FOR OFFICIAL USE ONLY

HISTORICAL REPORT

DET #3 SITE ACTIVATION TASK FORCE

BEALE AF BASE, CALIFORNIA

PERIOD

1 January 1961 through 31 December 1961

FOR OFFICIAL USE ONLY

XVIII-20-4

BEALE AREA

HISTORICAL SUMMARY

October 1959 – March 1962

CORPS OF ENGINEERS
BALLISTIC MISSILE
CONSTRUCTION OFFICE
CEBMCO

BEALE AIR FORCE BASE
BEALE, CALIFORNIA

FOR OFFICIAL USE ONLY

HISTORY

OF

CORPS OF ENGINEERS

ACTIVITIES

AT

BEALE AIR FORCE BASE

OCTOBER 1959 --- MARCH 1962

Respectfully Submitted By:

Joseph H. Sherrard

JOSEPH H. SHERRARD
Lt. Col, CE, Area Engineer

Beale Area, United States Army
Corps of Engineers Ballistic Missile Construction Office

"FOR OFFICIAL USE ONLY"

UNITED STATES ARMY
CORPS OF ENGINEERS BALLISTIC MISSILE CONSTRUCTION OFFICE
LOS ANGELES 45, CALIFORNIA

WS-107 A-2 TECHNICAL FACILITIES
BASE T-5
COMPLEX 1A, 1B and 1C
BEALE AIR FORCE BASE
CALIFORNIA

TABLE OF CONTENTS

INTRODUCTION

PART I

ADMINISTRATION

LIST OF FIGURES

INTRODUCTION

This history is a factual summary of contract and construction activities encountered by the Corps of Engineers during the construction of the three complex, Titan I Squadron at Beale Air Force Base, California.

It provides a concise history of construction progress, a detailed review of contract administration actions and will furnish a background of experience for consideration in solving similar problems and development of techniques for future ICBM construction.

This history includes, but is not limited to, the following areas of interest - scope of work, personnel and organization at Area Office and SATAF, delays, construction procedures and problems, unusual and unforeseen events, accident prevention, total costs, relations with SATAF, conclusions and recommendations.

Also included are 89 photographs and 12 charts.

There were four main agencies involved in the construction and installation of this missile program; two military and two civilian. Each had a definite and unique function:

1. U. S. Army Corps of Engineers Ballistic Missile Construction Office (CEBMCO) directly supervised the construction of the launch facilities through the Prime Contractor (Peter Kiewit Sons Co.), and several support facilities by other contractors.

2. USAF Site Activation Task Force (SATAF) Ballistic Missile Division "Purchasing or Using" Agency, was responsible for the following:

a. Approval of changes in plans and specifications of technical facilities.

b. Waivers to specifications.

c. Approval for substitution of materials.

3. Peter Kiewit Sons Co., the Prime Contractor, physically constructed that portion of the launch structures and facilities described in the construction section of this history, excluding the installation of the missile and numerous other installation items.

4. The Martin Co. designed the Titan I ICBM, was designated as integrating contractor for installing the missiles and other items, and installed the missiles after completion of the construction phase.

This history covers paragraph 1 above completely, and paragraphs 2 and 3 only to the extent necessary for a complete report. A discussion of paragraph 4 is not considered pertinent to this summary.

PART I

ADMINISTRATION

U. S. ARMY

1. CORPS OF ENGINEERS BALLISTIC MISSILE CONSTRUCTION OFFICE (CEBMCO)

ESTABLISHMENT AND FUNCTION

The new Corps of Engineers Ballistic Missile Construction Office was opened in Los Angeles, California on 1 August 1960. The office was established to streamline, strengthen and expedite ICBM site construction. ICBM construction consisted of Atlas, Titan and Minuteman squadron sites at various bases, as well as certain testing facilities at Vandenburg AFB, California and Cape Canaveral, Florida.

The Commanding Officer of the Corps of Engineers Ballistic Missile Construction Office (CEBMCO) was Colonel T. J. Hayes, and the Directorate of Titan I was Col. Whitesell who also was the Contracting Officer for the contracts administered by the Beale Area Office.

CEBMCO, through the various "Construction Directorates", controlled the overall missile site construction program and furnished the Area Offices guidance, ie: Construction, Electrical, Mechanical, Engineering, P.L.S., Administration, etc. Numerous visits were made by CEBMCO representatives to the Areas, thus assuring CEBMCO of continual "up-to-date" information on what was occurring in the field.

The organization chart (Figure 1) shows the five directorates

under CEBMCO, with a further breakdown of the Titan I Directorate, showing its five areas.

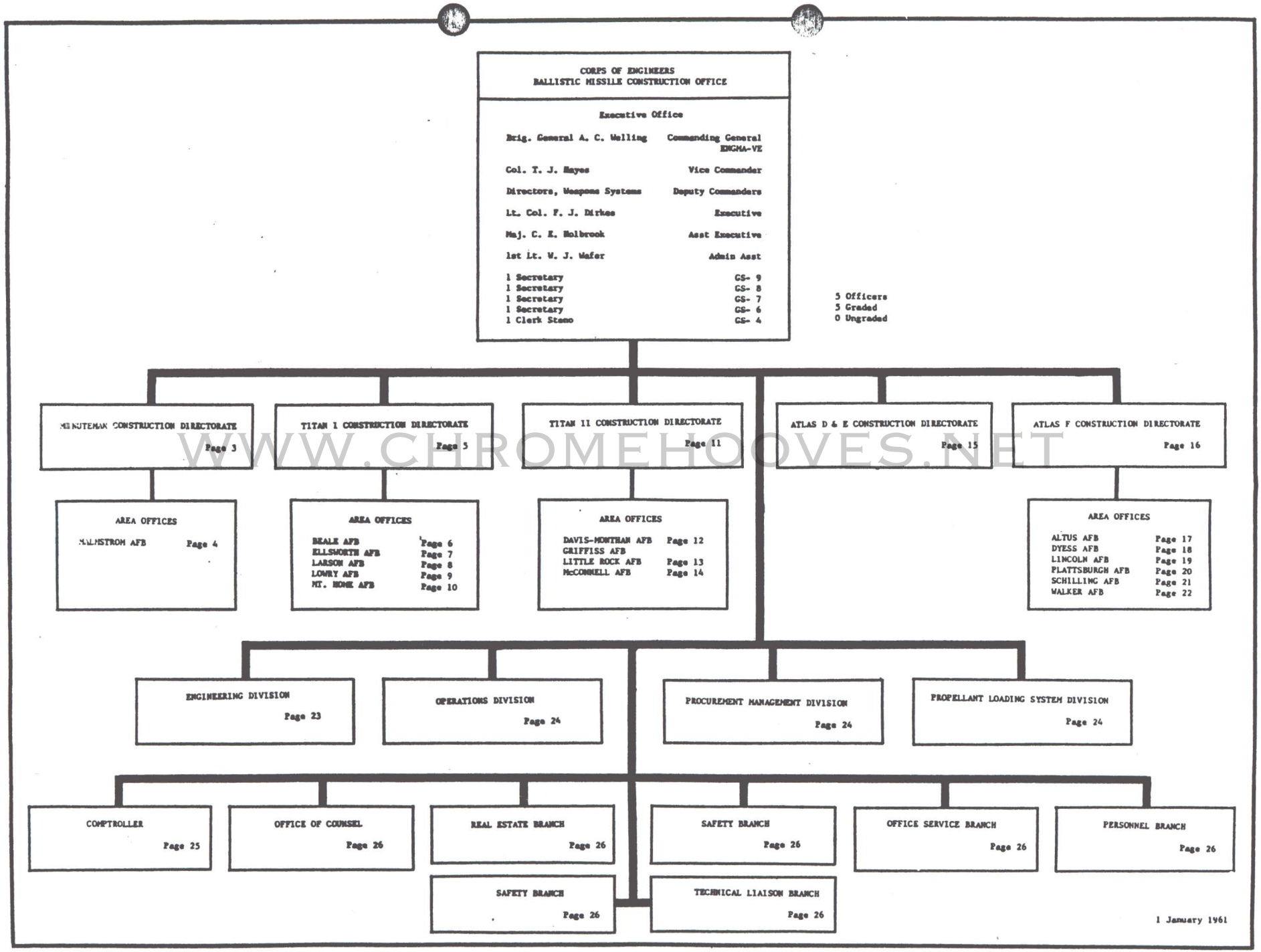


Fig. 1

2. BEALE AREA ORGANIZATION

ESTABLISHMENT OF AREA OFFICE

The Valley Area Office (Mil.) was established as a field unit of the Sacramento District by District Order No. 59-51, dated 30 September 1959. This Area Office was subsequently given the responsibility for supervising construction of ICBM facilities and Titan I Missile Launch Complexes in the vicinity of Beale Air Force Base. District Order No. 59-52, dated 1 October 1959, assigned Mr. Olaf Lein as Area Engineer of the Valley Area Office. District Order No. 58, dated 30 September 1960, effective 3 October 1960, assigned Lt. Col. Joseph H. Sherrard as Area Engineer and Mr. Olaf Lein as Deputy Area Engineer and changed the name of the Area Office to Beale Area Office.

