VALUE ENGINEERING STUDY REPORT

LINAC COHERENT LIGHT SOURCE (LCLS) CONVENTIONAL FACILITIES

STANFORD LINEAR ACCELATOR CENTER
STANFORD UNIVERSITY

JE JACOBS

March 30-31, 2004

EXECUTIVE SUMMARY

The Stanford Linear Accelerator Center (SLAC) is proposing to construct a new Linac Coherent Light Source (LCLS) Facility to be located on the eastern half of existing SLAC Site on the Stanford campus. The LCLS will be a research facility used for future research and experiments in such fields as atomic, plasma and x-ray laser physics as well as femtosecond chemistry and studies on condensed matter structures.

Several new conventional facilities will be required to house the new components and equipment needed for the energy beams created by the LCLS. These facilities will include modifications to the existing research yard and access road as well as new structures such as a Beam Transport Hall, Undulator Hall, Front End Enclosure, Electron Beam Dump Enclosure, Near and Far Experimental Halls, X-ray Transport and Diagnostic Tunnel and additional structures for office space, mechanical rooms and future experiments. The total estimated construction cost for these new facilities and structures (with contingencies), is approximately $65 million ($54 million without contingencies). The LCLS operations are scheduled to commence on October 2008.

The Value Engineering (VE) team was tasked with a two-day study on March 30 and 31, 2004, to apply the value engineering principles and methods to the design of the LCLS Conventional Facilities. The primary objectives of the VE study were to analyze and evaluate the designer's conceptual level set of Title I (preliminary) plans and to develop alternative methods of design and construction.

The intent was to revisit functions, which represent the intentions of the design and its components, and offer additional or new alternatives to satisfy those functions. The VE study team concentrated their efforts on functional aspects of the project while developing alternatives during their study, and recommendations for implementation by SLAC committee. These recommendations have been presented in greater detail within the VE report.

The costs and savings shown below are based upon the cost estimate provided on March 30, 2004, which is included in this report. (Note: Contingency factors have not been applied to the documented Potential Cost Savings listed below).

VE STUDY ITEMS / RECOMMEDATIONS

VE1: Headhouse/BTH Tunnel

Function: Carry the high-energy beam into the Undulator Hall, while allowing for additional beam angles of 2 and 4 degrees to be constructed in the future.

Recommendation: Shorten Headhouse to 61 meters, and extend BTH tunnel to new location; and use a removable wall system (thin wall with removable blocks provided by SLAC) to allow for easier construction for future 2 and 4 degree beams lines. Building 113 will not require demolition.

Potential Cost Savings: $1,300,000

VE2: XTD Tunnel/Access Tunnel/FEH

Function: To house the X-Ray beams, which travel to the Far Experimental Hall for additional experiments.

Recommendation: Reduce X-ray tunnels by 40-meters, to a length of 250 meters; reduced equally among all three of the segments of the tunnel and

modify the X-Ray tunnel cross section for a constant 18-foot wide section. Align the south side of the X-Ray Tunnel with southern beam.

Potential Cost Savings: $900,000

VE3: Near Experimental Hall

Function: To house three experimental hutches and the prep areas for a variety of experiments with the high energy X-ray beam.

Recommendation: Item should be further discussed with Central Lab Office Building (FEL Center) in future meetings.

Potential Cost Savings: $0

VE4: Undulator Hall (UH) Tunnel/Alcoves

Function: The Undulator Hall will house several magnets and ancillary equipment to use on the electron beam before it enters the FEE. The Alcove's function is to house the mechanical/electrical equipment to meet the temperature requirements of the tunnel.

Recommendation: The Alcove's design is driven by stringent requirements on the modified environment inside the Undulator Hall, and therefore cannot be evaluated within this study. However paint type should be specified within the tunnel to insure non-peeling and improve brightness. It was determined that Jacobs can reduce the size and number of alcoves to reduce cost by approximately $200K.

Potential Cost Savings: $200,000

VE5: Service Buildings

Function: To house the control equipment for the tunnel and to contain most of the HVAC, mechanical and electrical equipment to support the facility.

Recommendation: The Service Building concepts have not been developed at this stage to a level for the VE team to investigate alternatives. No alternatives have been developed for this study item.

Potential Cost Savings: $0

VE6: Headwall

Function: Retain soil and by provide a tunnel portal into the existing hillside.

Recommendation: Reduce the size of retaining wall to accommodate only the two 0-degree beams.

Potential Cost Savings: $100,000

VE7: Front End Enclosure

Function: Provide a structure in which the electron beam and the X-ray beams are separated.

Recommendation: Reduce length of Tunnel by Modifying access tunnel and reduce passageway length by approximately 8 meters.

Potential Cost Savings: $0

VE8: Service Road

Function: Provide site access to both sides of the facility and satisfying the fire access requirements.

Recommendation: The Design team is to provide a vibration analysis to the client, which will follow with a SLAC meeting to discuss future impacts.

Potential Cost Savings: $0

VE9: Far Experimental Hall Offices

Function: Provide space for labs and offices to perform additional experiments at the end of the X-Ray Tunnel, using an underground caverns.

Recommendation: Extend the cavern, which is closest to the PEP Ring Road, an additional 112-feet, to add labs and mezzanine offices above, eliminating the need for an above ground structure with elevator/stair access. Service Road to above ground structure will no longer be required.

Potential Cost Savings: $1,130,000 (cost avoidance $500,000)

VE10: Research Yard Modifications

Function: Provide necessary space and accommodate the construction of the Headhouse and Beam Transfer Tunnel in the existing yard.

Recommendation: There was not enough data provided for the VE Study to provide adequate sound alternatives. Upon further discussion by the VE team, of the items involved with the modifications, it was recommend by the team that that amount currently estimated should be reduced by 15-20%.

Potential Cost Savings: $500,000

VE11: Far Experimental Hall Build-Out

Function: underground caverns to house experiments in the FEH.

Recommendation: Upon review of SF cost VE team recommends a reduced SF cost of this item

Potential Cost Savings: $1,000,000

If the recommended VE alternatives summarized above are fully implemented, costs can potentially be reduced by $5,130,000 (cost avoidance $500,000). This is a reduction of 10.4 percent of the current $54,025,406 (ROM) construction cost for the LCLS conventional facilities.

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Introduction

The Stanford Linear Accelerator Center (SLAC) is a federally funded laboratory operated for the US Department of Energy by Stanford University. SLAC is currently proposing to construct a new Linac Coherent Light Source (LCLS) facility to be located in the eastern half of the SLAC campus, just east of the existing Linac (Linear Accelerator) facility. The LCLS will begin in the Beam Switch Yard (Research Yard) and travel approximately 2700-feet to the east. The LCLS will require a 150 MeV injector be constructed at Sector 20 of the 30 Sector SLAC Linac, in order to create the electron beam required for the X-ray Free Electron Laser. This Laser will be used as a powerful research tool in the future in the physical and life science fields.

This project will require the construction of several new structures, tunnels, roadways, service buildings, and underground facilities to house the LCLS. The total Project Cost of the entire LCLS project is estimated between $250-300M, with the conventional facilities (structures, retaining walls, tunnels, roads, etc.) estimated at $65M ($54M without contingencies).

The Value Engineering (VE) team was tasked with a two-day study (March 30 and 31, 2004), to evaluate the LCLS facilities and apply the VE concepts to develop and investigate design alternatives. The VE study was based upon information, sketches, and cost estimates provided by the design team. The intent of the VE study is to furnish alternatives to accomplish what needs to be done without impairing quality, reliability, and functionality.

