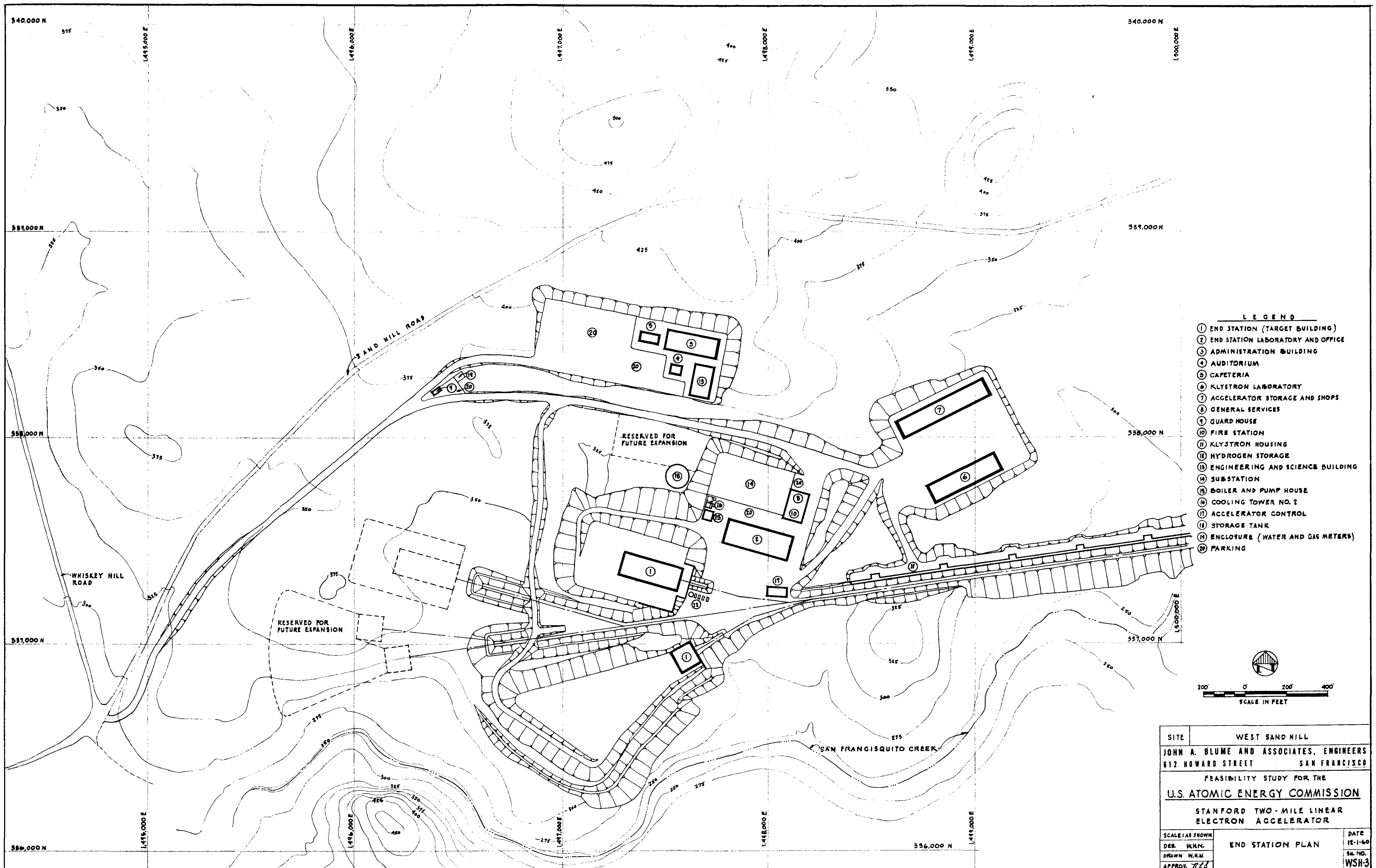
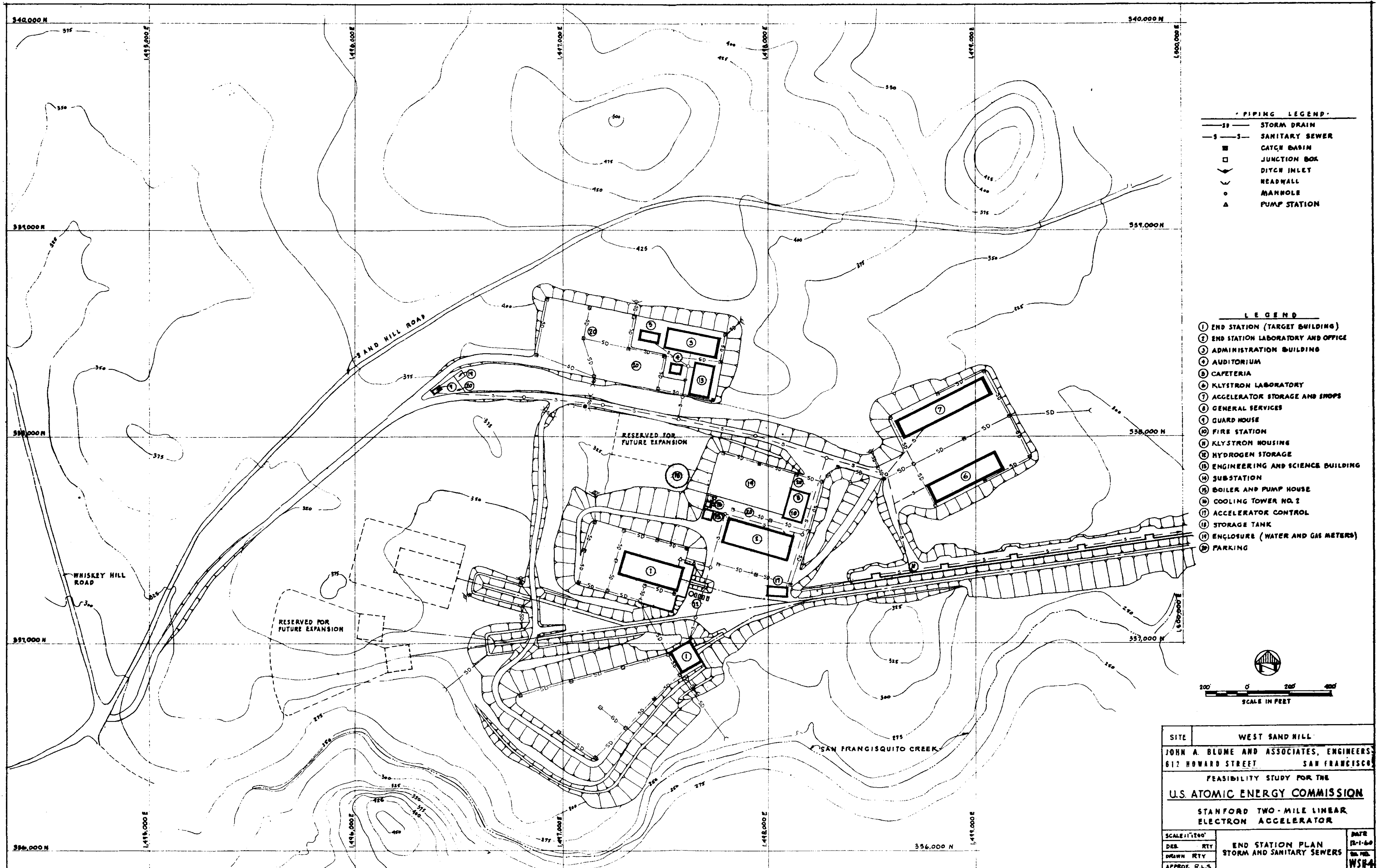
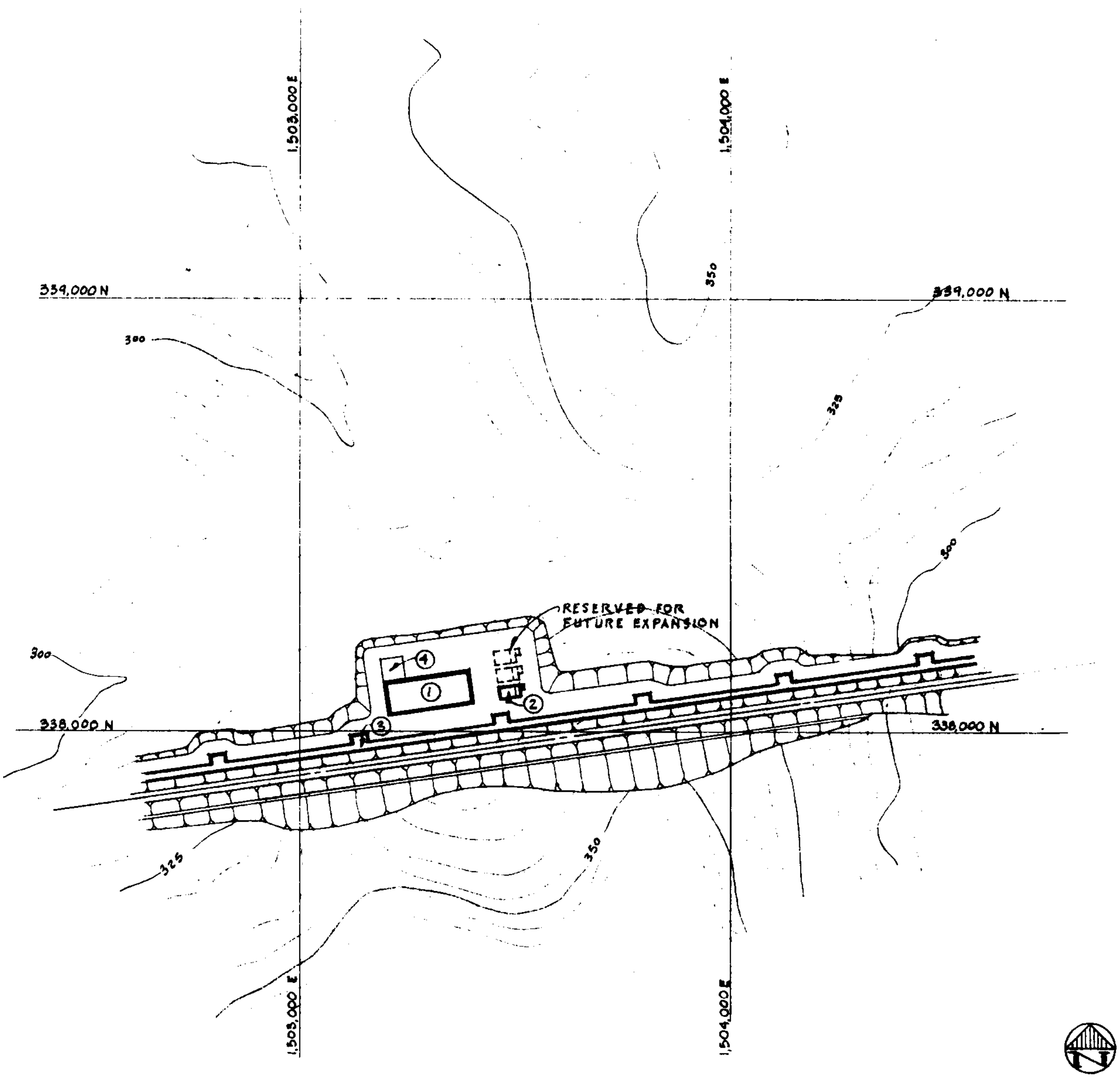

