

Report on the

**PROPOSED STANFORD TWO-MILE
LINEAR ELECTRON ACCELERATOR
AT SAND HILL SITE
ON STANFORD UNIVERSITY LANDS**

including:

**SITE FEASIBILITY
EARTHQUAKE RISK
COST ESTIMATES**

VOLUME IV

Prepared for

**THE UNITED STATES ATOMIC ENERGY COMMISSION
SAN FRANCISCO OPERATIONS OFFICE**

By

**JOHN A. BLUME & ASSOCIATES, ENGINEERS
SAN FRANCISCO, CALIFORNIA**

December 1960

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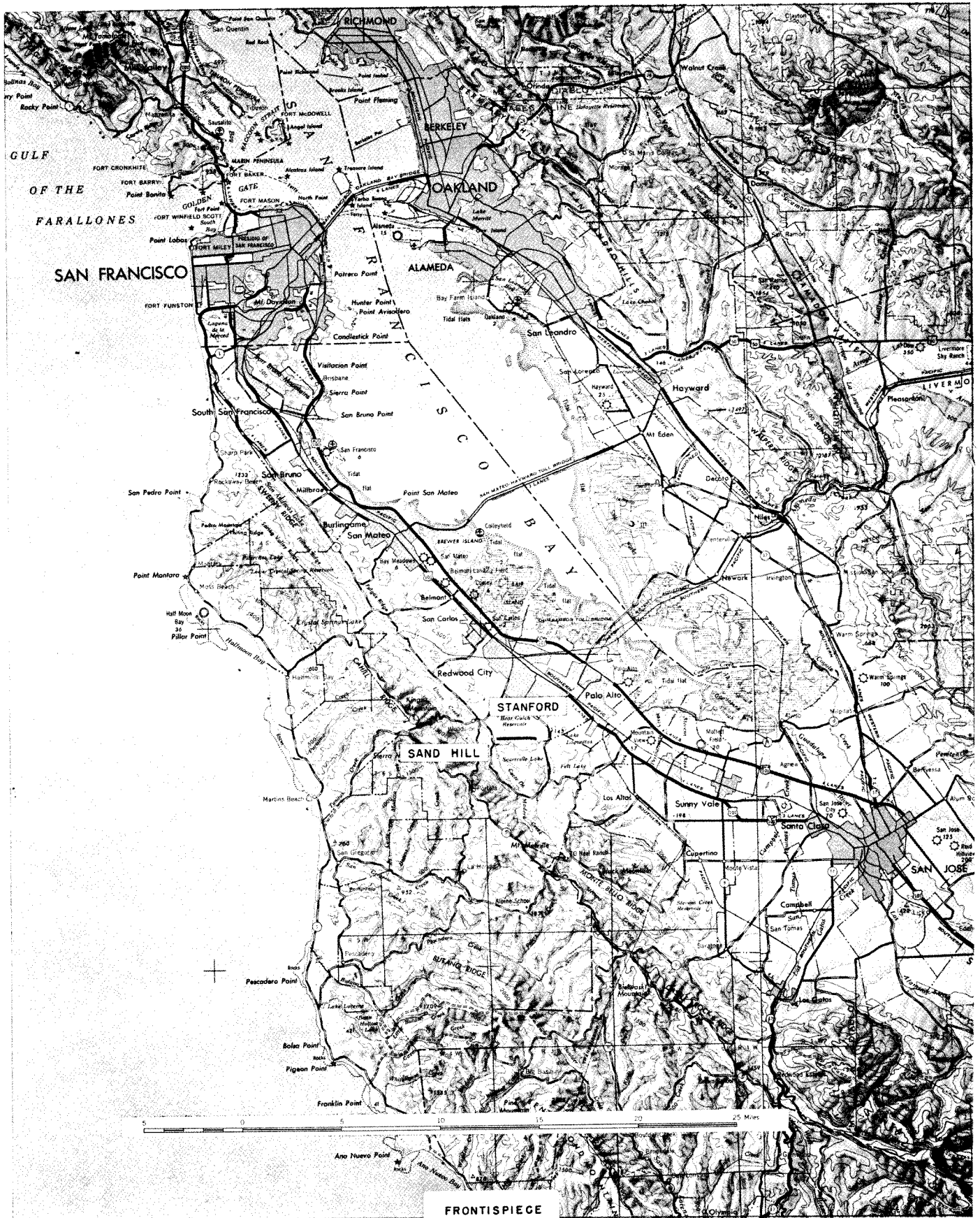
Cost Estimates

