM(B$17:B22)-B22/2+200)*2/600)/60*1.15+(+H22*(SUM(B$17:B22)-B22/2+200)*2/600)/60*1.15,1)
=ROUND((E23*G23+I23)/60*1.15,1)	=ROUND(E23*(+F23*(SUM(B$17:B23)-B23/2+200)*2/600)/60*1.15+(+H23*(SUM(B$17:B23)-B23/2+200)*2/600)/60*1.15,1)
=ROUND((E24*G24+I24)/60*1.15,1)	=ROUND(E24*(+F24*(SUM(B$17:B24)-B24/2+200)*2/600)/60*1.15+(+H24*(SUM(B$17:B24)-B24/2+200)*2/600)/60*1.15,1)
=ROUND((E25*G25+I25)/60*1.15,1)	=ROUND(E25*(+F25*(SUM(B$17:B25)-B25/2+200)*2/600)/60*1.15+(+H25*(SUM(B$17:B25)-B25/2+200)*2/600)/60*1.15,1)
=ROUND((E26*G26+I26)/60*1.15,1)	=ROUND(E26*(+F26*(SUM(B$17:B26)-B26/2+200)*2/600)/60*1.15+(+H26*(SUM(B$17:B26)-B26/2+200)*2/600)/60*1.15,1)
=ROUND((E27*G27+I27)/60*1.15,1)	=ROUND(E27*(+F27*(SUM(B$17:B27)-B27/2+200)*2/600)/60*1.15+(+H27*(SUM(B$17:B27)-B27/2+200)*2/600)/60*1.15,1)
=ROUND((E28*G28+I28)/60*1.15,1)	=ROUND(E28*(+F28*(SUM(B$17:B28)-B28/2+200)*2/600)/60*1.15+(+H28*(SUM(B$17:B28)-B28/2+200)*2/600)/60*1.15,1)
=ROUND((E29*G29+I29)/60*1.15,1)	=ROUND(E29*(+F29*(SUM(B$17:B29)-B29/2+200)*2/600)/60*1.15+(+H29*(SUM(B$17:B29)-B29/2+200)*2/600)/60*1.15,1)
=ROUND((E30*G30+I30)/60*1.15,1)	=ROUND(E30*(+F30*(SUM(B$17:B30)-B30/2+200)*2/600)/60*1.15+(+H30*(SUM(B$17:B30)-B30/2+200)*2/600)/60*1.15,1)
=ROUND((E31*G31+I31)/60*1.15,1)	=ROUND(E31*(+F31*(SUM(B$17:B31)-B31/2+200)*2/600)/60*1.15+(+H31*(SUM(B$17:B31)-B31/2+200)*2/600)/60*1.15,1)
=ROUND((E32*G32+I32)/60*1.15,1)	=ROUND(E32*(+F32*(SUM(B$17:B32)-B32/2+200)*2/600)/60*1.15+(+H32*(SUM(B$17:B32)-B32/2+200)*2/600)/60*1.15,1)
=ROUND((E33*G33+I33)/60*1.15,1)	=ROUND(E33*(+F33*(SUM(B$17:B33)-B33/2+200)*2/600)/60*1.15+(+H33*(SUM(B$17:B33)-B33/2+200)*2/600)/60*1.15,1)
=ROUND((E34*G34+I34)/60*1.15,1)	=ROUND(E34*(+F34*(SUM(B$17:B34)-B34/2+200)*2/600)/60*1.15+(+H34*(SUM(B$17:B34)-B34/2+200)*2/600)/60*1.15,1)
=ROUND((E35*G35+I35)/60*1.15,1)	=ROUND(E35*(+F35*(SUM(B$17:B35)-B35/2+200)*2/600)/60*1.15+(+H35*(SUM(B$17:B35)-B35/2+200)*2/600)/60*1.15,1)
=SUM(J17:J35)	=SUM(K17:K35)

=1+	=1+L8	=1+M8	=1+N8	=1+O8	=1+P8
DIES					
			Total Hours for Each Segment		
Crew	Science	Utility and Maintenance	Service Loci Idle Time, hours	Service Loci Tram Time, hours	Idle & Muck Load Total Time, hours
0	0	6	=ROUND((L17+M17+N17)*10*E17/60*1.15,1)	=ROUND(((SUM(B$17:B17)-B17/2+200)/600*(L17+M17+N17))*E17/60*1.15,1)	=+O17+J17
0	0	6	=ROUND((L18+M18+N18)*10*E18/60*1.15,1)	=ROUND(((SUM(B$17:B18)-B18/2+200)/600*(L18+M18+N18))*E18/60*1.15,1)	=+O18+J18
0	0	6	=ROUND((L19+M19+N19)*10*E19/60*1.15,1)	=ROUND(((SUM(B$17:B19)-B19/2+200)/600*(L19+M19+N19))*E19/60*1.15,1)	=+O19+J19
0	0	6	=ROUND((L20+M20+N20)*10*E20/60*1.15,1)	=ROUND(((SUM(B$17:B20)-B20/2+200)/600*(L20+M20+N20))*E20/60*1.15,1)	=+O20+J20
0	0	6	=ROUND((L21+M21+N21)*10*E21/60*1.15,1)	=ROUND(((SUM(B$17:B21)-B21/2+200)/600*(L21+M21+N21))*E21/60*1.15,1)	=+O21+J21
7	10	6	=ROUND((L22+M22+N22)*10*E22/60*1.15,1)	=ROUND(((SUM(B$17:B22)-B22/2+200)/600*(L22+M22+N22))*E22/60*1.15,1)	=+O22+J22