On 1 November 1960, by Memorandum of Understanding by CEBMCO and Sacramento District dated 28 October 1960, the Beale Area Office was placed under the control of CEBMCO and was removed from the control of the Sacramento District.

MISSION

The mission of the Beale Area Office was to perform the contract administration and construction supervision functions delegated by the Titan I Directorate of the Corps of Engineers Ballistic Missile Construction Office, to the Beale Area Office. The contracts to which this mission applied were those under the WS-107 A-2 Technical Facilities, Complex 1A, 1B and 1C, Base T-5 for Beale Air Force Base, California Project and the related support facilities. Administrative and logistical support was

provided the Area by CEBMCO and the Sacramento District to the extent indicated in the "Memorandum of Understanding".

INDOCTRINATION & TRAINING

Rocketry Familiarization Training

In October 1959 when the Sacramento District was alerted to its impending participation in the missile program, arrangements were made for Rocketry orientation of key personnel of the District. Ten training sessions (a total of 15 hours) were presented by specialists from Aerojet General Corporation and Douglas Aircraft. Forty nine persons were selected and attended this training. Selection was based on a need-to-know basis and the general belief that every key employee involved in the missile program would do a better job if he knew something about the history and make-up of rockets and rocket facilities. The orientation consisted of the following:

Date	Session	Title
Oct. 19	1	History of Rockets
Oct. 20	2	Solid Rocket Motors
Oct. 21	3	Liquid Rocket Engines
Oct. 22	4	Metals and Plastics
Oct. 23	5	High Energy Fuels
Oct. 26	6	Guidance Systems
Oct. 27	7	Missile Launching and Facilities
Oct. 28	8	Ground Support Equipment
Oct. 29	9	Trajectory and Orbital Problems
Oct. 30	10	Rocketry Tomorrow

Training

Personnel from the Sacramento District and the Beale Area Office attended the following training sessions in preparation for this project:

Date	Location	Title	No. Hours	Personnel Attended
13 Oct. 59	Inglewood	Ballistic Missile Orientation	16	1
18 Nov. 59	Denver	Shock Requirements	16	3
7 Dec. 59	Vandenburg	Propellant Loading System	40	2
18 Jan. 60	Omaha	Propellant Loading System	15	4
26 Jan. 60	Vandenburg	Propellant Loading System	24	2
29 Feb. 60	Vandenburg	Propellant Loading System	40	2
7 July 60	Vandenburg	Titan Operation	16	3
24 Nov. 60 to 12 Dec. 60	Denver	Propellant Loading System	40	22
9 Dec. 60	Vandenburg	Propellant Loading System	40	5

In addition to the above, training at the Area Office level was provided as follows:

6 hours of PLS training at the Area Office in Sept. 1960 for Area staff personnel.

6 hours of PLS training at each complex for Government inspection personnel.

Military Training

All military personnel assigned to the Beale Area Office completed "on the job" training as part of their assigned duties. The training objective was to thoroughly study the contract drawings and specifications, the techniques of preparing government estimates and the conducting of negotiations with the contractor.

"On the job" training for Resident Office personnel was provided to acquaint them with TEMPCO type reporting procedures and use.

Meetings were held weekly in the Area Office during the months of January, February and March 1961 with mechanical personnel at the Area Office and the three complexes, to present problems anticipated and to review the contract requirements.

The Resident Engineers conducted "on the job" training of inspection personnel as the work progressed.

AREA ORGANIZATION AND FUNCTIONS

The Sacramento District Valley Area Office was initially responsible for supervision and construction of the ICBM facilities at Beale Air Force Base. Organization Chart, Fig.2, shows the organization under Mr. Olaf Lein, the Area Engineer, from 1 October 1959 to 3 October 1960. Lt. Col. Joseph H. Sherrard was designated Area Engineer, with Mr. Lein as Deputy, effective 3 October 1960.

On 1 November 1960 the Valley Area Office was transferred to CEBMCO and the name of the office was changed to Beale Area. Immediately after take-over by CEBMCO, the organization was

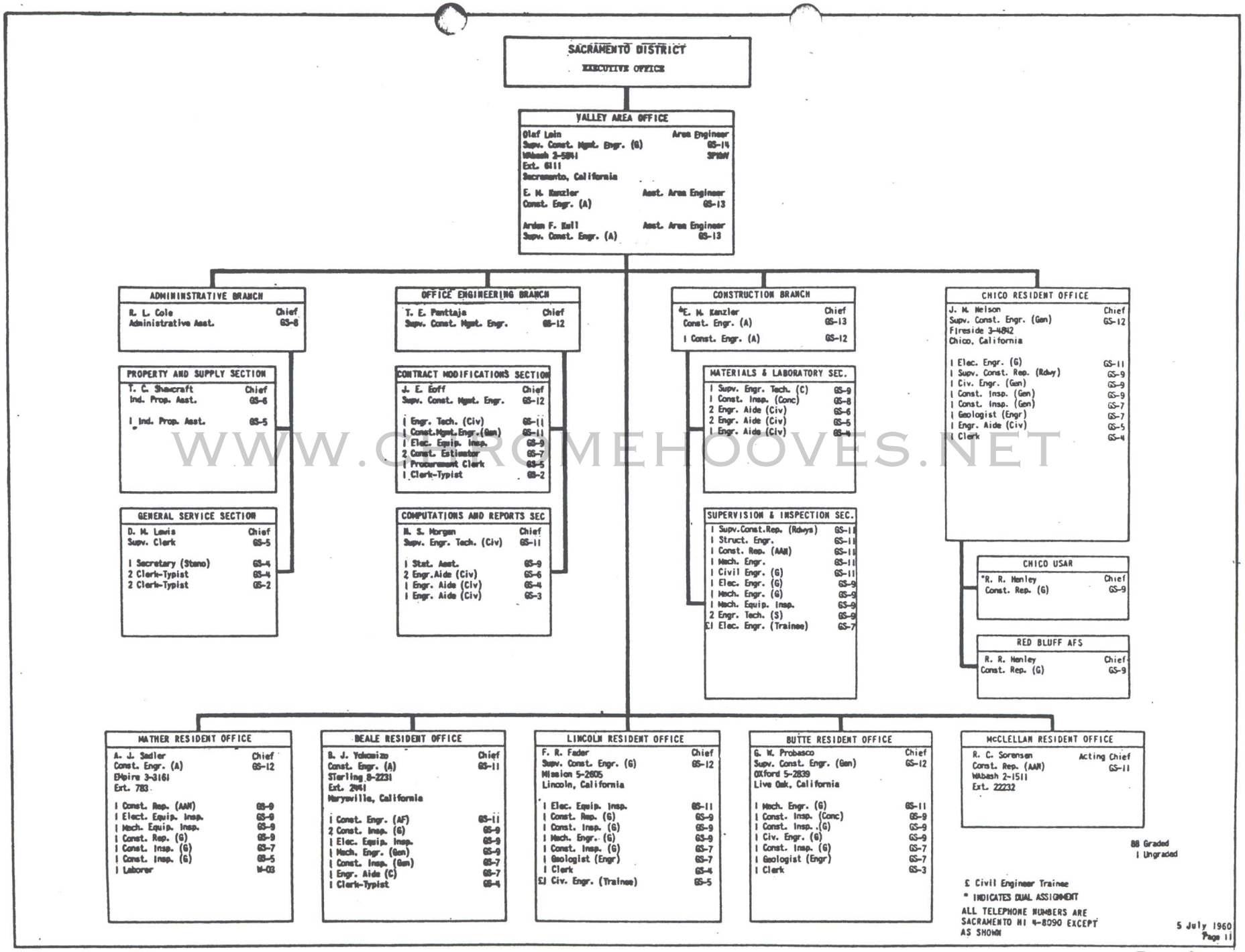


Fig. 2

expanded to seven branches: Administrative, Construction, Engineering, Contract Administration, Propellant Loading System, Safety, and Office of Counsel, as shown on Organization Chart, Fig. 3.

Resident Offices were established at each of the complexes, and one at Beale Air Force Base to supervise the construction of the support facilities. The Propellant Loading System (PLS) was a separate branch for approximately one year before becoming a section under the Construction Branch. The Organization Chart for SATAF, Fig. 4, is included for reference.

The functions of the branches at the Beale Area Office were as follows:

AREA ENGINEER

The Area Engineer, who was the Contracting Officer's representative for contracts administered by the Beale Area Office, enforced the contract provisions and directed and coordinated the Area Branch activities.

DEPUTY AREA ENGINEER

Assisted the Area Engineer, and acted as the Area Engineer during his absence.

Provided direction to the technical, advisory and administrative staff in all matters of a technical nature.