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December 12, 1960

Mr. E. C. Shute, Manager
San Francisco Operations Office
United States Atomic Energy Commission
2111 Bancroft Way
Berkeley 4, California

ATTENTION: Mr. J. E. Armstrong, Director
Engineering Division

SUBJECT: Contract No. AT(04-3)-323
Report on Proposed Stanford
Two-Mile Linear Electron
Accelerator

Dear Mr. Shute:

We are submitting herewith Volume IV of our report on the investigation and analysis of the proposed Stanford Two-Mile Linear Electron Accelerator project at the Sand Hill Site on Stanford University lands. Our report presents the results of a detailed site investigation; a comparative evaluation of two possible locations for the end station area including cost estimates and relative seismic risk; and an updating of project cost estimates to reflect the findings of our investigation, the effect of the passage of time since previous estimates, and recent developments in accelerator criteria.

Volumes I, II and III of our report, submitted in January 1960, presented results of investigations of the proposed accelerator facility at alternate sites.

A summary of principal results and conclusions from all volumes of the report is presented on pages XVIII-1 to XVIII-4 of Volume IV.

Very truly yours,


JOHN A. BLUME


ROLAND L. SHARPE

VOLUME IV

REPORT ON THE PROPOSED STANFORD
TWO-MILE LINEAR ELECTRON ACCELERATOR

TABLE OF CONTENTS

(Section numbers continued from Vol. III)

<u>Section</u>		<u>Page</u>
	Frontispiece	
	Letter of Transmittal	
XVIII	Summary of Results and Conclusions	XVIII-1
XIX	Introduction	
	General	XIX-1
	Basis for Estimate	XIX-2
	Acknowledgements	XIX-3
	Definition of Terms	XIX-4
	Presentation of Report	XIX-5
XX	Factors Considered	
	Scope of Report	XX-1
	Procedures Followed	XX-1
	General Site Considerations	XX-2
	State Highway	XX-3
	San Francisquito Creek Flood Control Project	XX-3
	Earthquake Risk	XX-7
	Sources of Data	XX-10
XXI	General Project Requirements	
	Functional Requirements	XXI-1
	Principal Machine Parameters	XXI-2
	Structural Requirements	XXI-3
	Earthwork	XXI-7
	Buildings and Utility Areas	XXI-8
	Shielding	XXI-10
	Water Supply	XXI-11
	Electrical Distribution	XXI-13
	Mechanical Systems	XXI-15
	Safety Provisions	XXI-22
	Landscaping	XXI-23

TABLE OF CONTENTS (continued)

<u>Section</u>		<u>Page</u>
XXII	East Sand Hill Site	
	Project Implementation	XXII-1
	Site Characteristics	XXII-2
	Site Adaptation	XXII-2
	Architectural Studies	XXII-4
	Project Cost Estimate	XXII-4
	List of Drawings	XXII-18
XXIII-	West Sand Hill Site	
	Project Implementation	XXIII-1
	Site Adaptation	XXIII-2
	Project Cost Estimate	XXIII-3
	List of Drawings	XXIII-10
XXIV	Comparison of East and West Sand Hill Sites	
	Comparative Costs	XXIV-1
	Relative Seismic Risk	XXIV-3
	Foundation Conditions	XXIV-3
	Flexibility and Adaptability of Site	XXIV-3