LEGEND
1 END STATION (TARGET BUILDING)
2 END STATION LABORATORY AND OFFICE
3 ADMINISTRATION BUILDING
4 AUDITORIUM
5 CAFETERIA
6 KLYSTRON LABORATORY
7 ACCELERATOR STORAGE AND SHOPS
8 GENERAL SERVICES
9 GUARD HOUSE
10 FIRE STATION
11 KLYSTRON HOUSING
12 HYDROGEN STORAGE
13 ENGINEERING AND SCIENCE BUILDING
14 SUBSTATION
15 BOILER AND PUMP HOUSE
16 COOLING TOWER NO. 2
17 ACCELERATOR CONTROL
18 STORAGE TANK
19 ENCLOSURE (WATER AND GAS METERS)
20 PARKING
SAND HILL ROAD
WHISKEY HILL ROAD
RESERVED FOR FUTURE EXPANSION
RESERVED FOR FUTURE EXPANSION
SAN FRANCISQUITO CREEK
SCALE IN FEET
SITE
WEST SAND HILL
JOHN A. BLUME AND ASSOCIATES, ENGINEERS
612 HOWARD STREET SAN FRANCISCO
FEASIBILITY STUDY FOR THE
U.S. ATOMIC ENERGY COMMISSION
STANFORD TWO-MILE LINEAR
ELECTRON ACCELERATOR
SCALE: AS SHOWN
DES. W.H.N.
DRAWN W.H.N.
APPROV.
END STATION PLAN
DATE 12-1-60
SH. NO. WSH-3