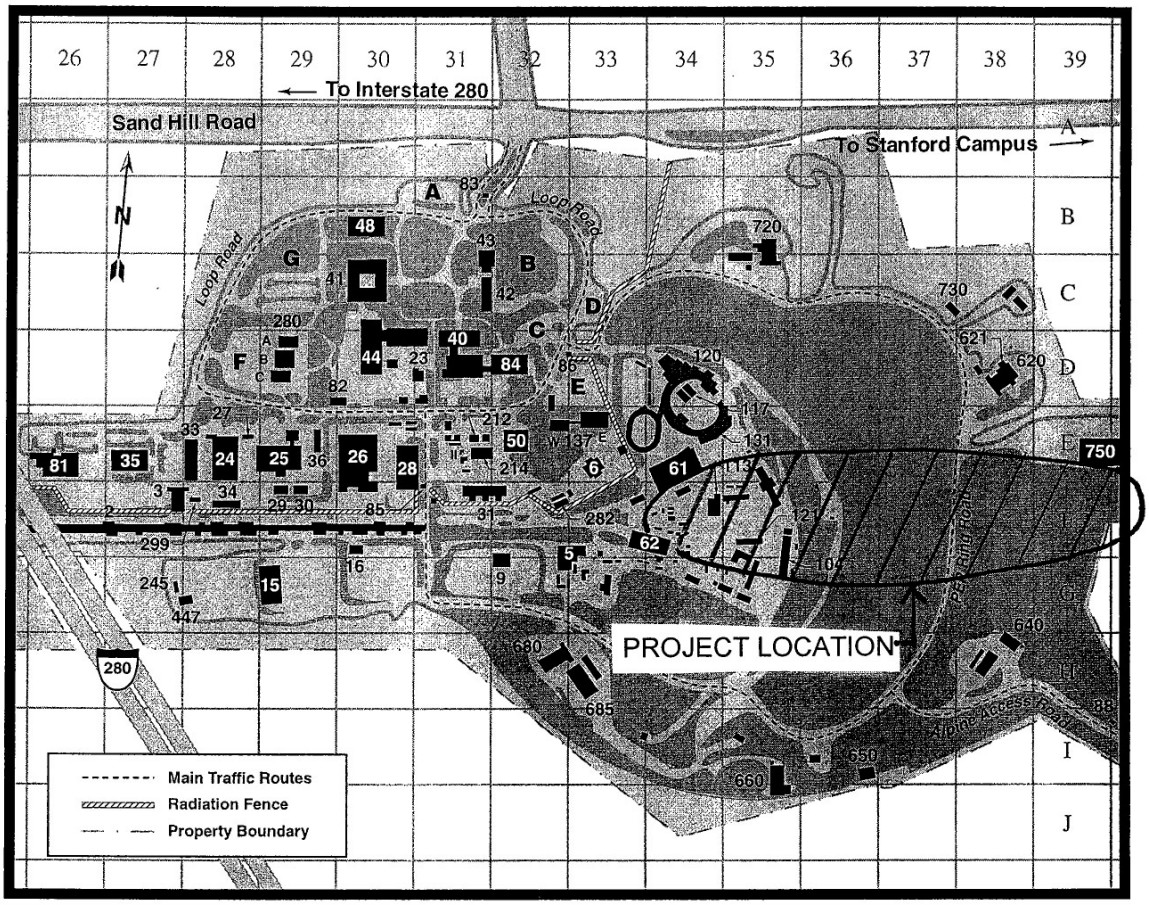
The VE team concentrated their efforts on functional aspects of the project while developing alternatives during the study and providing recommendations for each study item, to be implemented by the SLAC team. The VE costs savings shown, are based upon the cost estimate data provided. The VE team focused on the initial cost savings and did not include factors for contingencies.

The VE team reviewed the designer's current Cost Estimate and the Cost Models provided, which reflect the project cost breakdown at this design stage.

Project Cost Estimate

The Cost Estimate and Cost Models provided to the VE team at the beginning of the study reflect the current design level. The cost estimate is divided into sections indicating the Rough Order of Magnitude Cost (ROM), the contingencies and the total cost. Cost savings indicated in the VE study items to follow, use the ROM Cost and does not include mark-ups for the contingencies.

Review of the Cost Models indicated that the Central Lab Office Building (previously know as the FEL Center) appears to be the largest percentage of the project costs at 37.6 percent, or $20,289,701. However, during a meeting the previous day (March 29, 2004) this item was discussed at length, and additional meetings are to follow during Title II Design. Therefore it was decided upon by the VE team that this item would not be studied, and the VE team should focus on the other components of the project for this study.



SLAC Area Map

VICINITY MAP

COST ESTIMATE

Stanford Linear Accelerator Center
Project Summary
Conceptual Statement of Probable Cost

PROJECT SUMMARY

Element	Quantity	Unit	Unit Cost	ROM Subtotal	%	Conting.	ROM Total
1 Research Yard Modifications				2,000,000	30%	600,000	2,600,000
2 Beam Transfer Hall, 106 meters, (348 lf)	348	lf	4,793	1,389,914	20%	277,983	1,667,897
3 UH Tunnel, 175 meters, (574 lf)	574	lf	5,955	2,848,580	20%	569,716	3,418,296
4 Add 14.5' tunnel in lieu of 12.5' tunnel	574	lf	1,114	533,065	20%	106,613	639,678
5 Front End Enclosure	3,395	sf	508	1,437,852	20%	287,570	1,725,423
6 Electron Beam Dump	729	sf	732	444,881	20%	88,976	533,857
7 Near Experimental Hall	10,000	sf	446	3,716,893	20%	743,379	4,460,272
8 XTD Tunnel, (925 lf)	925	lf	6,433	4,959,012	20%	991,802	5,950,814
9 Far Experimental Hall, Build Out of Interiors	6,758	sf	405	2,280,319	20%	456,064	2,736,383
10 FEH Caverns, 33' diameter x 112' (2 ea), 200' access tunnel	424	lf	7,496	2,445,000	30%	733,500	3,178,500
11 Access Tunnel	482	lf	4,591	1,843,899	20%	368,780	2,212,678
12 Free Electron Laser and Ultra Fast Center	70,000	sf	348	20,289,701	20%	4,057,940	24,347,641
13 Stairwell, Elevator at FEH	9,120	sf	189	1,436,202	20%	287,240	1,723,443
14 Staff Support Space	5,000	sf	243	1,014,280	20%	202,856	1,217,136
15 Service Buildings, 26'x 28' at Wall	728	sf	152	92,456	20%	18,491	110,947
16 40'x 40' at Headhouse (2 ea)	3,200	sf	152	406,400	20%	81,280	487,680
17 50'x 22' at Berm	1,100	sf	152	139,700	20%	27,940	167,640
18 39'x 22' outside Berm	858	sf	152	108,966	20%	21,793	130,759
19 39'x 22' part of FEL	858	sf	152	108,966	20%	21,793	130,759
20 39'x 22' at FEH	858	sf	152	108,966	20%	21,793	130,759
21 Headhouse	22,560	sf	203	3,823,891	20%	764,778	4,588,669
22 Alcoves, (10 each)	10	ea	123,600	1,030,000	20%	206,000	1,236,000
23 Service Road	1400	lf	585	682,463	20%	136,493	818,956
24 Parking at FEL	30,000	sf	5	120,000	20%	24,000	144,000
25 Headwall	4,800	sf	66	264,000	20%	52,800	316,800
26 Metal Block, (15'x17'x13), Recycled from Duratek	812	ton	739	500,000	20%	100,000	600,000
Subtotal				**54,025,406**		**11,249,581**	**65,274,987**

COST MODEL 1A

ITEM/FUNCTION COST MODEL 1A

Total Project Costs

BID ITEM/Function(s)		%	TOTAL (IN $)
Research Yard Modifications		3.7%	$2,000,000
Beam Transfer Hall		2.6%	$1,389,914
UH Tunnel		5.3%	$2,848,580
Add 14.5' Tunnel in lieu of 12.5'		1.0%	$533,065
Front End Enclosure		2.7%	$1,437,852
Electron Beam Dump		0.8%	$444,881
Near Experimental Hall		6.9%	$3,716,893
XTD Tunnel		9.2%	$4,959,012
Far Experimental Hall		4.2%	$2,280,319
FEH Caverns		4.5%	$2,445,000
Access Tunnel		3.4%	$1,843,899
FEL Center		37.6%	$20,289,701
Stairwell Elevator at FEH		2.7%	$1,436,202
Staff Support Space		1.9%	$1,014,280
Service Buildings	at Wall	0.2%	$92,456
	at Headhouse	0.8%	$406,400
	at Berm	0.3%	$139,700
	outside Berm	0.2%	$108,966
	part of FEL	0.2%	$108,966
	at FEH	0.2%	$108,966
Headhouse		7.1%	$3,823,891
Alcoves		1.9%	$1,030,000
Service Road		1.3%	$682,463
Parking at FEL		0.2%	$120,000
Headwall		0.5%	$264,000
Metal Block		0.9%	$500,000
TOTAL		100%	**TOTAL CONSTRUCTION COST** **$54,025,406**