LIST OF TABLES

<u>Table</u>		<u>Page</u>
XVIII-1	Comparison of Project Cost Estimates- Stage I Construction	XVIII-2
XXI-1	Principal Machine Parameters	XXI-2
XXI-2	Differential Settlement Tolerances	XXI-4
XXI-3	Description of Buildings and Structures	XXI-9
XXI-4	Electrical Power Requirements	XXI-14
XXII-1	Project Cost Estimate-East Sand Hill Site	XXII-8
XXII-2	Suggested Fiscal Year 1962 Obligations	XXII-13
XXII-3	Obligation and Cost Schedule	XXII-15
XXII-4	Stage II Conversion Cost Estimate Breakdown	XXII-16
XXIII-1	Project Cost Estimate-West Sand Hill Site	XXIII-6
XXIV-1	Comparison of Project Cost Estimates- Stage I Construction	XXIV-2

LIST OF FIGURES

<u>Figure</u>		<u>Facing Page</u>
11	Location Plan - Stanford Sites	XX-1
12	Sand Hill Site - Aerial View	XXII-1
13	Sand Hill Site - Looking Southeast	XXII-2

APPENDICES

- Appendix P - Soils and Geological Investigations for Proposed Linear Electron Accelerator, Sand Hill Site, by Dames & Moore, and Frank W. Atchley.
- Appendix Q - Letter Reports on Sand Hill Linear Accelerator Site, by Perry Byerly and Garniss H. Curtis.
- Appendix R - Letter from U. S. Army Engineer District, San Francisco, Corps of Engineers, Regarding San Francisquito Creek Flood Control Project.
- Appendix S - Letter Report on Effects of Accelerator on Power Company System, by M. D. Horton.
- Appendix T - Revision of Estimate of Stanford Two Mile Linear Accelerator - Stage I Accelerator Construction Cost, by William M. Brobeck & Associates.
- Appendix U - Letter from State of California, Division of Highways, District IV, Regarding Proposed Highway Route 239.
- Appendix V - Summary of Topographic Data Compiled but not Bound in Volume IV.

VOLUME IV

SECTION XVIII

SUMMARY OF RESULTS AND CONCLUSIONS

The preceding Volumes I, II and III of the Blume Report presented results of investigations of the proposed Stanford Two-Mile Linear Electron Accelerator at alternate sites. A cut-and-cover site in the Sand Hill Road area on Stanford University lands was recommended in Volume III.

Volume IV presents the results of a detailed study of the Sand Hill Site and investigations of other aspects of the project. An investigation of the soils and geology of the site was made, including detailed geological mapping, study of ground water conditions, analyses of cut-and-fill slope stability and evaluation of excavation and foundation problems. The work included a comprehensive program of trenching, drilling, core sampling, and soil testing. Detailed results of the subsurface exploration are presented in Appendix P. The completed explorations provide adequate data for final design of the project with recognition that certain foundations might be designed with maximum economy if some additional borings are made at points of heavy loading during the design stage.

Other investigations included a comparative evaluation of two possible end station area locations, one at the east end and one at the west end of the same alignment. The area was mapped in detail at 2 foot contour intervals. Studies were also made of the possible

effects of a proposed flood control project, and a future highway crossing of the accelerator site; relative seismic risk; various water supply and other utility sources; and the effect of passage of time on project costs. In addition, studies were made in conjunction with Stanford University personnel of the possible effects of the accelerator operation on the power company system, shielding criteria, and the effects of recent design developments on the project cost.