PIPING LEGEND
SD STORM DRAIN
S SANITARY SEWER
CATCH BASIN
JUNCTION BOX
DITCH INLET
HEADWALL
MANHOLE
PUMP STATION
LEGEND
1 END STATION (TARGET BUILDING)
2 END STATION LABORATORY AND OFFICE
3 ADMINISTRATION BUILDING
4 AUDITORIUM
5 CAFETERIA
6 KLYSTRON LABORATORY
7 ACCELERATOR STORAGE AND SHOPS
8 GENERAL SERVICES
9 GUARD HOUSE
10 FIRE STATION
11 KLYSTRON HOUSING
12 HYDROGEN STORAGE
13 ENGINEERING AND SCIENCE BUILDING
14 SUBSTATION
15 BOILER AND PUMP HOUSE
16 COOLING TOWER NO. 2
17 ACCELERATOR CONTROL
18 STORAGE TANK
19 ENCLOSURE (WATER AND GAS METERS)
20 PARKING
340,000 N
339,000 N
338,000 N
337,000 N
336,000 N
1,495,000 E
1,496,000 E
1,497,000 E
1,498,000 E
1,499,000 E
1,500,000 E
SAND HILL ROAD
WHISKEY HILL ROAD
RESERVED FOR FUTURE EXPANSION
RESERVED FOR FUTURE EXPANSION
SAN FRANCISQUITO CREEK
200 0 200 400
SCALE IN FEET
SITE WEST SAND HILL
JOHN A. BLUME AND ASSOCIATES, ENGINEERS
612 HOWARD STREET SAN FRANCISCO
FEASIBILITY STUDY FOR THE
U.S. ATOMIC ENERGY COMMISSION
STANFORD TWO-MILE LINEAR ELECTRON ACCELERATOR
SCALE: 1"=200'
DES. RTY
DRAWN RTY
APPROV. R.L.S.
END STATION PLAN STORM AND SANITARY SEWERS
DATE 12-1-60
WSE4