EXECUTIVE OFFICER

Assisted the Area Engineer and the Deputy Area Engineer in a staff capacity in delegated matters not requiring the immediate or personal attention of those officials, normally assumed duties

which included coordination, review or approval of matters where guidelines of action were clearly defined, served as focal point in all matters relating to the Administrative and Advisory Staff, coordinated matters of organization, personnel staffing and space allocation, served as the principal Administrative Assistant to the Area Engineer, coordinated in those matters relating to overall administration where executive action was required, supervised the preparation of transfer documents, and participated in the formal transfer of completed construction to the Using Agency. Supervised military personnel administration as directed and performed additional duties as specifically assigned.

ADMINISTRATION BRANCH

Provided administrative assistance to all branches of the Area Office. Distributed and dispatched incoming and outgoing mail. Maintained area correspondence files and directed the records retirement program. Furnished instructions to clerical personnel and provided stenographic and typist assistance to other branches of the area. Maintained control of all required periodic reports not assigned to other branches. Provided office service including: supply, communication, reproduction and transportation. Directed civilian personnel actions and maintained records including: time and attendance, leave and travel orders.

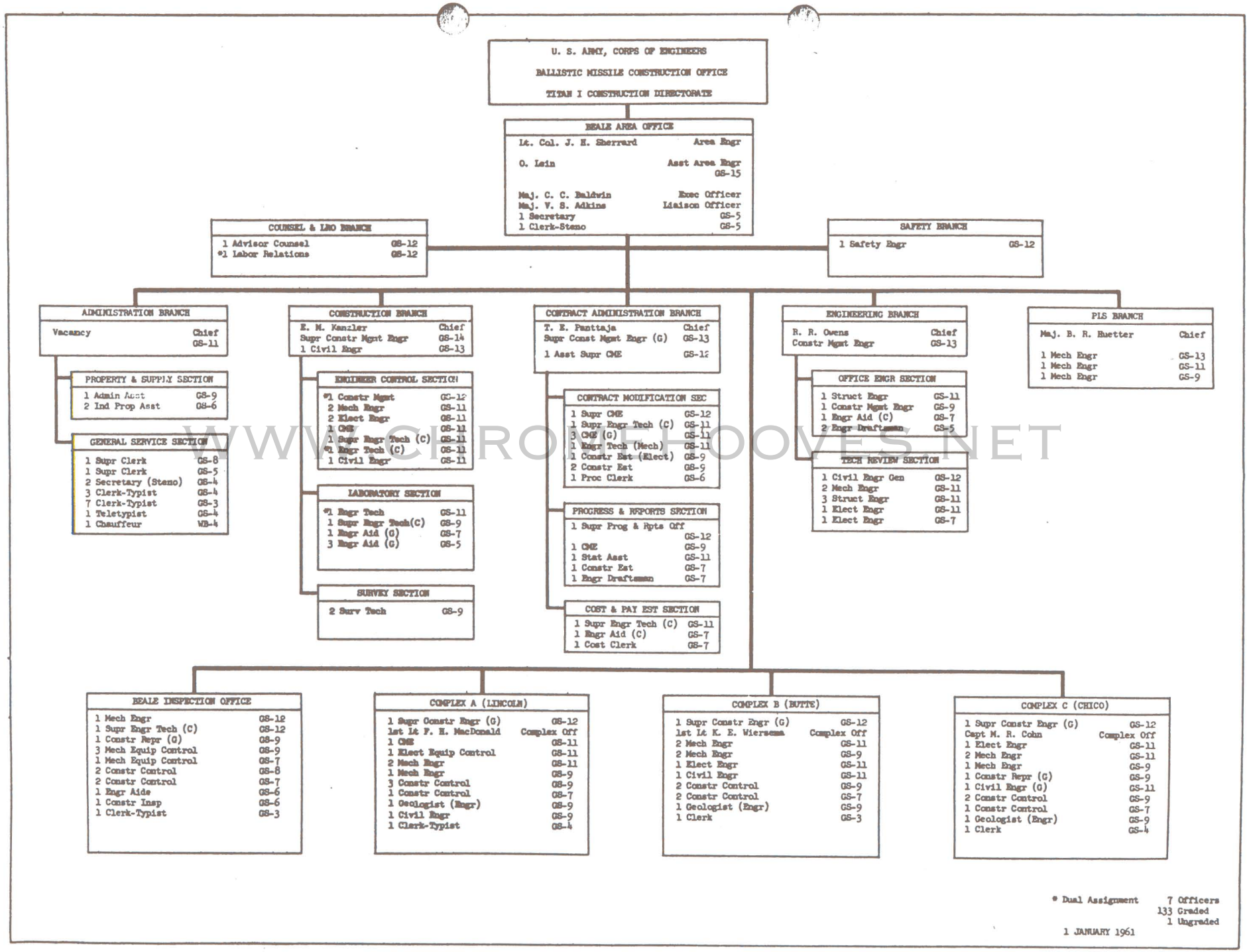
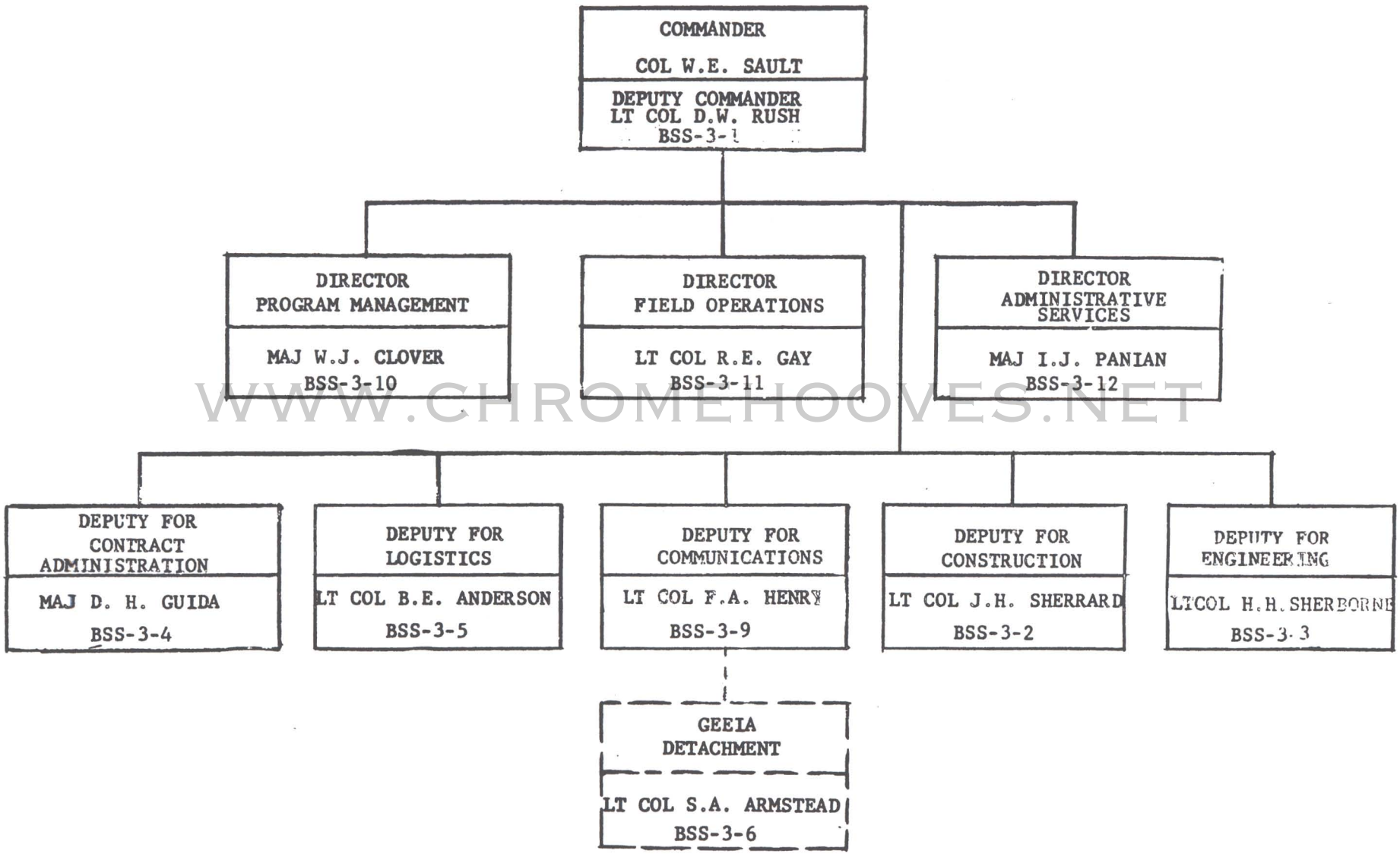


Fig. 3

SITE ACTIVATION TASK FORCE



DATE: 17 November 61

Fig. 4

Property Section

Property Section was responsible for furnishing and maintaining records of all office furniture and inspection equipment utilized in the area. The contract specifications required the contractors to submit purchase orders for all materials purchased for the project. This was for the purpose of allowing Government follow-up and expediting assistance when necessary. Property Section coordinated the review of the purchase orders and issued inspection requisitions when needed.