PERCENTAGE OF STUDY ITEM

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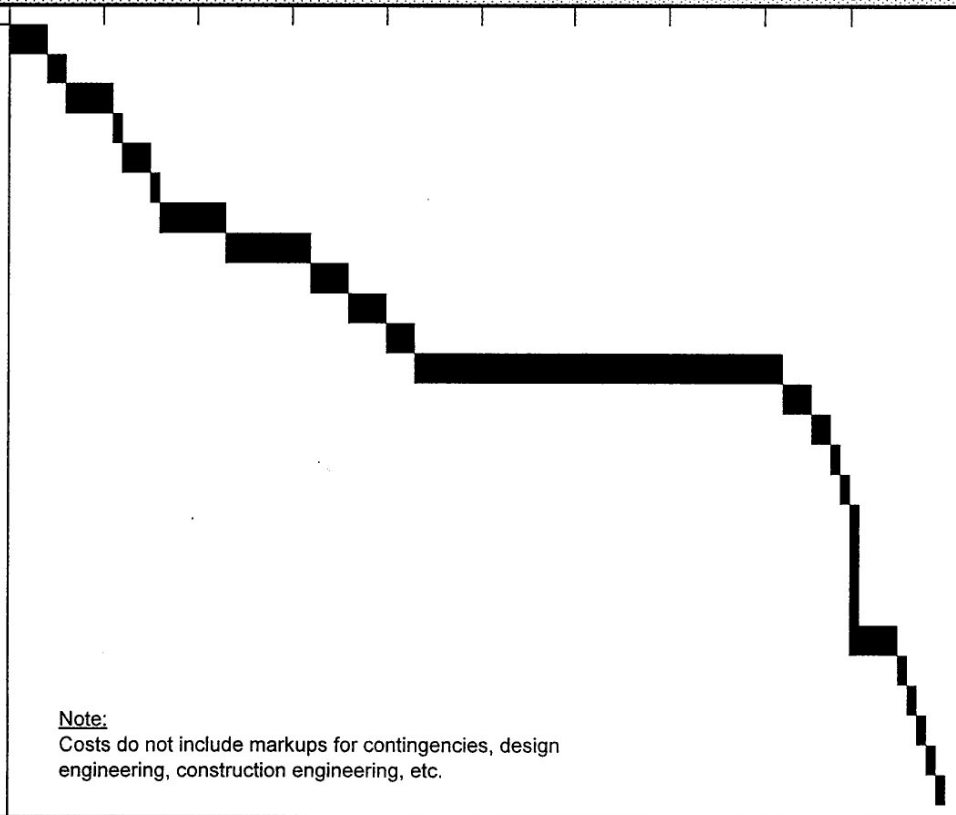


Note:
Costs do not include markups for contingencies, design engineering, construction engineering, etc.

COST MODEL 1B

ITEM/FUNCTION COST MODEL 1B

Total Project Costs WITHOUT the Central Lab Offie Buidling (FEL Center)

BID ITEM/Function(s)		%	PERCENTAGE OF STUDY ITEM (0 10 20 30 40 50 60 70 80 90 100)	TOTAL (IN $)
Research Yard Modifications		5.9%		$2,000,000
Beam Transfer Hall		4.1%		$1,389,914
UH Tunnel		8.4%		$2,848,580
Add 14.5' Tunnel in lieu of 12.5'		1.6%		$533,065
Front End Enclosure		4.3%		$1,437,852
Electron Beam Dump		1.3%		$444,881
Near Experimental Hall		11.0%		$3,716,893
XTD Tunnel		14.7%		$4,959,012
Far Experimental Hall		6.8%		$2,280,319
FEH Caverns		7.2%		$2,445,000
Access Tunnel		5.5%		$1,843,899
Stairwell Elevator at FEH		4.3%		$1,436,202
Staff Support Space		3.0%		$1,014,280
Service Buildings	at Wall	0.3%		$92,456
	at Headhouse	1.2%		$406,400
	at Berm	0.4%		$139,700
	outside Berm	0.3%		$108,966
	part of FEL	0.3%		$108,966
	at FEH	0.3%		$108,966
Headhouse		11.3%		$3,823,891
Alcoves		3.1%		$1,030,000
Service Road		2.0%		$682,463
Parking at FEL		0.4%		$120,000
Headwall		0.8%		$264,000
Metal Block		1.5%		$500,000
TOTAL		100%	TOTAL CONSTRUCTION COST	**$33,735,705**

Note:
Costs do not include markups for contingencies, design engineering, construction engineering, etc.

Items for Speculation

Based upon the review of the Cost Estimate and Cost Models, the VE team developed a list of Items for Speculation, and prioritized the items for evaluation. The VE team then began the VE Evaluation phase with the first VE Study Item using VE principles and methodologies.

Rank	Item(s)
1	Headhouse/Beam Transfer Hall (BTH)
2	X-Ray Transport Diagnostics (XTD) Tunnel/ Access Tunnel/(FEH)
3	Near Experimental Hall (NEH)
4	Undulator Hall (UH) /Alcoves
5	Service Buildings
6	Headwall
7	Front End Enclosure (FEE)
8	Service Roads
9	Far Experimental Hall (FEH) Offices
10	Research Yard Modifications
11	Far Experimental Hall Build out

VE Study Item 1:
Headhouse/Beam Transport Hall (BTH) Tunnel

The Headhouse and Beam Transport Hall are the first structures in the upstream end of the LCLS facility. Its function is to carry the high-energy beam into the Undulator Hall. The Headhouse layout allows for future beam angles of +/- 2 to +/- 4 degrees.

VE1 Alternatives

1. *Original Concept*: Above ground structure for the Headhouse 122 meters in length, which will allow for the two 0-degree beams and future +/-2 degree and +/- 4 degree beams north and south of the existing structure.

    - Advantages: Minimizes down time, allows for future +/-4 degree and +/-2 degree beams and allows for long-item access to tunnel.
    - Disadvantages: Highest cost among alternatives locks in geometry for the 2 and 4 degree beams and demolishes Building No.113.

2. *Shorten Headhouse*: Shorten Headhouse to 61 meters and extend BTH tunnel to new location. A pipe will need to be installed in a 6-foot thick concrete wall to accommodate future +2 and -2 degree beams.

    - Advantages: Allows Building No.113 to remain.
    - Disadvantages: Becomes potentially more difficult to construct future 2 degree beams.
    - Estimated Cost Difference from Original Concept: -$1,200,000

3. *No Headhouse*: No Headhouse, extend BTH tunnel straight to head wall

    - Advantages: Allows Building No.113 to remain.
    - Disadvantages: Adds down time for future expansion, does not allow long item access into tunnel, increases difficultly to construct future 2 and 4 degree beams.
    - Estimated Cost Difference from Original Concept: -$2,100,000

4. *Asymmetrical structure*: Construct Headhouse to accommodate the +2 and +4 degree beams to the north similar to existing; however, South side will only accommodate 0 degree beams.

    - Advantages: Reduces impacts to research yard.
    - Disadvantages: Accounts for half of the 2 and 4-degree beams and still will be difficult to construct –2 and –4-degree beams and Building No. 113 will be demolished.
    - Estimated Cost Difference from Original Concept: -$900,000

5. *Staggered Structure A*: Stagger the head house so the long side is on the north side to accommodate the +2-degree beam and the short side on the south to accommodate the –4-degree beam.

    - Advantages: Ties in with Near Hall as currently designed.

- Disadvantages: Does not accommodate the -2 and +4 degree beams and demolishes Building No. 113.
- Estimated Cost Difference from Original Concept: -$1,000,000

6. *Staggered Structure B*: Stagger the head house so the long side is on the south side to accommodate the -2 degree beam and the long side on the north to accommodate the +4 degree beam.

    - Advantages: Allows Building No. 113 to remain.
    - Disadvantages: Does not accommodate the +2 and -4 degree beams and Near Hall layout will need to be flipped.
    - Estimated Cost Difference from Original Concept: -$1,300,000

7. *Removable Wall System*: Similar concept to alternative 2, however use a removable wall system (either a thin wall with removable blocks or all removable blocks) to allow for future construction of the 2 and 4 degree beams.

    - Advantages: Building 113 Remains and allows for ease of construction for future beams.
    - Disadvantages: 2-degree line could still have conflicts during future construction.
    - Estimated Cost Difference from Original Concept: -$1,200,000

8. *Reduce the BTH cross section*: Reduce the BTH cross section by 1-foot on each side of the tunnel.

    - Advantages: Reduces construction cost
    - Disadvantages: Increases maintenance difficultly.
    - Estimated Cost Difference from Original Concept: -$100,000