## LEGEND

1. KLYSTRON D.C. SUPPLY STATION
2. COOLING TOWER NO. 1.
3. KLYSTRON HOUSING
4. SUBSTATION "A" AND "B"

200' 0' 200' 400'
SCALE IN FEET

| SITE | WEST SAND HILL |
|---|---|

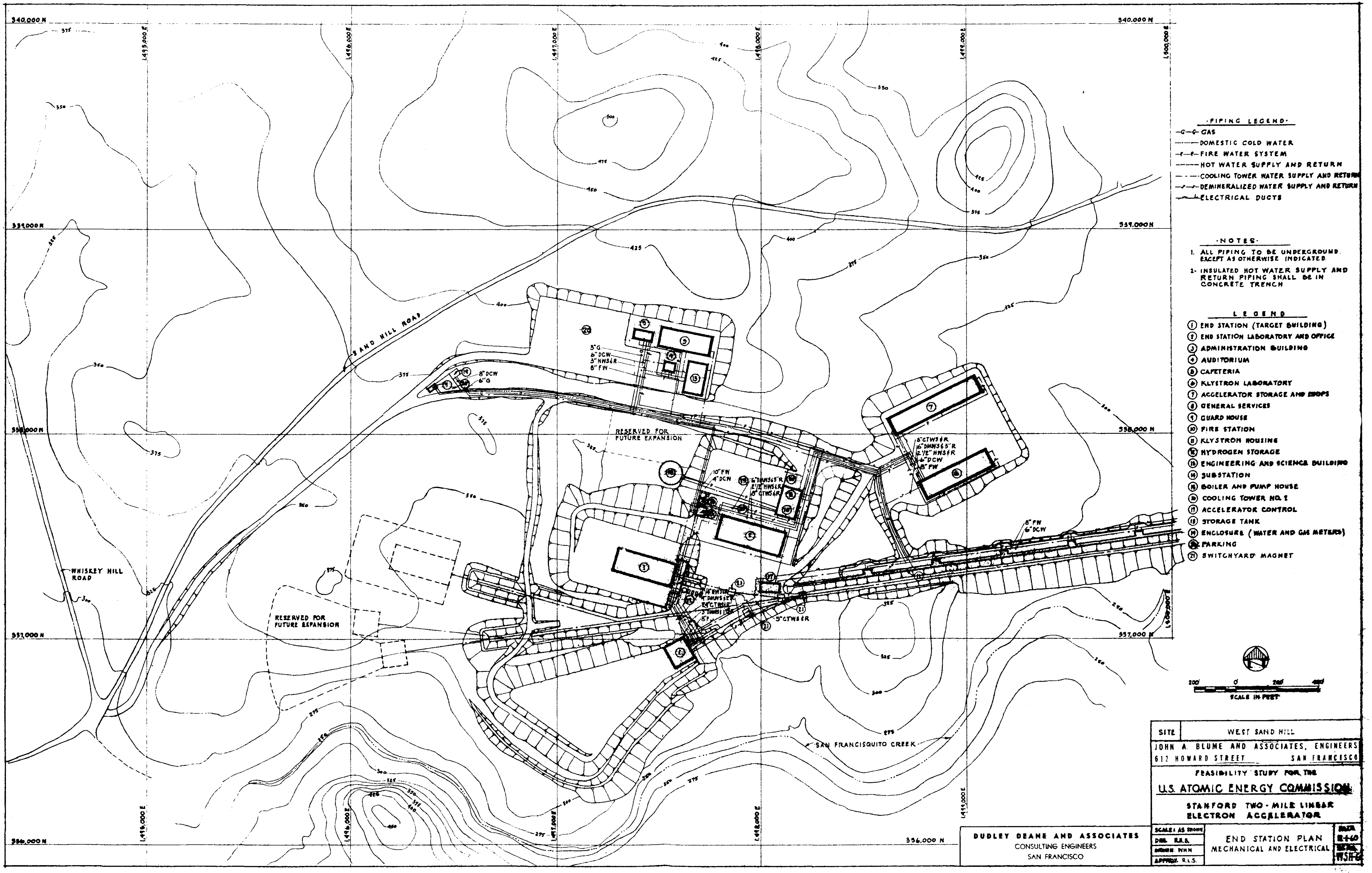
JOHN A. BLUME AND ASSOCIATES, ENGINEERS
612 HOWARD STREET SAN FRANCISCO

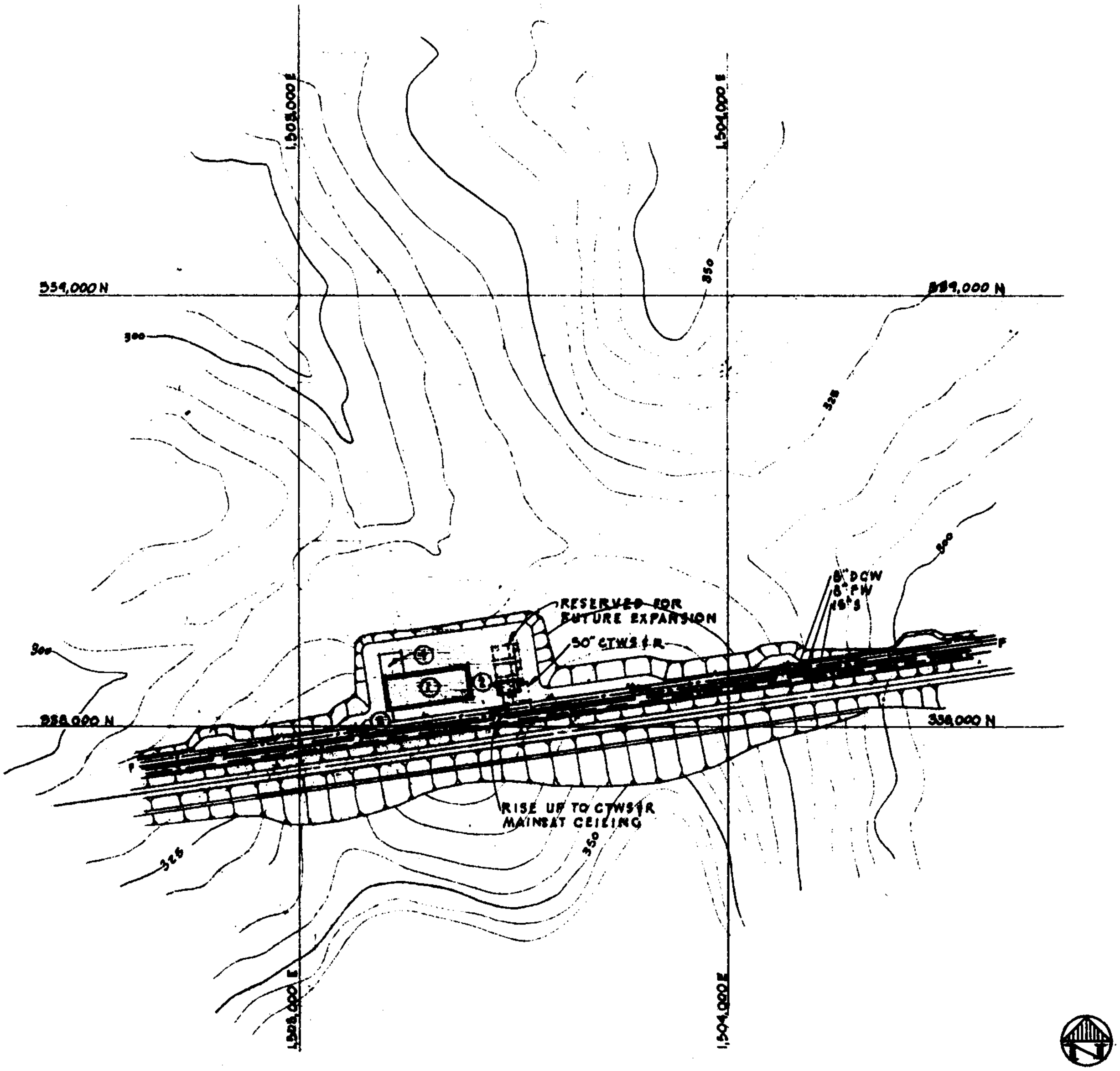
FEASIBILITY STUDY FOR THE

U.S. ATOMIC ENERGY COMMISSION

STANFORD TWO-MILE LINEAR ELECTRON ACCELERATOR

| | | |
|---|---|---|
| SCALE 1" = 200' | CENTER STATION PLAN | DATE 11-1-60 |
| DES. WHN | | |
| DRAWN WHN | | SH. NO WSH-5 |
| APPROV. E.L.S. | | |


·PIPING LEGEND·
G — G GAS
DOMESTIC COLD WATER
F — F FIRE WATER SYSTEM
HOT WATER SUPPLY AND RETURN
COOLING TOWER WATER SUPPLY AND RETURN
DEMINERALIZED WATER SUPPLY AND RETURN
ELECTRICAL DUCTS
·NOTES·
1. ALL PIPING TO BE UNDERGROUND. EXCEPT AS OTHERWISE INDICATED.
2- INSULATED HOT WATER SUPPLY AND RETURN PIPING SHALL BE IN CONCRETE TRENCH
LEGEND
1 END STATION (TARGET BUILDING)
2 END STATION LABORATORY AND OFFICE
3 ADMINISTRATION BUILDING
4 AUDITORIUM
5 CAFETERIA
6 KLYSTRON LABORATORY
7 ACCELERATOR STORAGE AND SHOPS
8 GENERAL SERVICES
9 GUARD HOUSE
10 FIRE STATION
11 KLYSTRON HOUSING
12 HYDROGEN STORAGE
13 ENGINEERING AND SCIENCE BUILDING
14 SUBSTATION
15 BOILER AND PUMP HOUSE
16 COOLING TOWER NO. 2
17 ACCELERATOR CONTROL
18 STORAGE TANK