This Section checked incoming Government furnished and standardized equipment while enroute to, or at warehouse or railhead. In connection with some Liquid Oxygen tanks, it was necessary for a Government representative to ride the trains to insure that these items were not side tracked or humped enroute. There were in excess of 250 vouchers of incoming Government furnished items that had to be checked in, reviewed for damage and transferred to the contractor. Items received in a damaged condition were photographed and visual damage report prepared. A large portion of the Government furnished property arrived 10 April 1960 through 21 April 1961, total cost of which was in excess of $5,000,000.

Test equipment for testing the PLS systems started arriving 5 April 1961. Most of the test equipment was mounted on semi-trailers with accessories, 17 filters and spare elements. There were 37 of these trailers transferred from the Air Force and

utilized by the contractor during testing of the PLS. At the conclusion of the PLS testing, all equipment was transferred back to the Air Force. Total value of testing equipment was in excess of $1,200,000.

Property Section prepared for signature, and distributed all Eng. Forms 290, including installed property lists for both Government furnished property and contractor furnished equipment. There were 92 Eng. Forms 290 required to transfer the three complexes. Government and contractor installed property lists required several visits to construction sites to obtain complete nomenclature of all items of equipment. Contractors were contacted for the unit prices of all contractor furnished equipment listed with the Eng. Forms 290.

ENGINEERING BRANCH

The Engineering Branch was composed of a Technical Review Section and an Office Engineering Section. The function of the branch was to provide technical support and guidance to the Area Engineer and to the Construction Branch.

Function of Technical Review Section

The Technical Review Section's prime responsibility was to check shop drawings, contractors' construction lift drawings, and mechanical and electrical layouts; contractors were advised of results. Necessary liaison between the Architect-Engineers and various components of the Beale Area Office was a responsibility of this section. This involved presenting design and field problems to the Architect-Engineers for review and after receipt of their

reply, analysis and distribution of this information to those concerned.

Support was given to the Contract Administration Branch by Engineering Branch in the preparation and negotiation with the contractor, of large, complex modifications.

Function of Office Engineering Section

This Section worked closely with the U. S. Air Force SATAF Deputy for Engineering so far as revisions to contract plans and specifications were concerned. The drawings and specifications were revised by Office Engineering Section and prints issued to the contractor and other agencies involved. "Marked-up" prints of "as-built" drawings were prepared and forwarded to the Architect-Engineers for final posting on the tracings. Engineering Branch maintained up-to-date sets of plans and specifications for all concerned and had files of all approved shop drawings, lift drawings and standardized equipment drawings.

When requested by the Area Engineer or Construction Branch, Engineering Branch performed inspections of construction to insure that the design intent had been accomplished.

Shop Drawings

The contractor submitted 980 shop drawing transmittals. Each transmittal contained an average of four sheets, all of which required checking. The items were structural, mechanical and electrical. In addition, there were 200 mechanical layout transmittals with an average of ten sheets each, and 100 electrical layout transmittals of approximately six sheets each.

The checking of these shop drawings was accomplished

either by Corps of Engineer forces or by those of the Architect-Engineer.

Construction Lift Drawings

Three hundred sixty construction lift drawings were submitted by the contractor for approval. This required highly skilled checking to insure that the configuration of structure was correct and that each embedded item was in place. Speed as well as accuracy was required since each drawing had to be checked before the concrete could be poured.

CONTRACT ADMINISTRATION BRANCH

Advised area personnel on contractual matters. Processed progress schedules from contractors, reviewed same with cooperation of Construction Branch, and initiated action for revision or approval. Furnished information, coordinated activities and distribution of "TEMCO" report, and prepared associated progress reports. Furnished Engineering Branch with comments for changes on plans and specifications. Maintained budget control of Government costs, construction contract costs, and prepared revised current cost estimates as required. Monitored proposed change orders within the area office and initiated change order action with the contractors. Prepared Government cost estimate for changes, conducted modification negotiations, and prepared and distributed modification documents. Researched all claims submitted by the contractor and furnished area counsel information and recommendations for preparation of findings of fact for contracting officer's decision.

PROPELLANT LOADING SYSTEM BRANCH

Provided engineering and technical assistance to area personnel on the PLS. Reviewed PLS shop and layout drawings for conformance to the contract plans and specifications. Resolved field conflicts and design inadequacies of the PLS and furnished this information to Engineering and Technical Branch for initiation of change order action. Performed engineering inspections of PLS construction to insure adequate construction standards and the compliance of material and equipment to design criteria. Directed the conduct of final field acceptance testing of the PLS. Provided Contract Administration with information for pay estimates of contract modifications and claims negotiations.

CONSTRUCTION BRANCH

Supervised and conducted continuous inspection of construction activities. Directed the job-level Training Program. Reported to Engineering Branch conflicts and design inadequacies occurring in the plans and specifications. Assisted in the negotiations for change orders and reviewed proposed changes for construction feasibility. Provided Contract Administration Branch with information for pay estimates and progress reports. Maintained a set of contract prints showing as-built conditions. Provided Property Section with data for Eng. Forms 290 and other transfer documents. Established and furnished construction completion and acceptance dates to Contract Administration Branch. Reported work stoppages to area Labor Relations representative.

SAFETY BRANCH

Worked under the general supervision of the Area Engineer. Duties included the administration and operation of the Area Accident Prevention Program. Reviewed contractors' pre-work accident prevention proposals. Advised on technical aspects of contractors construction work methods, detection of hazards, and recommended corrective action. Implemented regulatory controls, Safety Standards and Codes. Developed or reviewed design of safety guards, scaffolds, ventilating systems, etc. Was responsible for fire prevention and protection. Insured adequate and prompt reporting procedures were in effect.

Due to the difficulties in recruiting a competent Safety Engineer, this position was filled only for a few months during the later stages of construction. For the time that this position was not filled, the Assistant Chief of Construction Branch assumed the duties of this branch.

Experience

From January to October 1960 the overall safety program was supervised by the District safety engineer. After that time the District safety engineer continued to serve in an advisory capacity and performed periodic inspections of the job sites. The Area office continued the safety program instituted by the District safety officer. Figure 5 shows the Area safety program.

The Beale Area safety experience from the start of the project through February 1962, as compiled by CEBMCO Safety

Branch is as follows:

Man hours worked	3,895,049
Disabling injuries	26
Fatalities	1
Days lost	6,696
Frequency rate	6.68
Severity rate	1.72

Considering the nature of the work, the contractor had a good safety record. There was one fatality which was the only major injury during the course of the work. The fatality occurred when an end loader operator backed over a steep slope in a stockpile area. The vehicle overturned and crushed the operator. As the operator was alone in the area, the exact cause of the accident could not be determined. It was concluded that the operator lost control of the loader while backing over windrowed embankment material and could not stop in time to avoid going over the bank. The loader flipped over backwards and pinned the operator underneath.

As will be noticed in the area safety program, each resident engineer was directly responsible for effective safety implementation. This policy proved to be very effective.

BEALE AREA OFFICE SAFETY PROGRAM

1. The Valley Area Office Safety Council will be composed of the following:

Area Engineer
Assistant Area Engineers
Resident Engineer, Lincoln T-5
Resident Engineer, Beale Air Force Base
Resident Engineer, Buttes T-5
Resident Engineer, Chico T-5

2. Council Meetings will be held once a month or more often if considered necessary by the Area Engineer. The regular monthly meetings will be held on the first Monday of each month at 9:30A.M.

3. Meeting Procedure

a. Review of accidents or near accidents occurring during preceding month.

b. Written report from each Resident Engineer evaluating each contractor's performance during the past month. At this time Resident Engineers will present the reports prepared by the Resident Safety Inspector as described in paragraph below.

c. General discussion of Safety Program and suggestions for improving program. Resident Engineers should present at this time any suggestions or comments which may have been presented at the monthly resident meeting described in paragraph below.

4. Resident Offices:

a. Every inspector shall be thoroughly indoctrinated in accident prevention. Each inspector shall be made fully aware of his responsibilities in connection with administration of the

safety program.

b. Each Resident Engineer shall conduct a scheduled safety meeting with all inspectors monthly. Additional meetings shall be held if conditions warrant. Each Resident Engineer shall establish the time for the monthly meetings and shall advise the Area Office of the time established. The following subjects should be covered, but not limited to, at the resident meetings:

(1) Interest and cooperativeness of contractor's management.

(2) Effectiveness of contractor's indoctrination of supervisory personnel.

(3) Effectiveness of indoctrination at workman level. Is each workman safety conscious?

(4) Condition and adequacy of the contractor's safety equipment and materials.

(5) Inclusion of safety in contractor's planning of work operations.