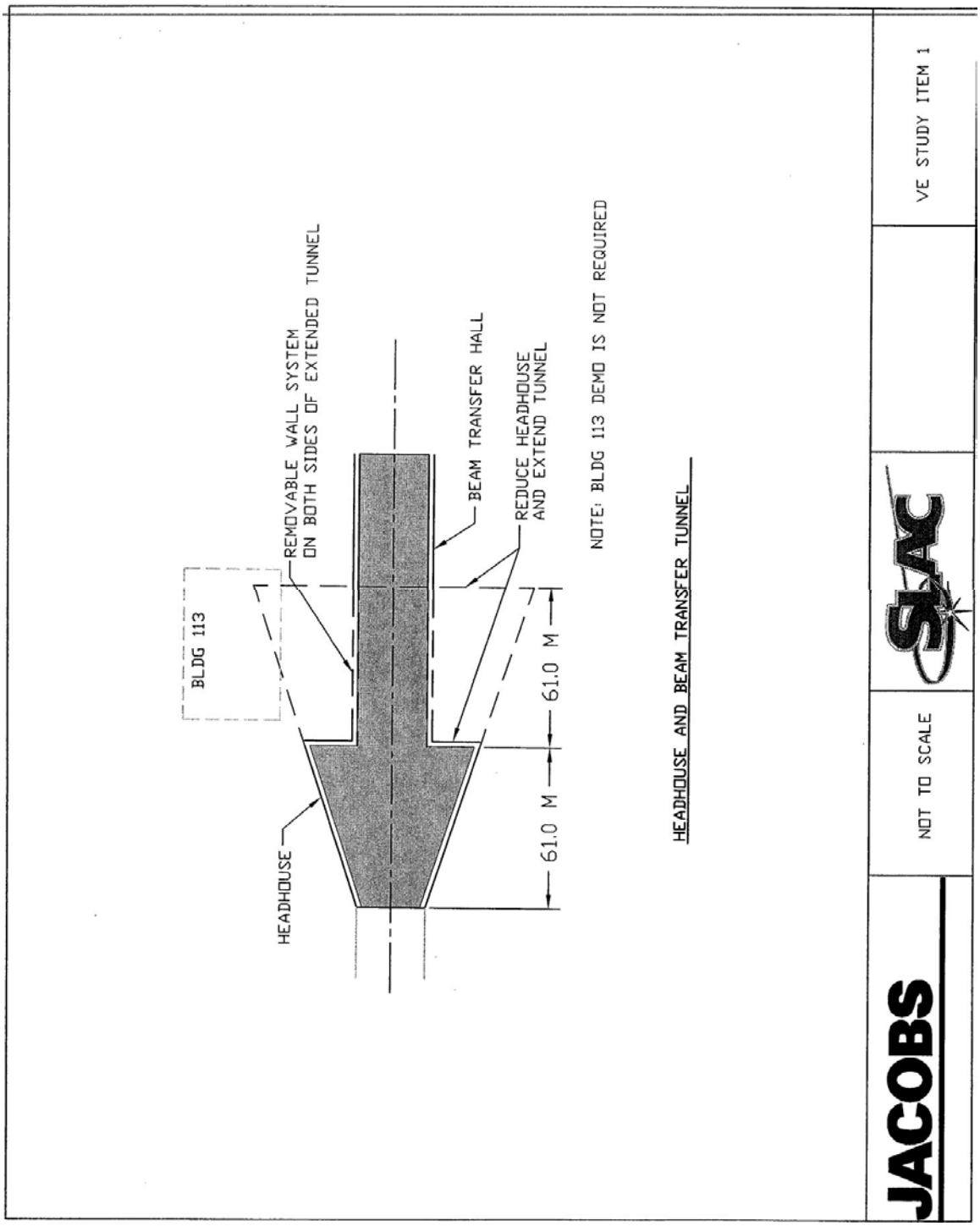
VE1 Recommendation

After evaluation of alternatives by the VE team, a recommendation of a combination of Alternative 2 with Alternative 7 was the selection. This new alternative shortens the Headhouse to 61 meters and extends the BTH Tunnel. The walls in the first 10 meters of the BTH tunnel (from the Headhouse) will be constructed partially with removable blocks to reduce construction cost. This will make construction easier when additional beams are added in the future.

The VE team did not approve of Alternative 8, which had proposed to modify the tunnel cross-section.

Additional Savings is recognized, by allowing Bldg 113 to remain; demolition is estimated at $100,000.

VE1 Cost Savings: $1,300,000



VE SKETCH OF RECOMMENDED CONCEPT

Stanford Linear Accelerator Center
Head House
VE STUDY ITEM 1: HEADHOUSE/BTH TUNNEL

ESTIMATED COST SAVINGS

CSI Category	A Shell 11,280 SF Total	Cost/SF	Building Total 11,280 SF Total
1 General Requirements	$ -		$ -
2 Sitework	$ 60,097	$5.33	$ 60,097
3 Concrete	$ 1,359,518	$120.52	$ 1,359,518
4 Masonry	$ -		$ -
5 Metals	$ 174,500	$15.47	$ 174,500
6 Wood & Plastics	$ -		$ -
7 Thermal & Moisture	$ 8,160	$0.72	$ 8,160
8 Doors & Windows	$ -		$ -
9 Finishes	$ -		$ -
10 Specialties	$ -		$ -
11 Equipment	$ -		$ -
12 Furnishings	$ -		$ -
13 Special Construction	$ -		$ -
14 Conveying	$ -		$ -
15 Mechanical	$ 169,200	$15.00	$ 169,200
16 Electrical	$ 157,920	$14.00	$ 157,920
Subtotal Subcontractors Cost	$ 1,929,395	$171.05	$ 1,929,395
General Conditions, OH&P,	$ 231,527	$20.53	$ 231,527
Bonds & Insurance	$ 23,770	$2.11	$ 23,770
Permits	$ -		$ -
Estimating Contingency	$ 218,469	$19.37	$ 218,469
Escalation	$ 144,190	$12.78	$ 144,190
Total Construction Cost	**$ 2,547,352**	$225.83	**$ 2,547,352**
ORIGINAL CONCEPT			**$ 3,823,891**
VE 1 ESTIMATED COST SAVINGS			**$ 1,276,539**

VE COST ESTIMATE OF RECOMMENDED CONCEPT

VE Study Item 2:

XTD Tunnel/Access Tunnel/Far Experimental Hall (FEH)

The function of the X-Ray Transport and Diagnostics Tunnel (XTD) is to house the X-Ray beams, which travel to the Far Experimental Hall (FEH) for additional experiments. The FEH is located underground and at the end of the XTD Tunnel and will include space for control areas and prep areas needed in the experiments. An access tunnel will be constructed to provide access to the FEH from the building #750 and is also required for fire and health safety issues.

VE2 Alternatives

1. *Original Concept*: 290 meter X-ray tunnel, constructed in 3 segments with cross sections of 14', 17' and 25'. Access tunnel from the NE corner of Bldg #750 will be 482 feet long with a 14-foot wide section and provide access to the FEH, X-Ray Tunnel and Caverns.

    - Advantages: Allows for longer x-ray tunnel.
    - Disadvantages. Increase cost and pushes the FEH to the east which would not allow for a future elevator and stairway directly to the surface.

2. *Reduce X-ray Tunnel Length*: Reduce X-ray tunnels by 40-meters, to a length of 250 meters; reduced equally among all three of the segments of the tunnel.

    - Advantages: Reduced length will allow for the FEH to align better with buildings above.
    - Disadvantages: X-ray optics may not be as good as with a longer tunnel.
    - Estimated Cost: Difference from Original Concept: -$660,000

3. *Reduce Tunnel Cross Section Segments*: Reduce tunnel cross sections along all the segments to widths of 12', 14' and 18' segments. Align the south side of the X-Ray tunnel with southern beam.

    - Advantages: Reduces cost of construction.
    - Disadvantages: Creates potential access issues and reduces space. The three different diameters do not provide full cost advantage.
    - Estimated Cost: Difference from Original Concept: -$440,000

4. *Reduce Tunnel Cross Section to 18 foot wide*: Modify X-Ray tunnel cross section for a constant 18-foot wide section. Align the south side of the X-Ray Tunnel with southern beam.

    - Advantages: Allows for better constructability and space for future expansion. Reduces cost of construction.
    - Disadvantages: Creates potential access issues and reduces space.
    - Estimated Cost: Difference from Original Concept: -$240,000

5. *Lengthen Underground Caverns*: Extend the underground caverns each 112' in the north direction; eliminating the need for surface building, elevator and stairs. This will create an additional 4,000 SF (net area) of office/lab space.

underground, replacing the 5,000 SF surface building. This alternative will require an additional 70' of the 10' diameter. Access Tunnel for emergency fire access.

- Advantages: Eliminates need for surface structures and elevator shaft
- Disadvantages: Creates working environment underground
- Estimated Cost Difference from Original Concept: +$2,200,000

6. *Widen Access Tunnel*: Widen the access tunnel along east side to accommodate more building space and eliminate the surface building, stairs and elevator.

    - Advantages: Building the new offices in the access tunnel, eliminates need for surface structures and elevator shaft. Elimination of surface building reduces community concerns.
    - Disadvantages: Requires a long row of offices and reduced aisle width. Not as desirable of working space for office/Lab layout.
    - Estimated Cost: Difference from Original Concept: +$1,500,000

7. *Maximize micro Tunnel length*: Maximize micro tunnel length of horizontal bore (to a maximum length of 100 feet)

    - Advantages: Reduces tunnel 25 ft. Dia. Tunnel to construct
    - Disadvantages: Requires 14 more feet of access tunnel and 10 ft. emergency access tunnel to build. Long Micro boring may cause alignment problems.
    - Estimated Cost Difference from Original Concept: -$0.0M

8. *Move surface building over access tunnel*: Relocate surface building over access tunnel and reduce elevator distance.