19 ENCLOSURE (WATER AND GAS METERS)
20 PARKING
21 SWITCHYARD MAGNET
SAND HILL ROAD
WHISKEY HILL ROAD
RESERVED FOR FUTURE EXPANSION
RESERVED FOR FUTURE EXPANSION
SAN FRANCISQUITO CREEK
340,000 N
339,000 N
338,000 N
337,000 N
336,000 N
1,495,000 E
1,496,000 E
1,497,000 E
1,498,000 E
1,499,000 E
1,500,000 E
SCALE IN FEET
SITE
WEST SAND HILL
JOHN A. BLUME AND ASSOCIATES, ENGINEERS
612 HOWARD STREET SAN FRANCISCO
FEASIBILITY STUDY FOR THE
U.S. ATOMIC ENERGY COMMISSION
STANFORD TWO-MILE LINEAR ELECTRON ACCELERATOR
SCALE: AS SHOWN
END STATION PLAN
MECHANICAL AND ELECTRICAL
APPROV. R.L.S.
DUDLEY DEANE AND ASSOCIATES
CONSULTING ENGINEERS
SAN FRANCISCO




LEGEND

1. KLYSTRON. D.C. SUPPLY STATION
2. COOLING TOWER NO. 1.
3. KLYSTRON HOUSING
4. SUBSTATION "A" AND "B"

PIPING LEGEND

- DOMESTIC COLD WATER
- SANITARY SEWER
- COOLING TOWER WATER SUPPLY AND RETURN
- FIRE WATER SYSTEM
- ELECTRICAL DUCTS

| | |
|---|---|
| SITE | WEST SAND HILL |

JOHN A. BLUME AND ASSOCIATES, ENGINEERS
612 HOWARD STREET SAN FRANCISCO

FEASIBILITY STUDY FOR THE

U.S. ATOMIC ENERGY COMMISSION

STANFORD TWO-MILE LINEAR ELECTRON ACCELERATOR

DUDLEY DEANE AND ASSOCIATES
CONSULTING ENGINEERS
SAN FRANCISCO

| | | |
|---|---|---|
| SCALE 1" = 200' | MECHANICAL AND ELECTRICAL CENTER STATION PLAN | DATE 12-1-60 |
| DES. R.E.B. | | SH. NO. WSH-7 |
| DRAWN WHN | | |
| APPROV. R.L.S. | | |