TABLE XVIII-1

COMPARISON OF PROJECT COST ESTIMATES -
STAGE I CONSTRUCTION
(costs in thousands of dollars)

	Blume Report		
	Volume III	Volume IV	
	Sand Hill Site	East Sand Hill	West Sand Hill
A. Engineering	\$ 9,538	\$ 10,460	\$ 10,590
B. Land	0	0	0
C. Construction			
1. Improvements to Land	1,666	2,005	2,240
2. Buildings	10,817	9,930	9,930
3. Utilities	14,111	15,265	15,450
4. Accel. & Klystron Housings	10,161	11,020	11,840
5. Accelerator	27,635	30,700	30,700
6. Equipment	8,507	9,960	9,960
D. Provisions for Future Escalation	10,765	9,800	9,990
E. Contingency	<u>14,000</u>	<u>14,860</u>	<u>15,100</u>
	<u>\$ 107,200</u>	<u>\$ 114,000</u>	<u>\$ 115,800</u>

A comparison is made in Table XVIII-1 above, of the resulting project cost estimates of Stage I construction for both the east and west end station locations, with the Volume III project cost estimate for the

Sand Hill Site. The changes in the present estimate over that submitted in Volume III can be attributed largely to three factors: (a) cost increase of \$4,700,000 due to one year delay in project; (b) additional costs caused by recent developments in accelerator criteria \$3,100,000; and (c) a decrease in provisions for future escalation of nearly \$1,000,000 resulting from the slightly advanced construction schedule now contemplated.

Based on the results of our present studies including the cost estimates in Table XVIII-1, we have the following conclusions and recommendations:

- (1) The results of detailed site studies confirm that the Sand Hill Site is the best site available and is suitable for the proposed project.
- (2) The proposed San Francisquito Flood Control Project is compatible with the proposed accelerator alignment. The cost of protective measures is included in the cost estimates.
- (3) The proposed highway crossing of the accelerator is practical in all engineering aspects.
- (4) The site is acceptable on the basis of earthquake risk. Estimated elastic strain accumulation during the life of the project is within acceptable tolerances.
- (5) Utilities such as electrical power, water, natural gas and sanitary sewers are available near the site or can be brought to the site for costs that are included in the estimates.
- (6) The effects of the accelerator on the power company system can be held to acceptable levels.
- (7) Each alignment considered (East Sand Hill Site and West

Sand Hill Site) is acceptable from the standpoint of earthquake risk and other factors. The East Sand Hill Site on the basis of its lower construction cost, less seismic risk, better foundation conditions, more stable earth slopes, and better site adaptability is preferred.

- (8) The project is practical and feasible. On the basis of lowest total cost, least Stage I cost, acceptable earthquake risk and greatest flexibility for future research, the East Sand Hill Site is recommended over all sites considered for the project location. The estimated project cost for Stage I construction on this site is \$114,000,000.

VOLUME IV

SECTION XIX INTRODUCTION

This volume is a supplement to Volume III of the "Report on the Proposed Stanford Two-Mile Linear Electron Accelerator at Alternate Sites" submitted in January 1960; and presents the results of studies made of the proposed accelerator installation at two possible alignments at the Sand Hill Site, located on Stanford lands.

General

The basis for the work was essentially the same as that used in Volume III, modified for developments resulting from recent work done by Stanford personnel and others, as well as some relatively minor changes developed during this engineering investigation. The investigation included the detailed examination of the Sand Hill Site on Stanford lands. Two potential alignments were studied; one with the End Station and support buildings at the eastern end of the site and one with these facilities located at the western end of the site.

The same principal machine parameters as listed in Section XIV, Volume III were followed with only a few modifications (See Section XX in this volume).

The work included mapping of the site at 2-foot contour intervals; extensive soil borings, testing and analysis; geological and seismological studies; a review of the effects of a proposed highway and dam and reservoir; a study of possible utility sources including water supply;

and the updating of project cost estimates. Stanford personnel provided data on the accelerator design and criteria for the shielding, cooling water and electrical power systems.