(6) Effectiveness of program in connection with sub-contractor activities.

(7) Discussion of the monthly safety inspector's report as prepared according to paragraph below.

c. Designate for each contract the inspector responsible for meeting with the prime contractor's superintendent and subcontractor's representatives prior to start of the subcontractor's activity and when there is a change of supervisors for either the prime contractor or subcontractors, report compliance

corrective action has not been taken, an explanation will appear in the log. The acting safety inspector will report orally at the monthly Resident Office Safety Meeting on his findings, problems and pending violations. A copy of inspection logs will be presented to the Area Office Safety Council at each monthly meeting of the council by the Resident Engineer.

h. Resident Engineers will evaluate the performance of employees under their supervision, for compliance and application of the Safety Program and shall consider this in determining the annual performance rating of the inspector.

5. Reports of the Safety Council Meetings, and evaluation follow-up by Area Office Staff and Resident Safety Inspectors' logs will be forwarded to the Safety Engineer after each council meeting.

or (noncompliance in red) in daily log.

d. Engineers and inspectors will include in their daily logs their activities pertinent to the application of the Safety regulations, programs and mutual understandings, noting in red all deficiencies. A follow-up of all deficiencies will also be recorded in the log.

e. All reportable accidents will be thoroughly investigated, and follow-up, to be assured that prescribed reports are properly prepared and submitted promptly. Be prompt in making verbal report of accidents to Area Office. Prepare a supplementary report for all contractors reportable accidents.

f. Check to see that corrective action indicated on accident reports is put into effect on the job. One copy of the accident report will be retained by the Resident Engineer for follow-up purposes.

g. Resident Engineers will assign one member of their staff on a monthly rotation basis as an acting safety inspector to check all operations, equipment and materials. Appointments will in no way relieve other staff members of their safety responsibilities. Development of the procedure and assignment of responsibilities will be accomplished locally. Acting safety inspectors will be required to prepare a log (pencil or ink), listing date of inspections; building, structure, equipment, material or operation inspected; findings; and name of person responsible for corrective action. The date corrective action was taken will be entered in the log opposite the deficiency involved. When

OFFICE OF AREA COUNSEL

Advised the Area Engineer and his staff on administrative actions where legal questions were involved and as to the Government's rights and obligations under construction contracts. Considered claims under construction contracts, made recommendations to the Area Engineer, and drafted findings of fact and decisions for consideration by the Contracting Officer. Advised personnel assigned to contract administration duties on legal problems confronting them during the administration of contracts requiring interpretation of contract clauses and/or technical provisions of contracts. Also provided advice on problems that arose via labor relations.

PERSONNEL

Personnel functions were administered by the Sacramento District during the entire duration of the job. Prior to the establishment of CEBMCO the Area Office was under the Sacramento District, and after CEBMCO's establishment the Sacramento District provided Administrative support to the Area on personnel matters.

The Valley Area Office was established in November 1959 to supervise all military construction assigned the Sacramento District. This construction included the ballistic missile construction work which was new to the District at that time. Since the normal military construction work was decreasing, it was possible for the District to staff for the construction of missile projects through gradual reassignment of current personnel. There was a shortage of mechanical and electrical engineers and inspectors.

These needs had to be met to a large extent through training of surplus personnel possessing the best potential for these specialized jobs, since all missile construction projects were recruiting for similar personnel in nearly all sections of the United States.

At the time of transfer of missile construction to CEBMCO, 1 November 1960, there were 95 employees assigned to the work in the field and a substantial part of the productive time of the Construction Branch was devoted to this work. Coincident with the transfer the name of the area was changed to Beale Area Office. Strength increased to 112 in December and to 122 in February 1961. From February through June, strength remained constant. There was a gradual decrease in personnel after July 1961 and on 20 December 1961 the strength of Beale Area Office was 101.

The Personnel Branch provided complete personnel services to Beale Area Office, including recruitment, in-service placement, training assistance, classification and wage, etc. The Area also was serviced by the Incentive Awards Committee and represented in the Civilian Welfare Council. The phase-out of personnel required much attention of the Personnel Branch after July 1961. The separation of employees was particularly complicated by the fact that approximately 90 employees had administrative reemployment rights with Sacramento District. Most of these employees had field experience and at the same time the District was undergoing reduction in force of personnel with similar backgrounds. Placement was further aggravated by the fact that other missile projects were phasing out, too, resulting in far more

surplus personnel than needed for vacancies throughout the CEBMCO organization.

PART II

CONSTRUCTION HISTORY

3. SCOPE OF WORK

GENERAL

The Beale T-5 Project consists of a 3 x 3 configuration of one squadron of TITAN ICBM Facilities, comprised of three complexes of three missiles each. The three sites are located near the cities of Lincoln (Complex 1A), Live Oak (Complex 1B), and Chico (Complex 1C) in Northern California and are arranged in a pattern around Beale Air Force Base near Marysville, which is the support base for technical, administrative and logistical support. All site investigations, topographic explorations and surveys were performed by the Sacramento District. Design of the launcher facilities was performed by an Architect-Engineer under the guidance of the Air Force Ballistic Missile Division. The Sacramento District accomplished the design of access roads and constructed the water wells at Complexes 1B and 1C. The combined bid documents were reviewed in the District and subsequently advertised and awarded by the District. The low bid received was submitted by the Peter Kiewit Sons' Company, in the amount of $30,157,150.50, of which one-third is attributable to each of the three sites. In addition, approximately $5,000,000 worth of Government furnished equipment was also involved in the construction. Completion of construction was scheduled to allow phase occupancy by the Air Force with the latest increment completed 1 February 1962. Construction was initiated on 22 January 1960.

TITAN MISSILE COMPLEX

The Intercontinental Ballistic Missile (ICBM) facility described herein is one of three such complexes constructed by the Corps of Engineers Beale Area Office for the Air Force. The several sites are located in the vicinity of Lincoln, Sutter Buttes and Chico. Essentially each of these are the same.

Each complex includes three missile silos with attendant propellant and equipment terminals; a control center; a powerhouse; two antenna silos; entry portal; and a system of tunnels, which connect the various elements. The attached diagram and sketch show the relative locations and configurations of the various components which comprise the complex.

The missile silos are approximately 155 feet in depth and have an inside diameter of 40 feet. The concrete walls of the silos have a thickness of from 2 to 3 feet. The top of each silo is covered with two horizontal leaf concrete doors weighing 125 tons each. The interior of the silo is fitted with an elevating mechanism which raises the missile into firing position.

The propellant terminals are cylindrical subsurface structures which contain the liquid fuels of the missile, in high pressure bottles, until the missile is to be readied for firing. This component is approximately 25 feet in diameter, approximately 25 feet in depth and covered by about 18 feet of earth.

The equipment terminals are also cylindrical subsurface structures having a diameter of 40 feet, a depth of 60 feet and covered by 16 feet of earth. This feature provides for housing

air conditioning equipment, work shop space and space for certain types of technical equipment.

Both the power house and the control center are hemispherically shaped subsurface structures. The power house contains four diesel electric generators and accompanying switchgear, thus allowing the entire installation to be independent of outside sources of power. The control center contains that equipment which is required to be the nucleus of operations within the complex.

Radar detection equipment is housed and operated from two antenna silos. These silos are 25 feet in diameter and are 65 feet in depth. Elevating mechanisms raise the radar detectors above the ground surface when this equipment is in use.

All of the structures in the complex are connected by a system of tunnels. In general, the tunnels are approximately 9 feet in diameter and about 30 feet below the surface of the ground.

To protect the structures and the equipment contained within them from the shock of atomic blast, protective construction requirements were designed into the project. Some of these requirements include the provision of "rattle space" for all floor slabs, and the shock mounting of all piping, equipment and fixtures.

MISSILE COMPONENT CONTRACTORS

The following associate contractors worked under the supervision of SATAF to develop the missile component indicated:

Martin Company	- furnishing the air frame including assembly and test of the missile
Bell Telephone Company	- radio guidance system
Remington-Rand-UNIVAC	- computer system
A. C. Spark Plug	- initial guidance system
Aerojet General Corp.	- propulsion system
Avco Corp.	- re-entry vehicle
American Machine and Foundry	- launcher system
A. D. Little	- propellant loading system

UTILITIES

The utilities during construction (as required by the specifications) were provided by the contractor. Commercial power was available at all three complexes.

Water at Complex 1B and Complex 1C was available from the water wells at the sites provided by contracts completed prior to award of the launcher contract. Water at Complex 1A was available from the city of Lincoln main located adjacent to the complex.

ACCESS TO SITES

The three launch sites have all-weather access roads from existing county or state roads. Road construction to the sites was one of the first scheduled items of work and was required to start during winter and inclement weather conditions.

Lincoln Site. The Lincoln site had temporary access over a rancher's cattle road for approximately three months, during which time the permanent access road was constructed. The permanent route, consisting of approximately 2,700 lineal feet

of road, was constructed from State Route No. 91 to the site property line.