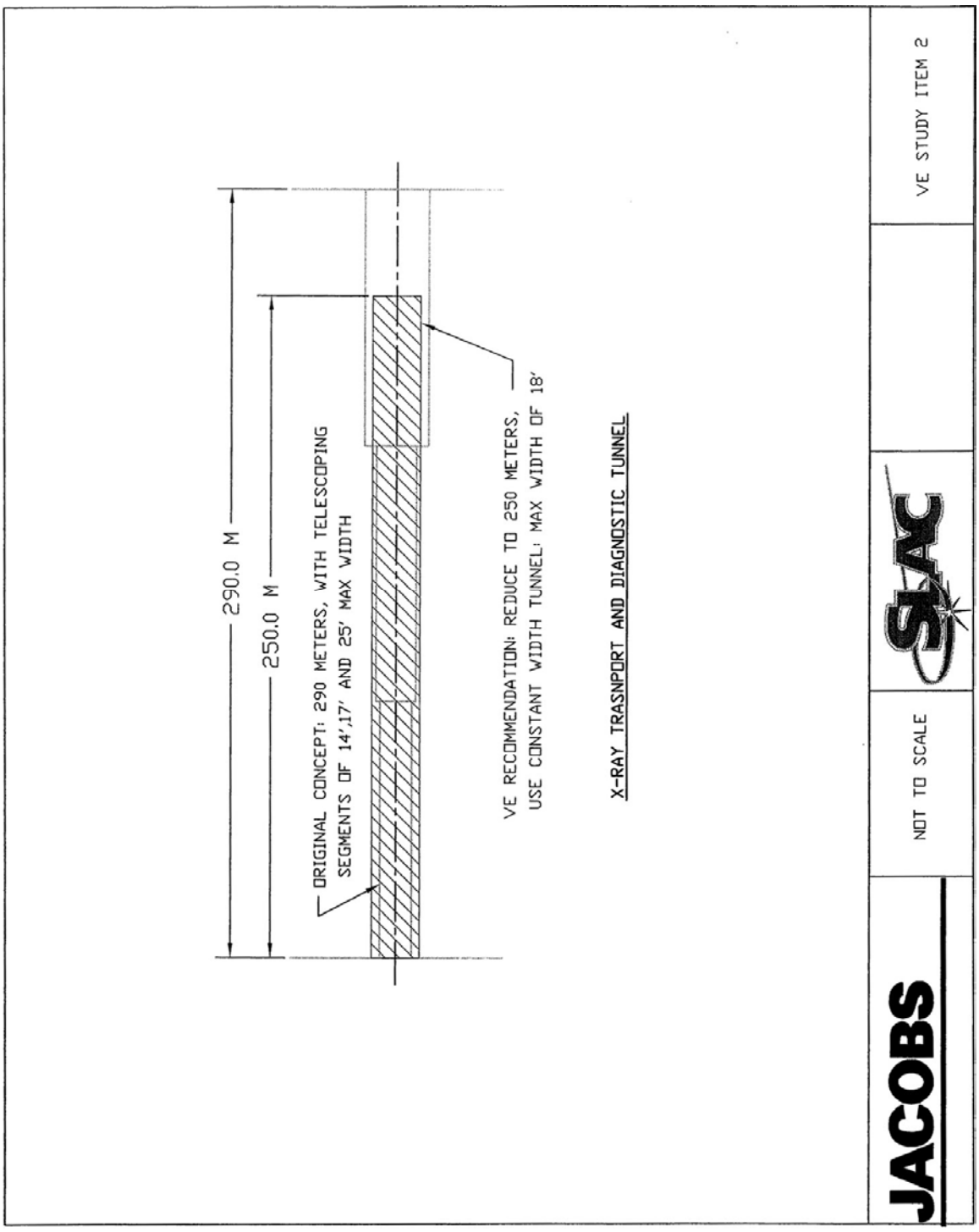
    - Advantages: Eliminates or shortens the elevator shaft
    - Disadvantages: Location increases visibility to the Northeast community. Would add considerable distance between the Hutches and the shops.
    - Estimated Cost Difference from Original Concept: Not Determined.

VE2 Recommendation/Discussion

The VE team selected a combination of Alternatives by combining Alternative 2 with Alternative 4. This modification will reduce the length of the X-ray tunnel and use a constant oval shape tunnel with a constant maximum width of 18 feet.

During the evaluation of Alternatives another potential alternative was discussed. This alternative would use micro-tunnels for the beams and one smaller access tunnel, which travels in the east-west direction and has periodic alcoves for maintenance and construction access. However, the VE team then decided this potential alternative would be too difficult for future maintenance, potential problems with leakage and most likely would not result in any cost savings. (See VE Study Item 9 & 11 for additional Studies on the FEH)

VE2 Cost Savings: $900,000



VE SKETCH OF RECOMMENDED CONCEPT

Stanford Linear Accelerator Center
Head House
VE STUDY ITEM 2: XTD TUNNEL/ACCESS TUNNEL/FEH

ESTIMATED COST SAVINGS

	CSI Category			Building Total
		Total	Cost/LF	Total
1	Reduce length from 290 to 250 meters, (132 lf)	132	$6,433.00	$ 849,156.00
2	Optimize tunnel cross section, 18' avg.			$ 70,000.00
3				
4				
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13				
14				
15				
16				
Total Construction Cost				$ 919,156
ORIGINAL CONCEPT				
VE 2 ESTIMATED COST SAVINGS				$ 919,156

VE COST ESTIMATE OF RECOMMENDED CONCEPT

VE Study Item 3:
Near Experimental Hall (NEH)

The function of the Near Experimental Hall is to house three experimental hutches and the prep areas. A variety of experiments with the high energy X-ray beam will be performed in the hutches.

It was determined during the discussion of this study item that the NEH is very closely related to the Central Lab Office Building (FEL Center), which is to sit directly above. The present and future +2-degree beam lines fix the footprint of the lower Hutch area. Reductions in this area could affect future experiments. No cost saving was recognized at this time.

VE3 Recommendation
No alternatives developed or VE recommendations at this time.

VE3 Cost Savings: $0.0M

VE Study Item 4:
Undulator Hall (UH) Tunnel/Alcoves

The Undulator Hall (UH) connects to the end of the Beam Transport Hall and contains magnets and ancillary equipment for use on the electron beam before it enters the Front End Enclosure (FEE) and Beam Dump. The Undulator Hall will include a monolithic floor to limit the impacts of vibration. Alcoves will be used to house the mechanical equipment and cable trays. The Undulator Hall will be located underground just east of the Research Yard.

VE4 Alternatives

The following Alternatives were developed for this VE Study Item:

1. *Original Concept:* 547-foot tunnel, with a 14'-8" horseshoe shape tunnel, which will house the electron beam, and 10 Alcoves spaced evenly along the tunnel, which alternate sides. The Alcoves are currently designed to be 15'-0" x 14'-8" underground rooms abutting the side of the tunnel.

2. *Symmetrical Bubble Alcoves*: Widen Tunnel width and increase height at periodic segments for additional space. This will eliminate the need for separate alcoves to be constructed.

3. *Taper Tunnel Section*: Provide additional space periodically in the tunnel by tapering in and out of wider sections, leaving the height constant. This will eliminate the need for separate alcoves to be constructed and will be easier to construct. However, each side may be only limited to an additional 5-feet on each side, which may not be enough for the mechanical requirements and cable trays.

4. *Increase Tunnel Cross Section*: Increase tunnel size to a uniform size to accommodate items in Alcove.

5. *Reduce the number of alcoves*: Investigate consolidating Alcoves to reduce the number of additional boring locations. The stringent temperature control requirements of the tunnel must be considered for this alternative.

6. *Bore Alcoves from surface*: Bore from surface above into tunnel to allow for HVAC equipment to be above tunnel. Buildings will be required to house the units above ground. However, the stringent temperature control requirements of the tunnel must be considered for this alternative.

VE4 Recommendation/Discussion

The VE team recognizes there is a cost savings in this item, however at this time the design is very dependent upon the Mechanical/Electrical needs for the HVAC and an alternative has not been selected. Steve Hill, the Jacobs Project Manager, recognized that the design could be modified to reduce the costs by at least $200,000.

The VE team would also like to ensure that the Undulator Hall is painted white inside to increase the visibility inside when performing maintenance. Paint type should be specified so peeling is not an issue. Currently the Linac uses an epoxy type of paint. Design team to include epoxy paint for the inside of the Undulator Hall Tunnel in the future cost estimates.

VE4 Cost Savings: $200,000

VE Study Item 5:
Service Buildings

There will be a total of six (6) service buildings on the site to house the control equipment for the tunnel and to contain most of the HVAC, mechanical, and electrical equipment to support the facility. All buildings will be constructed above ground.

VE5 Alternatives

The Service Building concepts have not been developed at this design stage to a level for the VE team to investigate alternatives. Therefore, no alternatives have been developed for this study item. This Study Item should be re-evaluated once the Service Building design has been further developed.

VE5 Recommendation:
No alternatives developed or VE recommendations at this time.

VE5 Savings: $0.0M

VE Study Item 6:
Headwall

The function of the headwall is to retain the soil by providing a retaining wall and tunnel portal into the existing hillside. The Headwall is located at the end of the BTH.

VE6 Alternatives

1. *Original Concept*: The headwall length currently supports a beam range from +2 degree to –4 degrees.

    - Advantages: Allows for future expansion without major construction of an additional Headwall or expansion of the existing headwall.
    - Disadvantages: Adds cost to current design.

2. *Reduce Size*: Reduce the size to accommodate only the two 0-degree beams.