Basis for Estimate

The cost estimates presented in Volume IV of this report were made by using current prices and wage rates adjusted to assumed July 1961 conditions. An escalation factor of $2\frac{1}{2}$ percent on current prices was assumed for this purpose. All construction required for the initial operation, such as cooling, ventilating, and electrical power facilities, plus the required provisions for later transition to Stage II operation, is included. The accelerator and klystron housing and the cooling and electrical systems are planned so that the transition to the ultimate requirements can be made without serious interruption of operations. All wiring to and including disconnecting means, piping to and including shut-off valves, and building areas required in Stage II are provided in the initial construction. Equipment for ultimate requirements is not provided initially except as needed to permit a smooth change-over.

Two possible alignments of the accelerator were studied at the Sand Hill Site. The major difference between these alignments is in the location of the End Station area. One alignment has the End Station at the eastern end of the site while the other has it at the western end. Cost estimates and drawings are presented for the preferred alignment. Drawings and differences in estimated costs are presented for the other alignment.

The cost estimates and designs were developed only after detailed

contour maps were prepared; extensive soil borings, tests and analyses were made; and further geological and seismological investigations were conducted. Other data such as power line costs, utility sources and connection costs were also studied.

The estimates included herein are predicated on a schedule starting July 1, 1961, and continuing for a period of five years and eight months to completion on February 28, 1967. The total project cost estimate is based on July 1961 prices, plus estimates of escalation of 5 percent per year on the unexpended balance at the end of each year from the first through the fifth years, plus 15 percent contingency on the overall construction cost. If the project is not authorized and operations initiated so that this schedule can be followed, the cost estimates should be increased for additional escalation at a consistent rate of 5 percent per year.

Acknowledgements

The work was conducted for the San Francisco Operations Office, Atomic Energy Commission, under the general supervision of Mr. E. C. Shute, Manager; and Mr. J. E. Armstrong, Director, Engineering Division. Staff members of the W. W. Hansen Laboratories of Physics, Stanford University, were most cooperative and furnished much pertinent information and assistance during the studies. In particular, Dr. E. L. Ginzton, Director of the Microwave Laboratory; Mr. F. V. L. Pindar; Dr. R. B. Neal; and Mr. K. Copenhagen were most helpful.

Several consultants were retained by John A. Blume & Associates, Engineers, to assist in specialized areas of the work. The firm of Dudley Deane & Associates analyzed the heating, ventilating, cooling

water, air conditioning, and electrical power requirements for the proposed facility. The Guy F. Atkinson Company assisted in the preparation of construction cost estimates for the grading and accelerator housing. Charles Luckman Associates provided certain design approach studies for the two End Station Buildings. Drs. Perry Byerly and Garniss Curtis made an analysis of the site for relative earthquake hazards. Dames & Moore, Soils Mechanics Engineers, tested soil samples and made an analysis of soil conditions and Dr. Atchley made a detailed geological survey. William M. Brobeck & Associates made a brief review of recent developments in the design of the accelerator and of Stage II conversion costs of the accelerator proper. Mr. M. D. Horton of the General Electric Company reviewed the possible effects of the accelerator on the Pacific Gas and Electric Company power system. Included in his review were electric model tests and analyses made by Stanford personnel.

The Pacific Gas and Electric Company made a brief study of power line and natural gas connection costs for the project. The Menlo Park Sanitary District was consulted regarding sanitary sewer costs. The San Francisco Water Department furnished data on water supply.

The U. S. Army Engineer District, San Francisco, Corps of Engineers cooperated in evaluating the compatibility of the accelerator and the proposed San Francisquito Creek Flood Control Project. Officials of District IV, Division of Highways, State of California, cooperated in a review of the effects of a crossing of a proposed state highway and the accelerator alignment. Officials of San Mateo County, the City of Menlo

Park, and the Santa Clara County Flood Control and Water Conservation District were also most helpful.

Definition of Terms

The following list of terms are used in the accompanying text and supplement the list on Page II-7, Volume I of the initial report.

Blume Report refers to the three volumes of the initial report. East Sand Hill Site refers to the proposed alignment on Stanford lands that runs more or less parallel and adjacent to Sand Hill Road with the End Station area at the eastern end of the site. West Sand Hill Site refers to the proposed alignment adjacent to Sand Hill Road with the End Station area at the western end of the site. Accelerator housing and klystron housing refer respectively to the structures in which the accelerator tube and klystron cubicles are housed.