VOLUME IV

****

# SECTION XXIV

## COMPARISON OF EAST AND WEST SAND HILL SITES

The two preceding sections have presented pertinent data and cost estimates for the East and West Sand Hill Sites.

In the selection of a recommended alignment, there are several major factors that should be considered, such as the following:

(1) Safety of operation, with respect to adjacent areas.

(2) Impact of the project on its environment.

(3) Comparative construction costs.

(4) Relative seismic risk.

(5) Foundation conditions.

(6) Flexibility and adaptability of the site.

The first two items, safety of operation, and impact of the project, are being evaluated by Stanford University. Safety of operation is considered to be equally assured at either location, provided that the stipulated earth shielding dimensions are observed. The visual impact of the project on its surroundings will be minimized by careful architectural and landscaping design. Initial End Station Building design studies are shown in Drawings ESH-9 and ESH-10. Other aspects of the effect of the project on its environment will not differ extensively whichever location is chosen for the end station development.

Comparative Costs

Comparative cost estimates are set forth in the following table. Higher costs for the west end are attributable primarily to greater earthwork costs and more expensive utility servicing.

TABLE XXIV-1

COMPARISON OF PROJECT COST ESTIMATES - STAGE I CONSTRUCTION

| | | EAST SAND HILL SITE | WEST SAND HILL SITE |
|---|---|---|---|
| A. | Engineering | $ 10,460,000 | $ 10,590,000 |
| B. | Land | 0 | 0 |
| C. | Construction | 78,880,000 | 80,120,000 |
| D. | Escalation | 9,800,000 | 9,990,000 |
| E. | Contingency | 14,860,000 | 15,100,000 |
| | | $114,000,000 | $115,800,000 |

Other possible costs in addition to the construction cost difference estimated for the two alignments should be considered. The costs of operation would be somewhat higher at the west end due to the greater circulation problems caused by the topography. Road grades are steeper and relative elevations between buildings are greater. The ground water drainage provisions required necessitate running of pumps at frequent intervals. The stability of the various cut slopes is poorer at the west end, which could cause greater maintenance costs. As a result additional area is required at the tops of cuts to provide for possible sliding. Facilities cannot be built on such areas and hence would be farther apart in some cases.

If future target areas are constructed at the western end there would be a large amount of rock removed which would not be needed for fill material. This presents a problem of disposal and probable greater cost.

It is also probable that some of this rock would have to be blasted which would add to the cost and also could interfere with operations of the target areas.

Relative Seismic Risk

Seismic risk is greater at the west end than at the east, according to a qualitative evaluation set forth in a letter from Doctors Byerly and Curtis, Appendix Q. The probable greater risk is due to the closer proximity of the west end to the San Andreas fault with the resulting greater likelihood of damage to the more vulnerable target buildings and other support buildings.

Foundation Conditions

Extensive soil borings, tests, and analyses, together with a detailed geological investigation, Appendix P, indicate substantially better foundation conditions and slope stability at the east end than at the west. Soft shale layers interbedded with sandstone at the west end present potential differential settlement problems under heavy target building loads. Additional problems are created by other inherent undesirable properties of these clays and shales, such as possible rebound and swelling. Ground water seepage appears to be greater at the west end which could increase slope stability problems.

Flexibility and Adaptability of Site

The gradual convergence of Sand Hill Road and San Francisquito Creek at the west end of the Sand Hill area tends to restrict the flexibility of arrangement of west end target areas. Shielding embankments on the creek side encroach upon proposed reservoir spaces and require slope protection measures. The more rugged topography to the north and west requires extensive earthwork for development of these areas at the necessary beam elevation. Restrictions are placed on access road intersection with the existing roads.

The area available between Sand Hill Road and San Francisquito Creek is quite restricted. The proximity of the creek and the possible reservoir on the south requires that future end station target areas be located near Sand Hill Road and hence these facilities would be visible to surrounding areas to the north.

In contrast, the east end station area provides more developable space for current and future use. It also does not adjoin the proposed flood control reservoir. Access roads can intersect with both Sand Hill Road and Alpine Road, providing better traffic distribution and greater accessibility for outside firefighting equipment.

Provided that safety of operation with respect to adjacent areas is equally assured at either end and impact on the environment is not a significant factor, the preponderance of evidence favors location of the end station area at the east end of the proposed alignment.

# APPENDIX P

## SOILS AND GEOLOGICAL INVESTIGATIONS FOR PROPOSED LINEAR ELECTRON ACCELERATOR SAND HILL SITE

By

Dames and Moore

and

Frank W. Atchley

November 16, 1960

John A. Blume & Associates, Engineers
612 Howard Street
San Francisco, California

Attention: Mr. Roland L. Sharpe

Gentlemen:

Report of Preliminary Soils Investigation
Proposed Linear Electron Accelerator
Sand Hill Site
Stanford University, California
For the United States Atomic Energy Commission

We transmit herewith twelve copies of our report of soils investigation at the subject site. Authorization for our work was covered in your acceptance of our letter of proposal dated July 21, 1960. During the course of work we have had frequent contact with your office and with our Consulting Geologist, Frank W. Atchley. Structural information and drawings used in our study have been supplied by your office.