Buttes Site. The Buttes site had no temporary means of access and required accelerated construction of the permanent road. This permanent access road, consisting of approximately 7,100 lineal feet, was constructed from an existing paved county road to the site property line.

Chico Site. The Chico site has two means of access by road. To the south of the site, a double bituminous surfaced road was constructed, which connected the site with a county road, Cohasett Road. This access road followed an existing dirt road to the site property line. This access road is still being used because of the shorter distance from the town of Chico.

The permanent access road to the Chico site was constructed and consists of 3,314 lineal feet of road from a county road, Kieffer Lane, to the site property line.

The nearest railroad facilities to the sites are located at Lincoln, Live Oak and Chico.

VICINITY MAP

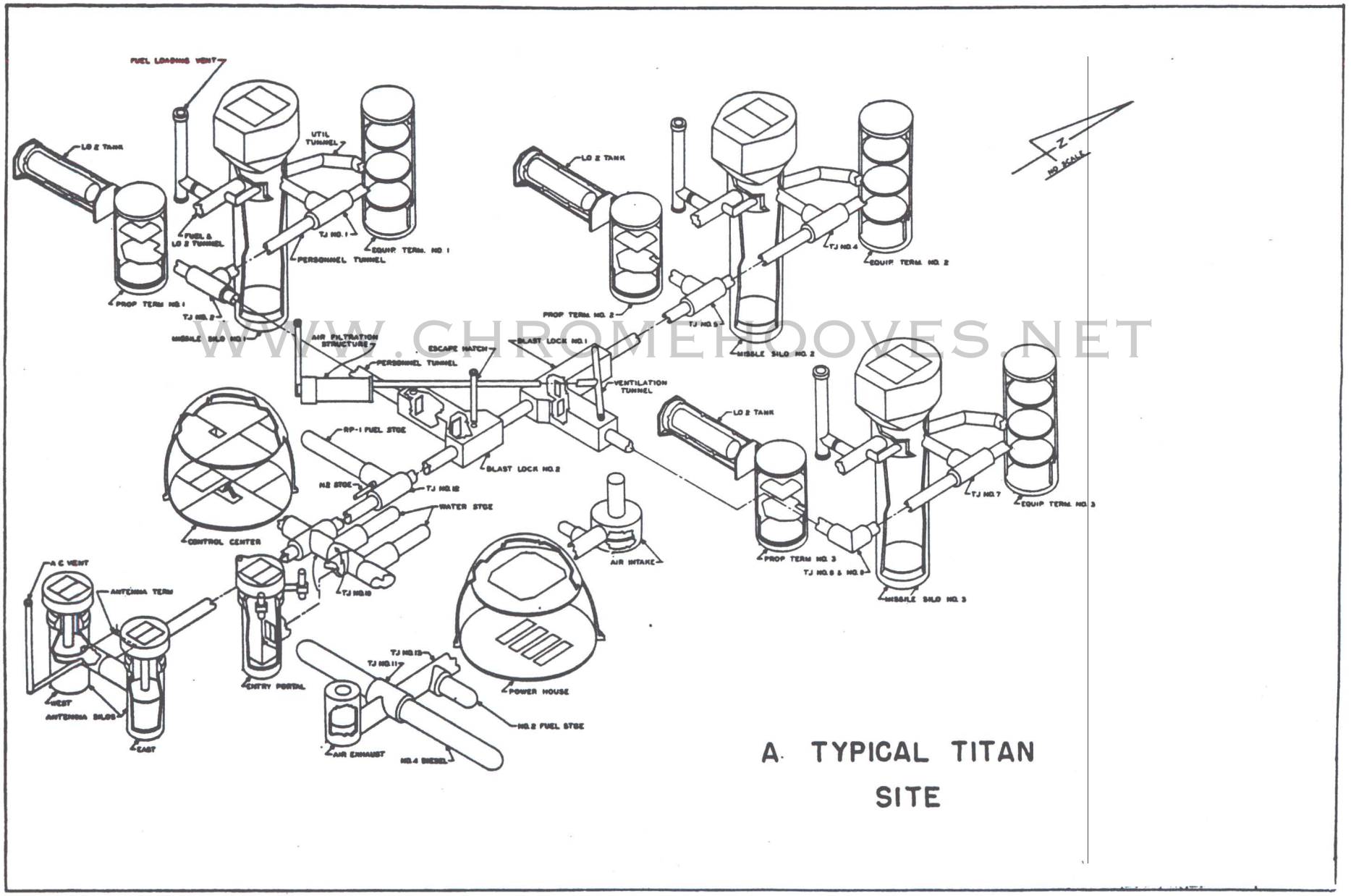
Figure 8 is a map showing the locations of the three complexes: 4A, Lincoln, 4B, Buttes and 4C, Chico, respectively.

These launcher sites are all within a sixty mile radius of Beale Air Force Base.

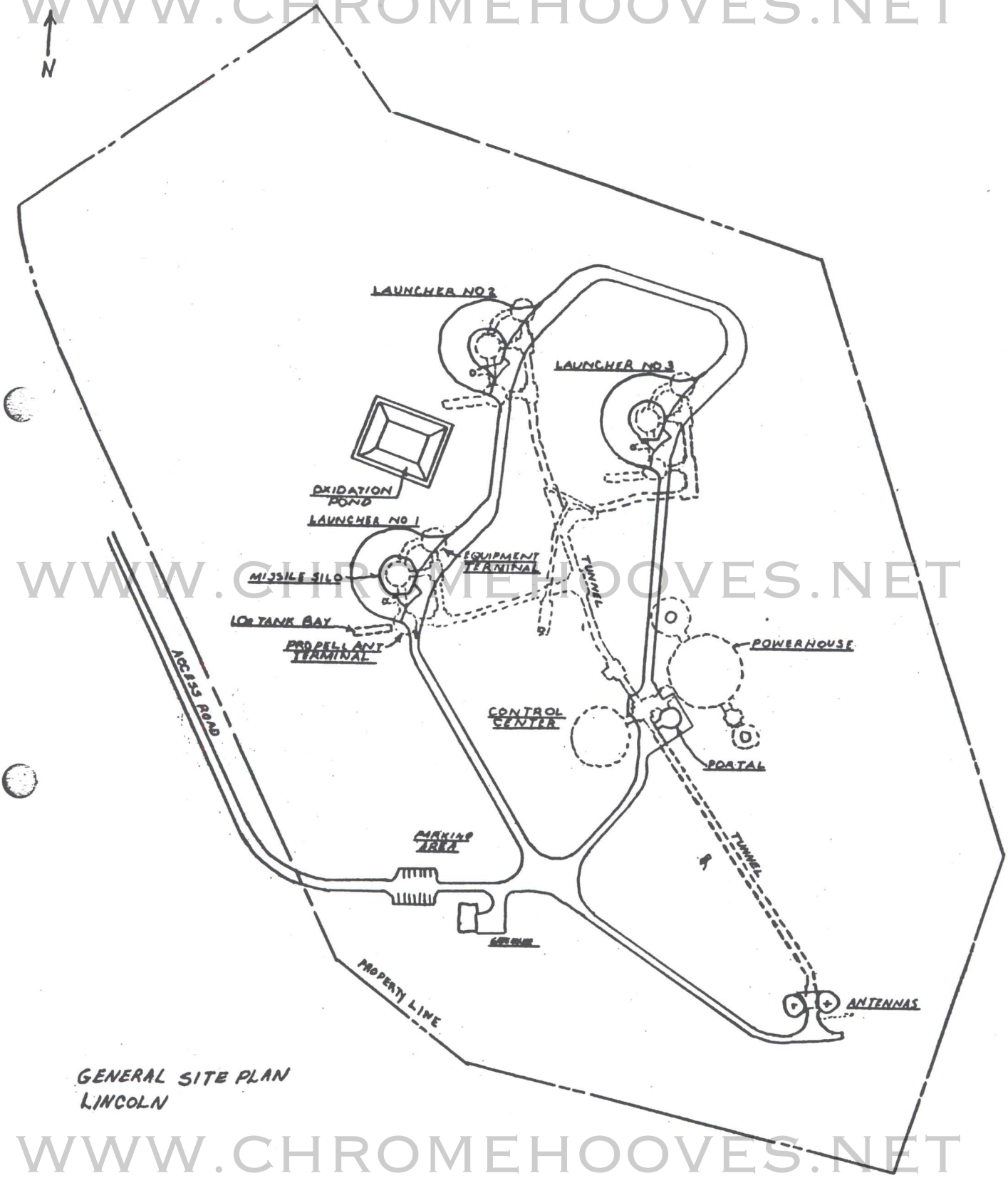
WEATHER

The yearly mean temperature in this area is 61°F, varying from a maximum of about 110°F to a minimum of about 25°F.