Presentation of Report

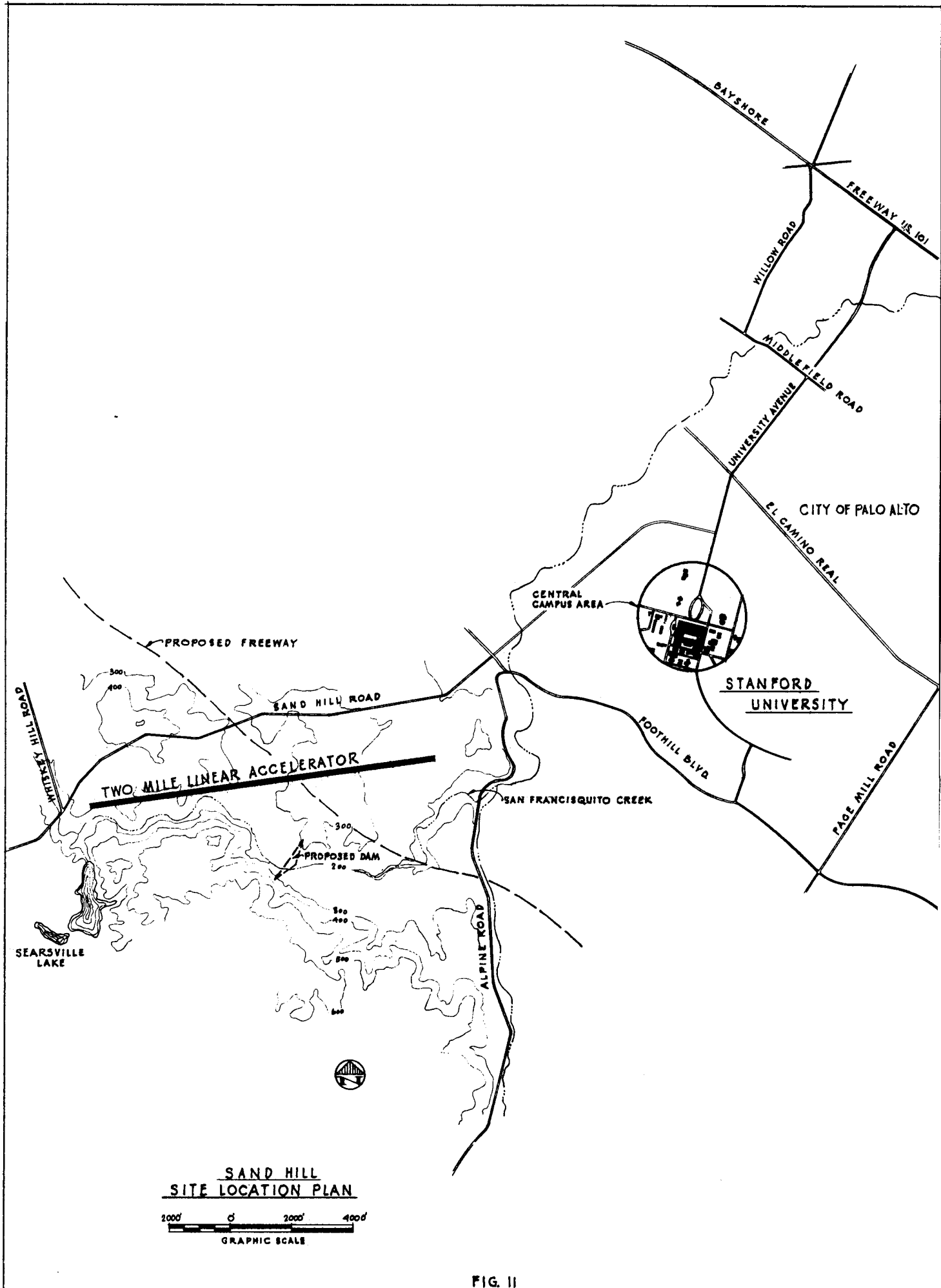
The present report is a supplement to the initial three-volume report. Volume I presented the results of the investigations and cost estimates for the Stanford Tunnel Site, Moffett Field Site and Coyote Hills Site. Volume II contained reports of consultants and letters from the Pacific Gas and Electric Company. Volume III presented the results of feasibility studies of two potential cut-and-cover sites on Stanford lands.