In summary, we believe that subsurface conditions at the site are suitable for the proposed use. The foundation conditions at the east end, where Miocene sandstone is predominantly encountered, are considerably superior to those at the west end where Eocene clay shale predominates. The clay shale is generally firm and can be used satisfactorily, but it will present more problems with cut and fill slopes, foundation support, settlement, and compaction.

The information in this report is sufficient for preliminary design. Certain other borings, tests, and analyses may be required for specific problems that may arise during final design. We recommend that a program of field observation be undertaken as construction progresses in order to observe the behavior of subsurface materials upon unloading and filling, and to make any modifications that are necessary or desirable.

We trust this report provides you with the information required at this time. Please contact us regarding any questions.

Yours very truly,

DAMES & MOORE

William W. Moore

Charles L. Nichols

WWM-CLN AT

REPORT OF PRELIMINARY SOILS INVESTIGATION

PROPOSED LINEAR ELECTRON ACCELERATOR

SAND HILL SITE

STANFORD UNIVERSITY, CALIFORNIA

## INTRODUCTION

This report presents the results of our investigation of the subject site. The site is southwest of Stanford University and is bounded on the north by Sand Hill Road, on the south by San Francisquito Creek, and on the east by Alpine Road. The location is shown on the Plot Plan, Plate 1.

## PROPOSED STRUCTURE:

The proposed Linear Electron Accelerator will be approximately 10,000 feet long. It will be placed in an underground housing, horsehoe-shaped in section, approximately 12 feet wide and 12 feet high, with invert at Elevation 276. The housing will be placed on a prepared level foundation, and a minimum of 35 feet of shielding earth cover will be backfilled around and over the accelerator housing. A Klystron housing structure, extending the full length of the accelerator, is proposed to be constructed along the edge of the fill with floor at approximately Elevation 300. There will be connections between the Klystron units and the accelerator housing every 10 feet; at 333-foot intervals there will be an alcove constructed adjacent to the Klystron housing with main access to the accelerator enclosure.

The area at one end of the accelerator will have target buildings and auxiliary structures, such as laboratories, offices, administration buildings, storage and shop spaces. It has not yet been decided whether the east end or the west end will be used as a target area.

As presently planned, cuts up to about 100 feet in vertical height and fills up to about 75 feet vertical height will be required along the alignment or in the end station area.

We understand that the U. S. Army Corps of Engineers is considering construction of a dam on San Francisquito Creek. According to present plans, water storage level could be at about Elevation 260 for as long as six months at a time. It is estimated that water would be at about Elevation 275 for a maximum of three days, and this would occur only about five times in one hundred years. Water would be at Elevation 285 only about 42 hours and its maximum elevation, about 297, for a much shorter period. Culverts would be constructed through the accelerator embankment at two points to permit the water to be at approximately equal elevation on both sides of the embankment, should the water level exceed the culvert invert elevation.

PURPOSE AND SCOPE:

The purpose of our investigation was to provide information regarding subsurface conditions to aid in evaluating the alternate alignments and layouts and to provide data for preliminary design of cuts, fills, and foundation support. For specific designs, some additional explorations may be required.

To provide additional engineering geological data, Mr. Frank W. Atchley was engaged to prepare a geological report, which is appended to this report.

Following is a list of the main engineering problems considered, utilizing the geological data, field inspection, laboratory testing, and analyses of the data:

1. Cut slopes up to about 100-foot height.
2. Fill slopes up to about 75 feet high.
3. Foundation preparation and support along the accelerator alignment and in the end station areas.
4. Settlements due to fill and/or structure foundation loads.
5. Earth pressure against the accelerator housing and the Klystron housing wall.
6. Drainage and seepage problems based on available information.
7. A brief discussion of possible effect of reservoir water on the proposed construction.

## SITE CONDITIONS

The site is rolling hills, grass covered, with occasional oak trees. San Francisquito Creek and the area to the south is more heavily wooded. Sedimentary rocks underlie the entire site. Shale and sandstones of Eocene age predominate in the west end, and Miocene sandstone and siltstone, with some weakly cemented sands and gravels of Pleistocene age near the east end. Alluvium is present to considerable depth along San Francisquito Creek, and in other low spots. The geology is described in more detail in the appended Engineering Geology Report by Dr. Atchley. For a description of explorations and laboratory testing refer to Appendix B.

## CONCLUSIONS AND RECOMMENDATIONS

GENERAL:

We believe the site will provide satisfactory subsurface conditions and can be suitably developed for the proposed accelerator. However, the geology is complex and there may be some problems to overcome as indicated in subsequent paragraphs and in the appended geological report. The east end would provide considerably better subsurface conditions than would the west end for the extensive cut and fill slopes and heavy foundations that will be required in the end station area. We believe that the shale portion of the Eocene formation, and the Miocene and Santa Clara Formation may be ripped with heavy equipment; however, the hard Eocene sandstone layers will probably require some blasting. We have listed our evaluation of the ease or difficulty of excavation on the boring logs. Also, the appended Engineering Geology Report by Dr. Atchley discusses this problem on page 7, and we believe the evaluation given is reasonable.