7	10	10	=ROUND((L23+M23+N23)*10*E23/60*1.15,1)	=ROUND(((SUM(B$17:B23)-B23/2+200)/600*(L23+M23+N23))*E23/60*1.15,1)	=+O23+J23
7	10	6	=ROUND((L24+M24+N24)*10*E24/60*1.15,1)	=ROUND(((SUM(B$17:B24)-B24/2+200)/600*(L24+M24+N24))*E24/60*1.15,1)	=+O24+J24
7	6	10	=ROUND((L25+M25+N25)*10*E25/60*1.15,1)	=ROUND(((SUM(B$17:B25)-B25/2+200)/600*(L25+M25+N25))*E25/60*1.15,1)	=+O25+J25
7	10	6	=ROUND((L26+M26+N26)*10*E26/60*1.15,1)	=ROUND(((SUM(B$17:B26)-B26/2+200)/600*(L26+M26+N26))*E26/60*1.15,1)	=+O26+J26
7	6	12	=ROUND((L27+M27+N27)*10*E27/60*1.15,1)	=ROUND(((SUM(B$17:B27)-B27/2+200)/600*(L27+M27+N27))*E27/60*1.15,1)	=+O27+J27
7	6	10	=ROUND((L28+M28+N28)*10*E28/60*1.15,1)	=ROUND(((SUM(B$17:B28)-B28/2+200)/600*(L28+M28+N28))*E28/60*1.15,1)	=+O28+J28
7	10	10	=ROUND((L29+M29+N29)*10*E29/60*1.15,1)	=ROUND(((SUM(B$17:B29)-B29/2+200)/600*(L29+M29+N29))*E29/60*1.15,1)	=+O29+J29
7	10	10	=ROUND((L30+M30+N30)*10*E30/60*1.15,1)	=ROUND(((SUM(B$17:B30)-B30/2+200)/600*(L30+M30+N30))*E30/60*1.15,1)	=+O30+J30
7	10	10	=ROUND((L31+M31+N31)*10*E31/60*1.15,1)	=ROUND(((SUM(B$17:B31)-B31/2+200)/600*(L31+M31+N31))*E31/60*1.15,1)	=+O31+J31
7	6	10	=ROUND((L32+M32+N32)*10*E32/60*1.15,1)	=ROUND(((SUM(B$17:B32)-B32/2+200)/600*(L32+M32+N32))*E32/60*1.15,1)	=+O32+J32
7	10	10	=ROUND((L33+M33+N33)*10*E33/60*1.15,1)	=ROUND(((SUM(B$17:B33)-B33/2+200)/600*(L33+M33+N33))*E33/60*1.15,1)	=+O33+J33
7	6	10	=ROUND((L34+M34+N34)*10*E34/60*1.15,1)	=ROUND(((SUM(B$17:B34)-B34/2+200)/600*(L34+M34+N34))*E34/60*1.15,1)	=+O34+J34
7	10	10	=ROUND((L35+M35+N35)*10*E35/60*1.15,1)	=ROUND(((SUM(B$17:B35)-B35/2+200)/600*(L35+M35+N35))*E35/60*1.15,1)	=+O35+J35
					=SUM(Q17:Q35)

=1+Q8	=1+R8	=1+S8
COMBINED MU SERVICE TRAIN Total Hours for Eac		
Tram Total Time, hours	Total Oper Time, hours	Comments
=+P17+K17	=+R17+Q17	Start TBM tunneling at North Portal
=+P18+K18	=+R18+Q18	
=+P19+K19	=+R19+Q19	
=+P20+K20	=+R20+Q20	Bow Ridge Fault area, includes 2 additional days for steel set erection
=+P21+K21	=+R21+Q21	
=+P22+K22	=+R22+Q22	
=+P23+K23	=+R23+Q23	Drill and blast excavation, using diesel powered rubber tired equipment
=+P24+K24	=+R24+Q24	5 fault zones, 10 additional days for steel set erection
=+P25+K25	=+R25+Q25	Drill and blast excavation, using diesel powered rubber tired equipment
=+P26+K26	=+R26+Q26	3 fault zones, 6 additional days for steel set erection
=+P27+K27	=+R27+Q27	Mining operation is shut down during the conveyor installation
=+P28+K28	=+R28+Q28	Drill and blast excavation, using diesel powered rubber tired equipment
=+P29+K29	=+R29+Q29	
=+P30+K30	=+R30+Q30	Drill and blast excavation, using diesel powered rubber tired equipment
=+P31+K31	=+R31+Q31	
=+P32+K32	=+R32+Q32	Drill and blast excavation, using diesel powered rubber tired equipment
=+P33+K33	=+R33+Q33	1 fault zone, 2 additional days for steel set erection
=+P34+K34	=+R34+Q34	Drill and blast excavation, using diesel powered rubber tired equipment
=+P35+K35	=+R35+Q35	Tunneling to end TS North Ramp
=SUM(R17:R35)	=SUM(S17:S35)	