The supplementary report contained in this volume is presented in several sections. Section numbers are continued from the initial report. The Summary of Conclusions and the Introduction are therefore Sections XVIII and XIX. Section XX presents discussions of the scope

of the work, procedures followed, general site considerations, earthquake risk, and sources of data used for the work. Section XXI presents project requirements for the two Sand Hill alignments, including functional requirements, structural requirements, building and utility areas, criteria for the electrical and mechanical systems, and safety provisions.

Sections XXII and XXIII present detailed discussions of the two Sand Hill alignments including cost estimates and drawings. Section XXIV is a comparative discussion of the two alignments investigated.

This volume of the report concludes with Appendices P through V which include reports on soil conditions, geology, and relative seismic risk; a brief review of recent accelerator developments; letters regarding the compatibility of the accelerator with a proposed flood control project and a proposed highway through the site, a letter report regarding the effect of the accelerator on the power company system, and a summary of data compiled as part of this investigation but not bound in this volume.



SAND HILL
SITE LOCATION PLAN



FIG. 11

VOLUME IV

SECTION XX

FACTORS CONSIDERED

Scope of Report

The scope of this volume of the report is outlined in a modification to Contract No. AT(04-3)-323 with the United States Atomic Energy Commission. The work includes making a detailed soils and geological study; complete topographic mapping of the site; establishing a first order triangulation net; second order vertical control; investigation of the effect on the accelerator of the proposed flood control project for San Francisquito Creek; investigation of the effect of the proposed State highway crossing of the accelerator; further studies of the effect of the electrical characteristics of the DC power supplies on the Pacific Gas and Electric Company power system; reviewing and updating all cost estimates to include the effect of recent developments; a review of sources of water supply; a review of shielding requirements; and a limited study of architectural treatments of the two End Station Buildings.

Procedures Followed

The design requirements and operating specifications as listed in Volume III - Blume Report were used with some modifications made by Stanford representatives for the detailed study of the Stanford Sand Hill Site. The number of sectors was changed from forty 250-foot sectors to thirty 333-1/3 foot sectors. The electrical and mechanical systems were revised accordingly. Further developments in the End Station requirements were evaluated.

Concurrently with the review of the design, two potential alignments were analyzed for comparative construction costs, physical features adaptable to the facility, earthquake risk, foundation conditions, and geological characteristics. The two alignments considered are essentially the same except for location of the End Station areas.

Operating and space requirements for the klystron housing consistent with recent developments in klystron cubicle designs were determined in cooperation with Stanford personnel. The requirements for the accelerator proper were modified in several relatively minor respects from those noted in Volume I - Blume Report. These changes are discussed in Appendix T. Schematic designs and layouts of the facility site were then made with the End Station area at each end of the site and cost estimates prepared. Drawings and estimates are included with discussions of each alignment in Sections XXII and XXIII of this report.

General Site Considerations

The Sand Hill cut-and-cover site is located in the foothills just west of Stanford University. The lands under consideration are entirely owned by the University and are presently undeveloped. Existing centers of population along the east end of the site are expanding into land areas adjacent to the site and the effects of this development of adjoining lands on the project have been considered.

Other proposed developments in the Sand Hills area include a proposed state highway and a flood control project on San Francisquito Creek. The scope of this study included consideration of the effect of these developments on the accelerator project.