    - Advantages: Allows for present beam alignment.
    - Disadvantages: Disrupts operations due to construction of new headwall if needed for expansion. Potential higher cost for wall extension in future.
    - Estimated Cost Difference from Original Concept: -$100,000

VE6 Recommendation

Due to uncertainty of the future alignments that may be used, the VE team decided upon Alternative 2, reducing the headwall to just accommodate the two 0-degree beams for now. If future beam lines are developed, then the wall will be extended at that time.

VE6 Cost Savings: $100,000

VE Study Item 7:
Front End Enclosure (FEE)

The function of the Front End Enclosure (FEE) is to provide a structure in which the electron beam and the X-ray beams are separated. The electron beam will curve down into the beam dump, and the x-ray travels forward into the NEH. The FEE is an underground facility and is located between the Beam Dump and the NEH.

Original Concept of the FEE is an underground facility, which houses the varied optics and electron beam separation components. The FEE is to be located immediately downstream of the Undulator Hall. The current design indicates a building length of 40-meters.

VE7 Alternatives

1. *Original Concept*: A building length of 40 meters with a rectangular shaped tunnel.

2. *Reduce length of Tunnel*: Modify access tunnel to reduce passageway length by approximately 8 meters to the tunnel.

VE7 Recommendation

The VE team recommended that Alternative 2 be further investigated to provide a tunnel layout that reduces the length. However, after further discussions with the VE team concerning the radiological considerations in the tunnel, no additional savings were recognized.

VE7 Cost Savings: $0.0M

VE Study Item 8:
Service Road

The function of the Service Road is to provide access to both sides of the facility, and to also satisfy the fire access requirements. The current design indicates a 26-foot wide roadway, which will travel over the hillside providing access to each side of the Research Yard.

VE8 Alternatives/Discussion

After several discussions about the service road and the PEP Ring Road, the VE team decided that it would require more data on the traffic counts of the proposed new roadway before making a decision on changes to the layout. The general feeling from the VE team is that the traffic should not increase on the new roadway over the current amount present on the existing service road. A new roadway from PEP Ring road to the new FEH Office building may be needed in the future. If the office remains in its present location, a $500,000 add may occur, due to the impacts to the PEP Ring Road.

Future consideration should be made to combine the PEP Ring Road improvements with the Service Road. The Design team should further investigate realigning and combining roads, to provide the same function and access while reducing the amount of new road surface. However, after further discussion it was decided that PEP Ring road should remain as is and an additional road over the hill will not be needed.

The VE team suggested that vibrations from traffic could be a concern over the FEE, and this should be considered during any future design.

VE8 Recommendation

The Design team is to provide a vibration analysis to the client, and there will be an internal SLAC meeting to discuss.

VE8 Cost Savings: $0.0M

VE Study Item 9:
Far Experimental Hall

The function of the Far Experimental Hall (FEH) is for space to perform additional experiments. The FEH is located underground and at the end of the XTD Tunnel and will include control areas and prep areas needed in the experiments. An access tunnel will be constructed to provide access to the FEH from the Building #750, and is also required for fire and health safety issues.

VE9 Alternatives

1. *Original Concept:* Above Ground Building, with elevator and stair access to caverns and a 14-foot wide access tunnel to NE Corner of Building #750.

    - Advantages: Staff offices located above ground with easy access from parking lot.
    - Disadvantages: Elevator and stair shaft required for underground caverns.

2. *Eliminate Building and use existing space*: Eliminate the proposed building (above ground) along with elevator shaft/stairwell that is proposed for the FEH. Use space inside the existing Building #750 for the required FEH space. SLAC ACTION required for obtaining office space.

    - Advantages: No additional building space needed to be constructed
    - Disadvantages: Shops located further away from work area. Use of the existing facility is questionable.
    - Estimated Cost: Difference from Original Concept: $2,500,000

3. *Construct building in new excavated space east of Building #750*: Excavate into hillside approximately 75' (from face of Building #750) and approximately 200' long and construct a new 3-story building. The New Building will have 5,000 SF on floors 1 and 2 and 1,200 SF for mechanical space on floor 3. Building will be constructed against the new retaining wall. Wall will be approximately 15-feet high with the slope cut back at 2:1. Access tunnel will have total length of 200' and will now daylight earlier from a portal in the new retaining wall (reduction of 280' of tunnel). Eliminate above ground building, elevator/stairs, plus one mechanical service building that was needed for FEH. See notes 1 and 2 below.

    - Advantages: Need for an elevator and stair shaft is eliminated.
    - Disadvantages: Major cut in existing hillside required. The offices and shops will be located a long distance from work area.
    - Estimated Cost Difference from Original Concept: -$1,200,000

4. *Relocate Office Space to Wider Access Tunnel*: Relocate office space in the access tunnel to a slightly wider tunnel. Expand access tunnel width to 17' for entire length of 200-foot tunnel (previous VE Study Item reduces length of tunnel). Allowing a 7-foot walkway and 10-wide offices in tunnel. Tunnel floor should be level for office spaces, provides 2000 SF. This does not meet office space requirements.

- Advantages: Offices located close to work space
- Disadvantages: Space reduced to construct adequate offices and shops; reduction in program required due to only 2,000 SF available compared to 4,000 SF requested.
- Estimated Cost Difference from Original Concept: Not Determined

5. *Extend cavern (one) to the north for added office space*: Extend one 30-foot wide cavern 112-feet, to the north for office space. This will house a two story facility with the lower level used for shops and the top level used for office space. Approximately 4,000 SF. Above service building is relocated.

    - Advantages: Cavern provides for a future +2 degree beam line. Keeps offices and shop close to the work areas, and eliminates need for elevator and stair shaft.
    - Disadvantages: If the cavern is needed for a future beam line, the offices and shops will need to be moved. Not as desirable to workers to be underground for long periods of time.
    - Estimated Cost: Difference from Original Concept: -$1,130,000

Notes for the above Alternatives:

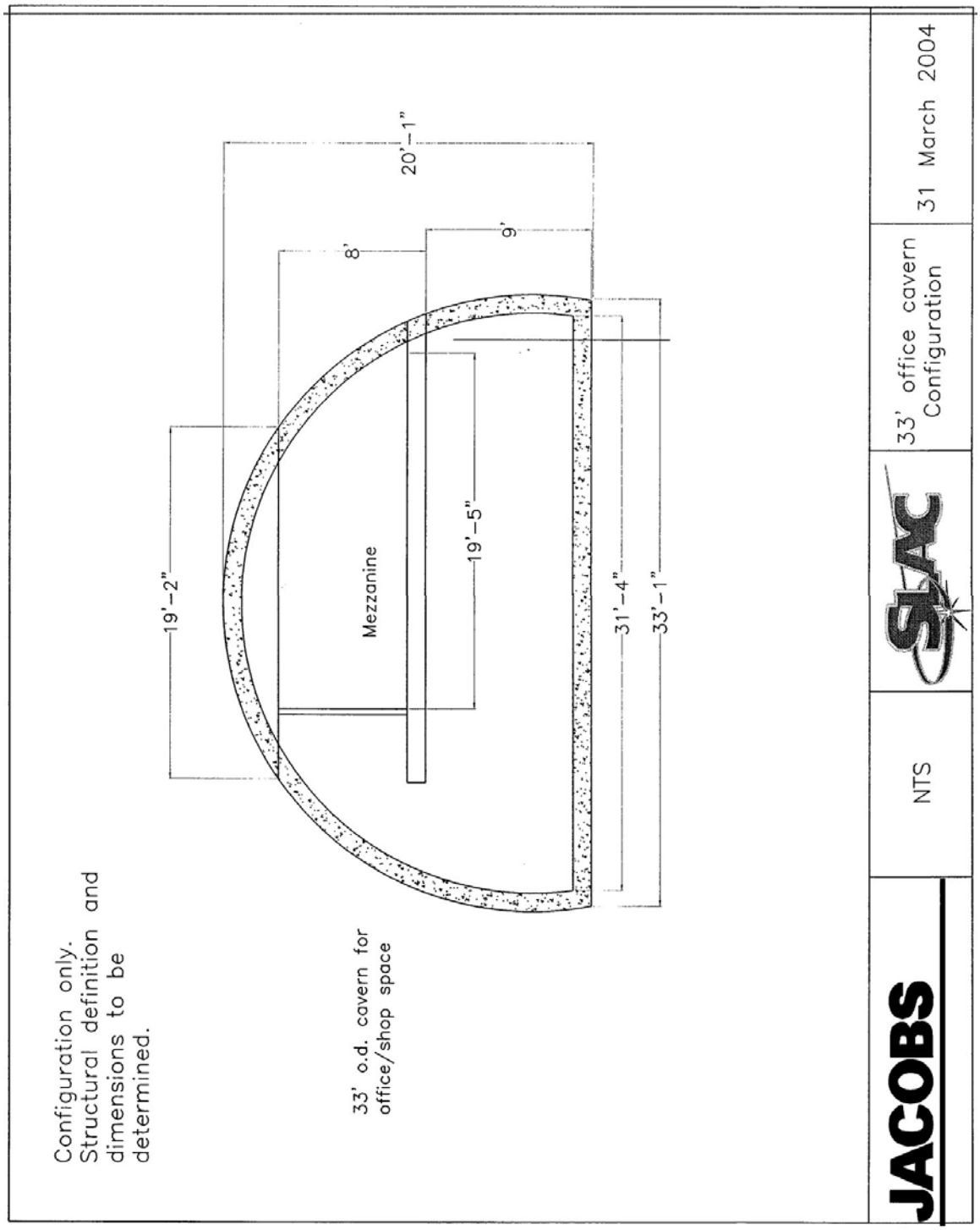
1. Increased cost for HVAC for options 3,4,5
2. Every alternative that eliminates elevator (3,4,5) ads 70-feet of access tunnel on south side of cavern.