The conclusions and recommendations presented below are suitable for present planning. There may be some conditions exposed during construction that will require additional analysis; however, the recommendations presented herein should be adequate for most of the conditions encountered. It is not possible to predict accurately the magnitude and rate of rebound that will occur on excavation, and the subsequent settlement due to weight of fill or structures. However, the values listed herein are in the range of those to be reasonably expected. A program should be developed during excavation and filling to further observe behavior of the soils during construction, to refine the conclusions presented herein.

ACCELERATOR ALIGNMENT:

General: It is anticipated that the accelerator housing will be founded in Eocene shale or sandstone from the west end station to approximately Station 45, and from approximately Stations 56 to 60, and 66 to 76. From approximately Stations 45 to 56, 60 to 66, and 76 to 120, the housing is expected to be in Miocene formations, predominantly sandstone, or in the Santa Clara sands and gravels of Pleistocene age. (See Plate 1 for locations of stations.) Definite points of contact could not be determined, but for present planning purposes the above distribution may be used. Because the shale is weaker than the sandstone in the Eocene formations, our recommendations are based on the shale properties. Since the Eocene shale and Miocene sandstone exhibit quite different properties, the recommendations will consider Eocene and Miocene formations separately as a foundation material, either of which can be used for supporting the accelerator housing or for shielding fill.

Cuts: In general, the sandstone is more competent than the shale, although there will be considerable variations in both. In some places the shale would stand on steep slopes to considerable height. However, planning should be based on long-term stability of the poorer material. This is a very difficult problem to assess, and should consider both deep-seated stability and shallow sloughing and erosion. Safety against deep-seated failure is mandatory. The degree of desired protection against shallow sloughing and erosion often depends on capital cost, aesthetics, and the amount of periodic maintenance that can be provided. We believe the slopes tabulated below would be suitable for present designs. Sufficient space should be provided at the tops of deeper shale cuts (30 feet plus) to flatten the slopes to 2:1 (two horizontal to one vertical), plus the recommended benches, if proved necessary during excavation.

**Shale**

| | Slopes | Benches |
|---|---|---|
| Permanent | 1-3/4:1 or flatter if over 30 feet high | 10 to 12 feet wide at no greater than 30-foot vertical intervals |
| | 1-1/2:1 if less than 30 feet high | None required |
| Temporary | 1:1 | 10 to 12 feet wide at no greater than 30-foot vertical intervals |
| | or | |
| | 1-1/2:1 with no benches<br>1/2:1 if less than 10 feet high | |

NOTE: We anticipate that temporary slopes may be exposed during one winter season.

**Sandstone**

| | Slopes | Benches |
|---|---|---|
| Permanent or Temporary | 1:1 if over 10 feet high | 10 to 12 feet wide at no greater than 30-foot vertical intervals |
| Permanent or Temporary | 1/2:1 if less than 10 feet high | None required |

The Eocene shales are not an isotropic homogeneous material. Locally the shale may be sheared and reduced almost to a clay, while nearby it may be relatively hard, but fractured. We have based our recommendations on the weaker material. There may be some local soft spots of still weaker material that may require special measures where exposed during excavation. We expect that very few of these special problems will be encountered toward the east end.

Provision should be made to control erosion and sloughing. Good drainage will be essential. Interceptor ditches should run parallel to the tops of slopes and along the benches. The benches will serve to intercept slope drainage and provide access for maintenance. Even where these measures are taken, exposed slopes may erode from heavy rains and some sloughing of a few feet in depth may occur in local areas. The attempt has been made to select safe slopes that would result in optimum over-all economy, realizing that all conditions cannot be predetermined.

Site Preparation and Filling: At some places along the accelerator alignment existing grade is below the elevation of the proposed accelerator housing. Therefore, fills will be placed for support of the accelerator as well as for shielding. Clayey alluvium encountered in some of these areas would be quite compressible under high fill loads and would result in large settlement, as discussed in subsequent paragraphs. Accordingly, we recommend removing this alluvium down to the shale or sandstone or other firm material under the accelerator or other important structural areas to receive high fills. Areas where the alluvium should be stripped, as indicated by present boring information, are tabulated below.

| Station | Represented by Boring | Estimated Lowest Elevation of Stripping Required |
|---|---|---|
| 32-38 | 10A | 230 or higher |
| 39-41 | 12 | 243 |
| 49-58 | 13, 14 | 235 |

Along much of the alignment, excavation for the accelerator housing will remove all of the alluvium and other soil. In other areas there will be some residual soil. In all cases, tree roots, vegetation, and other foreign material should be removed beneath the accelerator and Klystron structures. The exposed surface should then be well compacted prior to placing fill. Where the fill is placed on a side hill sloping downward away from the fill, even though the fill is not to support structures, the side hill should be horizontally benched progressively up the hill so that the fill is placed in horizontal layers.

The excavated material will be suitable for use as fill. The best material will be the weakly cemented sandstone or other sandy or gravelly soil which will break down and compact well. The shale material should break down, but it will be more difficult to condition properly and to compact well. The harder sandstone may not readily break down and may have to be selectively used.

The best material should be placed immediately beneath the accelerator. To the extent it is available, it would be desirable to use select material immediately beneath the Klystron housing for a minimum depth of several feet beneath the foundations. Also, it would be desirable to use the