The mean monthly temperatures vary from about 44°F in January to 79°F in July. The mean monthly precipitation is a minimum of 0 in July and a maximum of 5.8 in December. Freezing is rare and there is no snowfall. (See Figure 9)

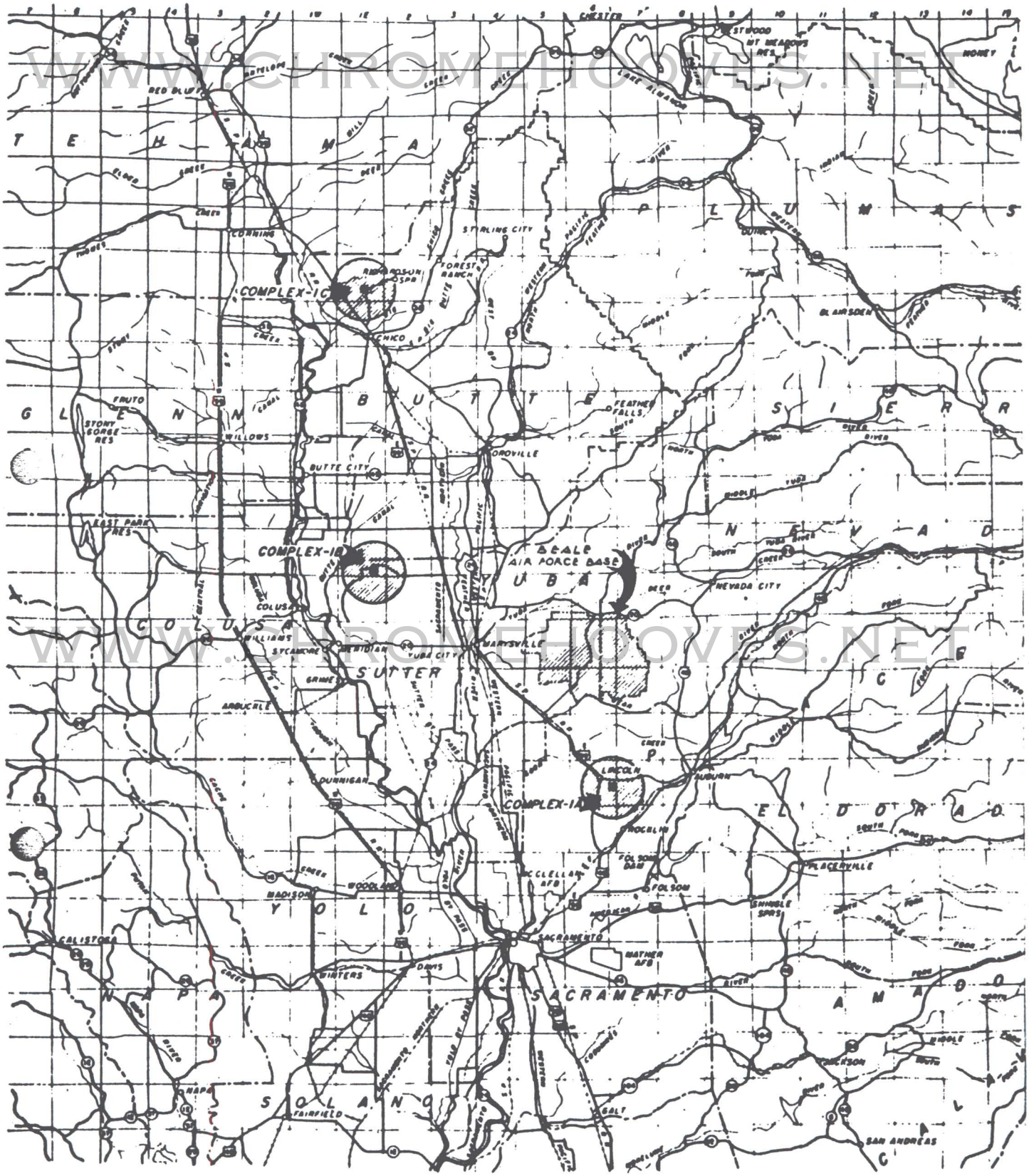


A. TYPICAL TITAN SITE



GENERAL SITE PLAN
LINCOLN

Fig. 7



VICINITY MAP
SCALE 1" = 6 MILES

Fig. 8

TAB 3-C

BEALE

TABULATION OF PRECIPITATION AND TEMPERATURES

AT CHICO, CALIFORNIA

PRECIPITATION (30 YEAR PERIOD)

	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.
NORMAL	.09	.19	1.59	2.62	5.78	4.67	4.22	3.44	2.30	1.10	.44	.01	.09	.19	1.59	2.62
1960-61	.0	.04	.44	5.44	2.10	4.55	3.47	3.70	.99	.66	.44	.01	.10	.40	.23	3.55

TEMPERATURE (20 YEAR PERIOD)

NORMAL	76.3	72.5	63.0	52.6	45.7	44.4	48.4	52.9	58.9	65.9	72.3	78.6	76.3	72.5	63.0	52.6
1960-61	77.0	73.5	63.1	52.7	44.9	42.9	50.9	52.5	59.3	63.0	77.4	79.5	78.6	70.6	63.1	51.1
AVG.MAX.	96.1	92.1	78.6	62.6	53.0	49.8	60.9	62.4	74.8	77.5	95.8	100.3	95.7	88.3	79.9	64.3
AVG.MIN.	57.9	54.8	47.6	42.8	36.8	36.1	41.0	42.5	43.8	48.5	58.9	58.6	61.8	52.9	46.4	38.0

YEARLY MEAN TEMPERATURE = 61.0° F.

NOTE: CHICO EXPERIMENT STATION CONSIDERED REPRESENTATIVE OF WEATHER PATTERN AT ALL THREE SITES.

Fig. 9

4. GEOLOGY OF THE SITES

SITE 1A - LINCOLN

The site is in the foothills of the Sierra Nevada about 40 to 50 feet higher than the adjacent Sacramento Valley. The area has rolling topography with an irregular drainage pattern to the west and southwest. The ground surface was strewn with occasional quartz cobbles and had a thin cover of native grass and oak trees with scattered outcrops of granite on the eastern edge of the site.

The site was underlain by a medium grained granite with a thin cover of overburden. The rock was granodiorite, referred to as granite. The overburden ranged from 4 to 18 feet which graded into a highly decomposed granite in thickness from 24 to 38 feet. The granite became progressively harder with depth, and was fresh, sound rock from 60 to 70 feet. The overburden was composed of a red, brown, sandy silt with subrounded gravels and occasional cobbles.

Ground water was encountered at about 20 to 30 feet below the ground surface. The approximate flow from a Missile Silo was 10 gallons per minute.

SITE 1B - BUTTES

The site is on the crest of one of the radial ridges on the north side of Sutter Buttes. The Sutter Buttes are nearly a circular cluster of hills about ten miles in diameter, which rise

abruptly from the floor of the Sacramento Valley. They are the remnants of an extinct volcano. Drainage of the site is to the north and east. The ground surface at the site was strewn with cobbles and boulders of andesite. There was scant cover of native grass and oak trees. Average ground slope was about $3\frac{1}{2}$ degrees to the north.

The site was underlain by a nearly homogeneous mixture of silt, sand, gravel, cobbles and boulders, all of volcanic origin with a predominence of tuffaceous silt and sand.

Ground water was encountered at 100 to 120 feet below ground surface. The approximate flow from a Missile Silo was 400 gallons per minute.

SITE 1C - CHICO

This site is located in the foothills of the Sierra Nevada range and is about 100 feet higher than the adjacent Sacramento Valley floor. This location is approximately six miles northeast of Chico, California. The immediate area is quite flat with a gradual slope to the west. Drainage on the north and south sides of the site is carried off by creeks flowing almost due west. The ground surface of the area is covered with cobbles from 2 inches to 12 inches in diameter. Lava outcroppings are prevalent throughout the adjacent areas. Oak trees are clustered throughout the areas in the near vicinity.

The site was covered with a gravelly, sandy silt to an average depth of six feet. This was heavily cemented and consolidated. The next ten to twelve feet consisted of lava

(andesite) grey, hard, fractured with clay in the joints. The material in the lava cap consisted of various layers of mixed lenses of gravelly, sandy silt and sandy silt. This generally was from eighteen feet to fifty five feet. Below fifty five feet the material consisted of agglomerate, grey brown, fine to medium grained sand matrix with angular volcanic fragments, moderately to well cemented.

Ground water was encountered at 140 feet below the ground surface. The approximate flow from a Missile Silo was 500 gallons per minute.

5. EXCAVATION AND BACKFILL

EXCAVATION

The contractor elected to use the open cut method of excavation for the tunnels and as a partial excavation for the Launcher structures and the Antenna Silos. Finished open cut depths were approximately 40 feet in the Launcher areas, 55 feet in the Powerhouse-Control area and 40 feet in the Antenna Silos area. (See Figure 10 . These depths varied in accordance with existing ground elevations. The open cut for the tunnels was taken to 12 feet above the tunnel invert. A tunnel cut was made with bottom width of 8 feet and top width of 21 feet. The width at limit of open cut excavation was 41 feet, leaving 20 feet for roadway. (See Figure 11) Ramps were constructed out of each Launcher area, the Control Center-Powerhouse area and the Antenna Silos area. All ramps had maximum 12 per cent slopes.