VE9 Recommendation

The VE team recommends Alternative 5, extending the cavern closer to the PEP Ring Road, 112-feet to add labs and mezzanine offices. The interior design of this cavern should be very sensitive to the acoustics, lighting, temperature, and additional comforts for occupants working underground.

With the above grade office and shop facility being relocated, a service road will not be required, avoiding an additional cost of $500,000.

VE9 Cost Savings: $1,130,000 (VE9 Cost Avoidance $500,000)



VE SKETCH OF RECOMMENDED CONCEPT

Stanford Linear Accelerator Center
Head House
VE STUDY ITEM 9: FAR EXPERIMENTAL OFFICES

ESTIMATED COST SAVINGS

	CSI Category			Building Total
		Total	Cost/LF	Total
1	Add Cavern 30' x 112'			896,000
2	Add two story space, lower level shops, upper level offices, 4,000 sf			945,000
3	Use Access Tunnel to route utilities			30,000
4	Cut, access driveway at Mechanical Room			104,000
5	Shorten Access Tunnel			(902,400)
6	Add Emergency Tunnel (70 lf)			245,000
7	Delete Support Staff Building			(1,014,280)
8	Delete Elevator/Stairs			(1,436,202)
9				
10				
11				
12				
13				
14				
15				
16				
Total Construction Cost				**$ (1,132,882)**
ORIGINAL CONCEPT				
VE 9 ESTIMATED COST SAVINGS				**$ 1,132,882**

VE COST ESTIMATE OF RECOMMENDED CONCEPT

VE Study Item 10
Research Yard Modifications

The Research Yard Modifications are required to construct the Headhouse and Beam Transfer Hall and Headwall for the X-Ray Tunnel. These modifications will require improvements to roadways, parking, underground utilities, drainage systems and earthwork necessary for the LCLS.

VE10 Recommendation/Discussion

The VE team had several discussions during the VE study concerning the work items related to the Research Yard Modifications. The VE team felt that the current estimated amount of $2,000,000 (before contingencies) was a bit high for the anticipated work involved for the improvements.

The VE team decided that this VE Study Item would need further examination at the next design level; however, the current estimate should still be reduced by $500,000. (This amount should be shifted into the contingencies column for this item).

VE Cost Savings: $500,000

VE Study Item 11
Far Experimental Hall Build-Out

The Far Experimental Hall is a cavern built out for three underground hutches. The VE team evaluated the cost estimate for this item and determined that the preliminary costing for this item seemed very high. After some discussion with the VE team a refinement to the cost per square foot was recommended, which resulted in a $1M reduction of the initial cost.

VE11 Cost Savings: $1,000,00067

VE Study Item Cost Savings Summary

VE Study Item	Description	Cost Savings
1	Headhouse/Beam Transport Hall (BTH) Tunnel	
	a) Shorten Headhouse	$ 1,200,000
	b) No demolition of Bldg 113	$ 100,000
2	XTD Tunnel/Access Tunnel	
	a) Reduced Length	$ 660,000
	b) Cross Section constant 18' wide	$ 240,000
3	Near Experimental Hall	$ -
4	Undulator Hall Tunnel/Alcoves	$ 200,000
5	Service Buildings	$ -
6	Headwall	$ 100,000
7	Front End Enclosure	$ -
8	Service Roads	$ -
9	Far Experimental Hall	$ 1,130,000
10	Research Yard Modifications	$ 500,000
11	FEH Build out	$ 1,000,000

Total VE Cost Savings	**$ 5,130,000**

Note that contingency multipliers have not been factored into cost savings.

Total VE Cost Avoidance	**$ 500,000**

Appendices

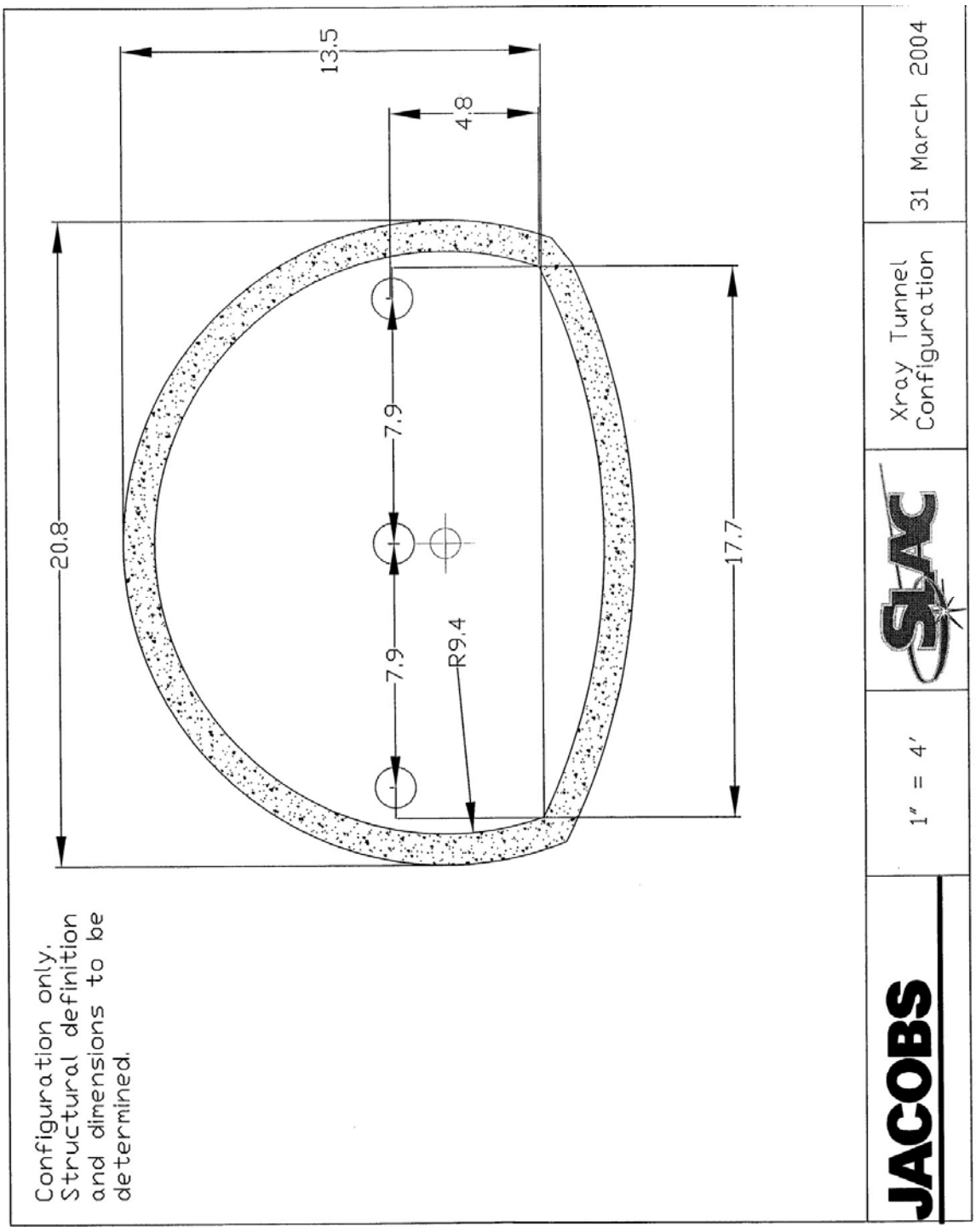
A. Value Engineering Participants
B. Tunnel Configurations

Value Engineering Participants
LCLS VE Study
March 30 & 31, 2004

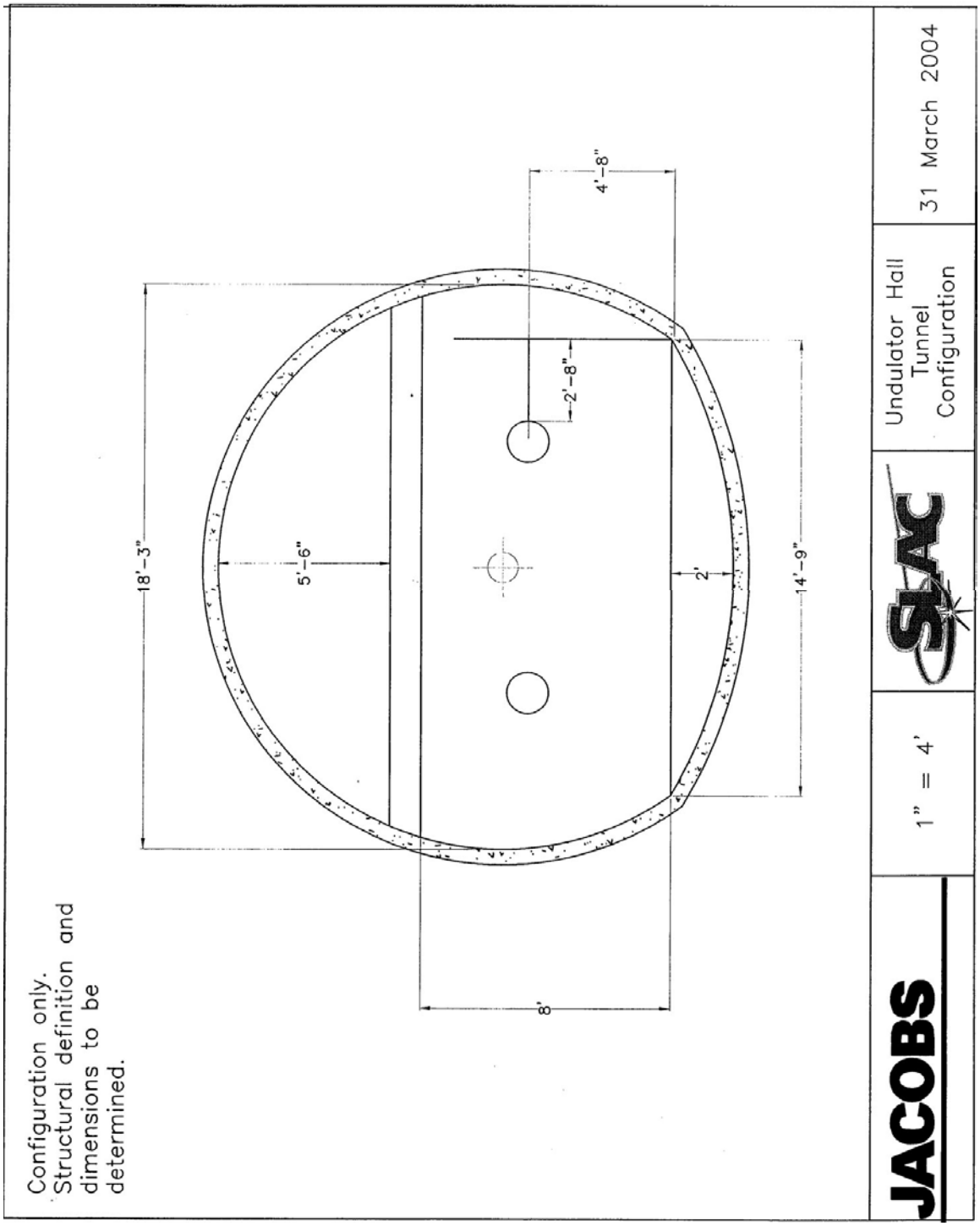
Name	Company/Org.	Phone	Email
Bill Hickey	Jacobs	425.452.8000	william.hickey@jacobs.com
Steve Hill	Jacobs	714.503.3524	steve.hill@jacobs.com
Ron Drake	Jacobs	805.473.8006	ron.drake@jacobs.com
Mo Siddiqi	Jacobs	312.612.6025	mohummad.siddiqi@jacobs.com
Mike Mills	Jacobs	714.503.3534	michael.mills@jacobs.com
Phillip Mcollough	Jacobs	925.256.7500	phillip.mcollough@jacobs.com
John Galayda	SLAC	650.926.2371	galayda@slac.stanford.edu
Mark Reichanadter	SLAC	650.926.8583	reich@slac.stanford.edu
David Saenz	SLAC	650.926.2512	saenzd@slac.stanford.edu
Jim Welch	SLAC	650.926.3165	welch@slac.stanford.edu
Rick Challman	SLAC	650.926.3004	challman@slac.stanford.edu
Brad Youngman	SLAC	650.926.3627	youngman@slac.stanford.edu
Jerry Hastings	SLAC	650.926.3107	jbh@slac.stanford.edu
John Arthur	SLAC	650.926.3169	jarthur@slac.stanford.edu
Eric Bong	SLAC	650.926.3457	bong@slac.stanford.edu
Frank Brenkus	SLAC	650.926.2038	brenkus@slac.stanford.edu
Hanley Lee	DOE	650.926.3207	hanley.lee@sso.science.doe.gov
Richard Bionta	LLNL	925.423.4846	bionta1@llnl.gov

Tunnel Configurations

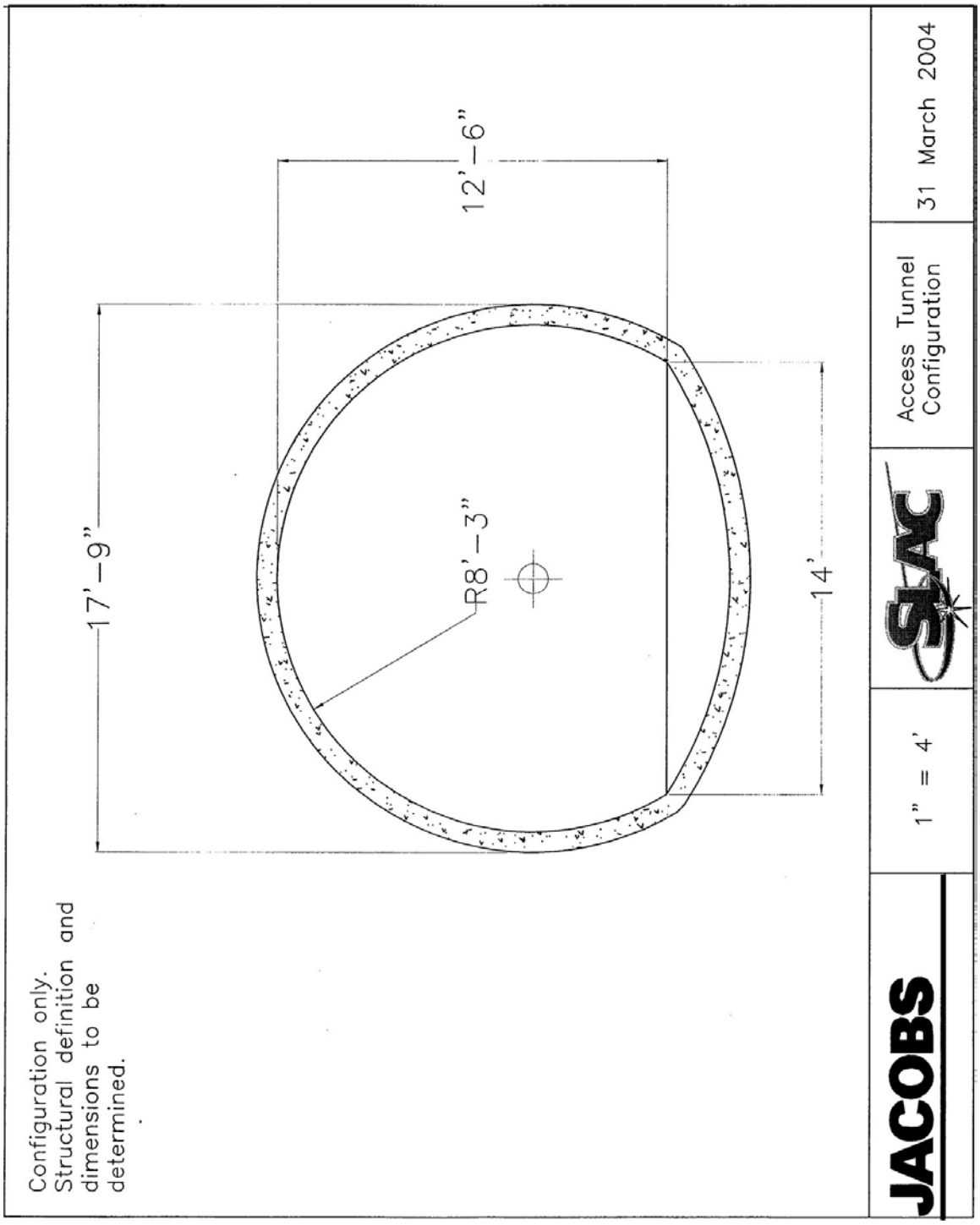
During the VE Study several discussions took place concerning the tunnel layouts for the various components of the LCLS. The VE team has provided the following sketches for the X-Ray Tunnel, Undulator Hall Tunnel and Access Tunnel, per input during the Study.



X-RAY TUNNEL CONFIGURATION



UNDULATOR HALL TUNNEL CONFIGURATION



ACCESS TUNNEL CONFIGURATION