Parish Bros. of Benicia, California was the subcontractor for the open cut excavation at Site 1A. At Sites 1B and 1C, Murphy Bros. of Spokane, Washington was the subcontractor.

Parish Bros. utilized DW 20's, DW 21's, DW 10 Side Dumps, D8 Cat Dozers, one with ripper, a D9 dozer with ripper, motor patrol, and a Northwest 80 shovel. (See Figure 12) Their operation was on a 10 hour, six day a week basis. Start of operations was on 22 January 1960 and completion on 27 June 1960. At Site 1B, Murphy Bros. utilized Euclid TD 24's and TD 18's, D8 Cat Dozers, two with rippers, and motor patrol. (See Figure 13) Their operation was on two 9 hour shifts, six days per week basis.

Start of operations was in February 1960 and completion in May 1960.

At Site 1C, Murphy Bros. utilized Euclid TD 24's, TD 18's, D8 Dozers, two with rippers, Euclid Dump Trucks and Huff Loaders. (See Figure 14) Their operation was on two 9 hour shifts, six days a week basis. Start of operations was in March 1960 and completion in May 1960.

During the early stage of the open cut excavation at Site 1A, operations were slowed because of the muddy ground conditions. After pioneer excavation this condition was lessened and operations proceeded normally. At Site 1B the mud was not as extensive as at Site 1A and the excavation operations were not severely hampered. At Sites 1A and 1B considerable overrun for excavation of the access road occurred because of the saturated condition of the subgrades. However, at Site 1A, placement of the select sub-base proceeded rapidly due to the fact that the decomposed granite from the open cut was utilized for the select material. The short haul, together with the excellent compaction characteristics of this material, compensated considerably for the time lost because of over-excavation.

At Site 1A, a changed condition of the foundation occurred during the open cut excavation of the Power House area. (See Figure 15) Information as shown on the contract drawings indicated the hardened granite would start occurring near bottom grade of the open cut excavation. However, this granite, especially in the easterly part of the area, appeared at elevations considerably above that indicated. The contractor was required to drill and blast to remove rock. In the launcher areas only a few rounds of

blasting were needed for rock removal.

Four significant slides occurred at Site 1A. Two of these slides happened in the tunnel cut from Blast Lock #1 to Launcher #2 (See Figure 16), one in the Blast Lock #1 cut and one on the east Powerhouse cut. There were numerous smaller slides and potential slide areas. These slides and potential slide areas were stabilized by berms, flattening of slopes and by shoring. (See Figures 17 and 18)

At Site 1B no unusual problems were encountered during the open cut excavation. Due to the type of soil, severe muddy conditions did not prevail. The in-place material was stabile and no sloughing of the cut slopes occurred.

At Site 1C a muddy condition existed which slowed excavation until pioneering had been accomplished. The removal of the lava cap, approximately 6 feet below existing ground surface and approximately 12 feet in depth required drilling and blasting. Approximately 150,000 cubic yards of rock was removed. Below the lava cap to bottom of open cut excavation, no unusual problems occurred. (See Figure 19) There was no sloughing of the cut slopes.

Ground water did not present a problem at any of the three sites during the open cut operations.

SHAFT EXCAVATION

The excavation of the shafts for the Missile Silos, Equipment Terminals and Propellant Terminals was part of the Prime Contractor's work. The operation was carried out on a 3 shift, 6 day a week basis at all three sites. Equipment used at each site consisted of a

Fig. 10

Excavation of Launcher #1, Site 1A

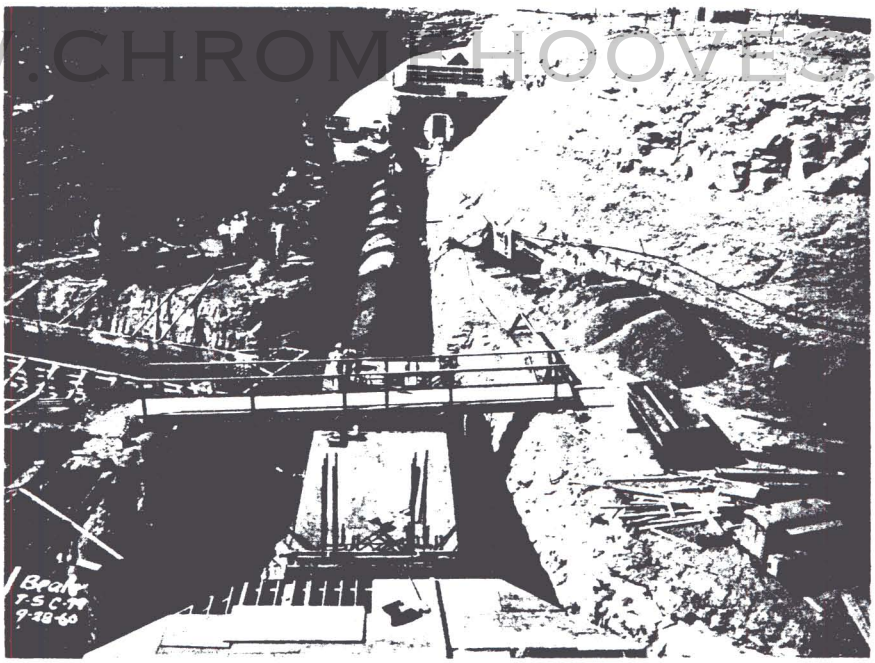


Fig. 11

Tunnel Excavation, Site 1C

Fig. 12

Excavation of Launcher #1, Site 1A

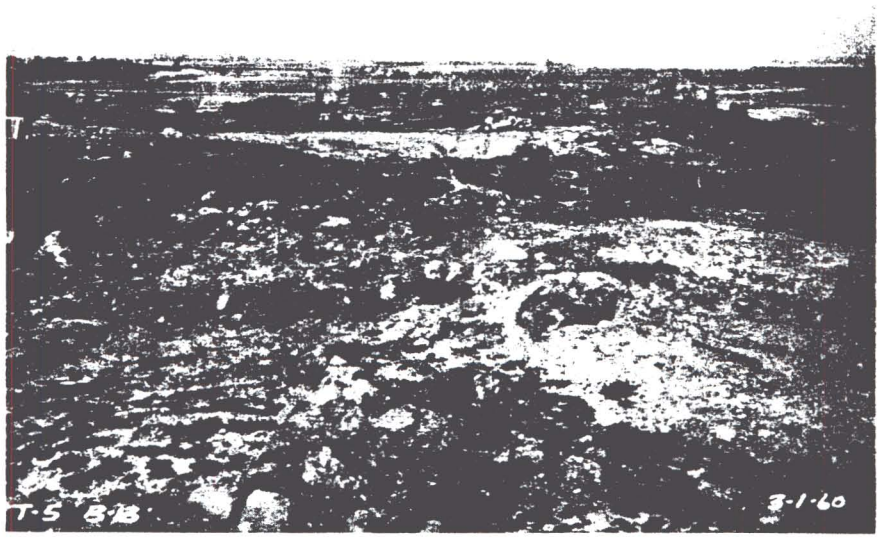


Fig. 13

Open Cut Excavation, Site 1B

Fig. 14

Open Cut Excavation Showing Huff Loader,
Launcher #2, Site 1C

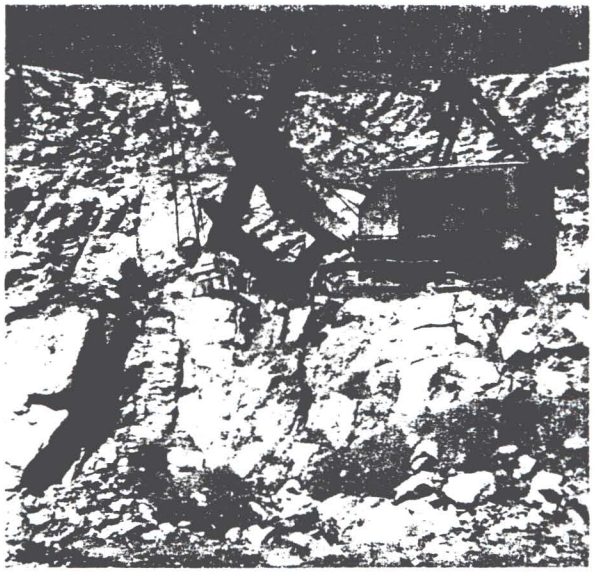


Fig. 15

Excavation-Powerhouse Area Showing Rock, Site 1A

Fig. 16

Launcher #2, Site 1A, Showing Slide

Fig. 17

Open Cut Excavation Showing Berm,
Launcher #2, Site 1A