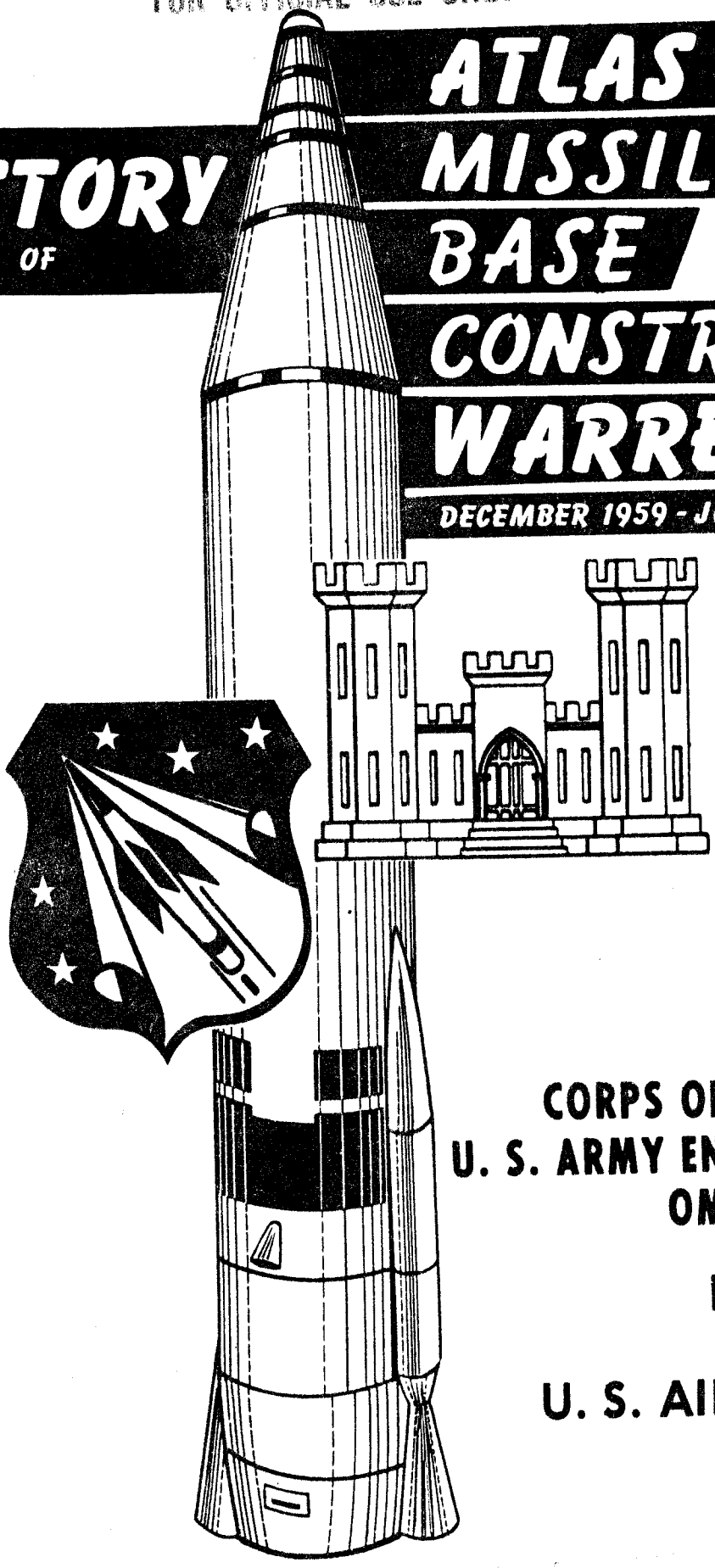
HISTORY OF ATLAS MISSILE BASE CONSTRUCTION WARREN III

DECEMBER 1959 - JULY 1961



BY
CORPS OF ENGINEERS
U. S. ARMY ENGINEER DISTRICT
OMAHA

FOR

U. S. AIR FORCE

HISTORICAL SUMMARY REPORT

OF

MAJOR ICBM CONSTRUCTION

PREPARED BY:

T. A. Coffey

M. A. Badtke

and

E. Thompson, Jr.

APPROVED BY:

Chief of Construction Division

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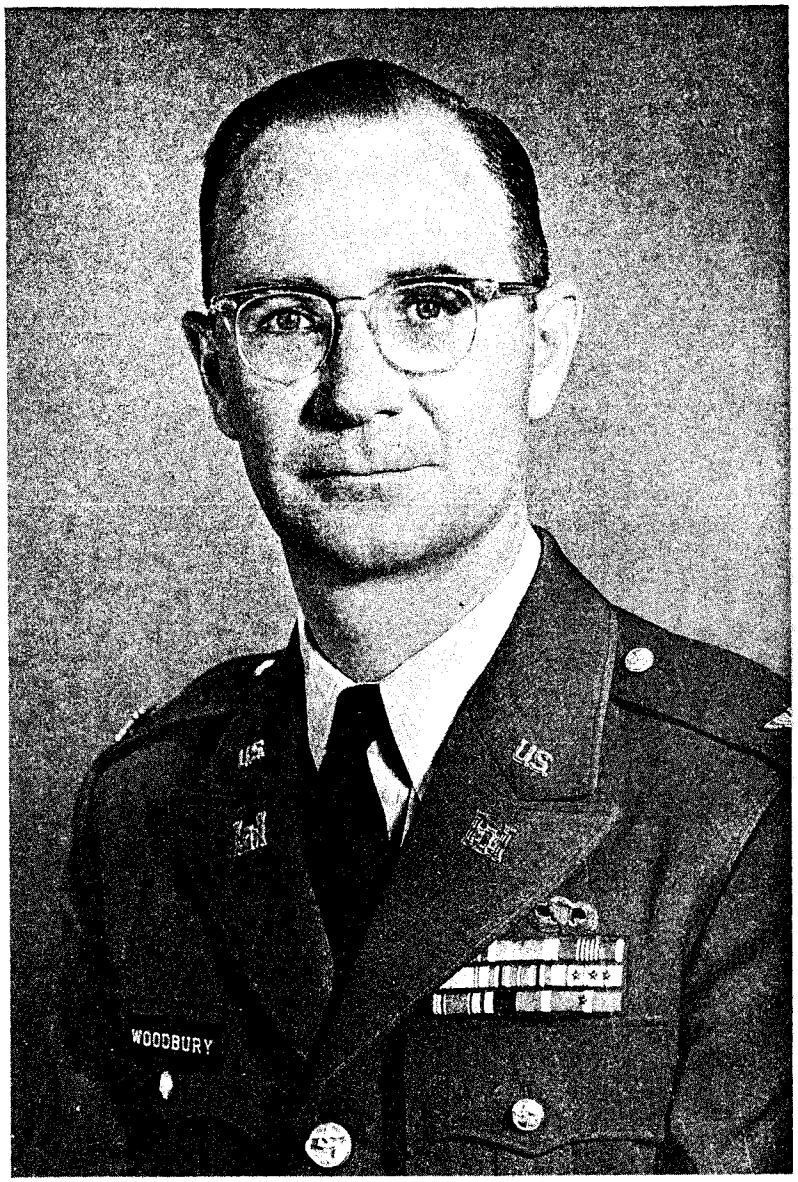
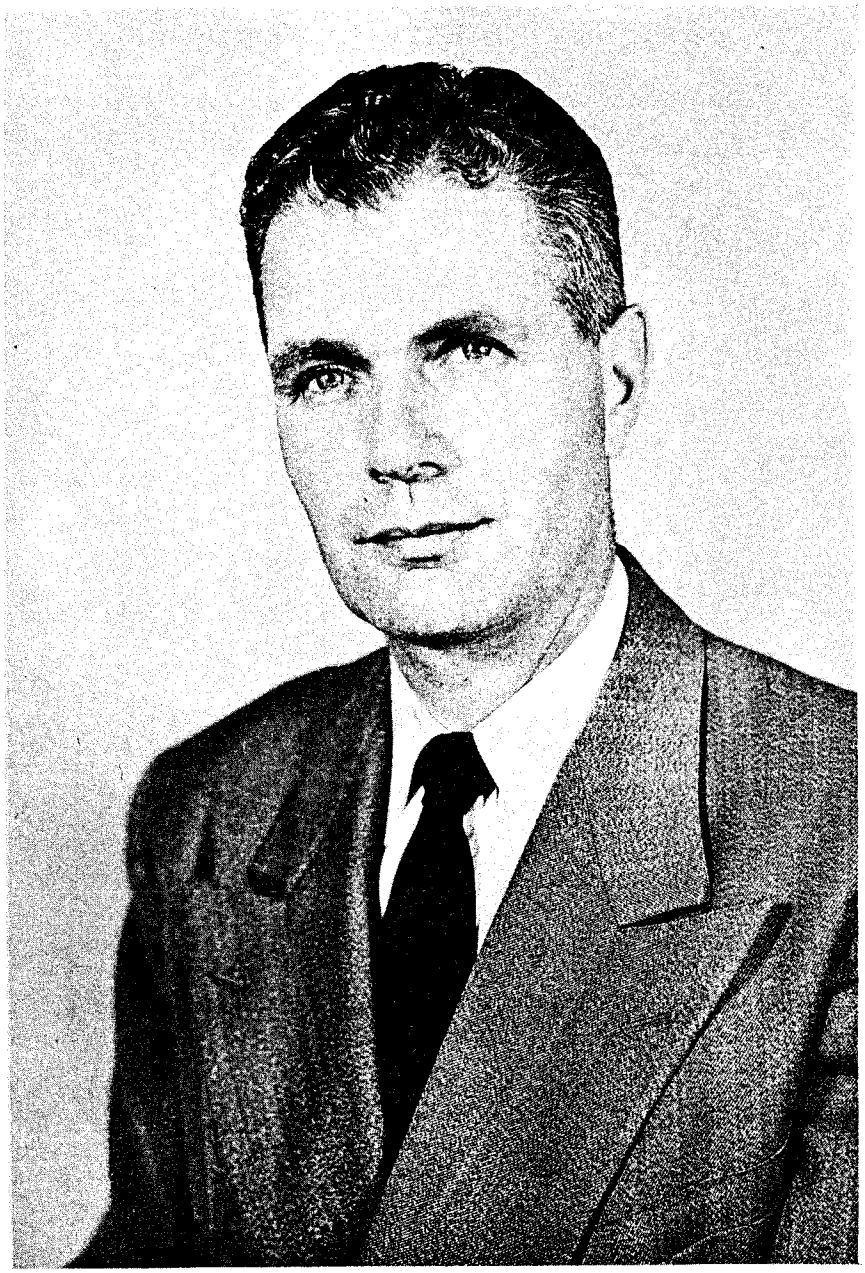


Colonel Harry G. Woodbury, Jr.

Omaha District Engineer 16 July 1960

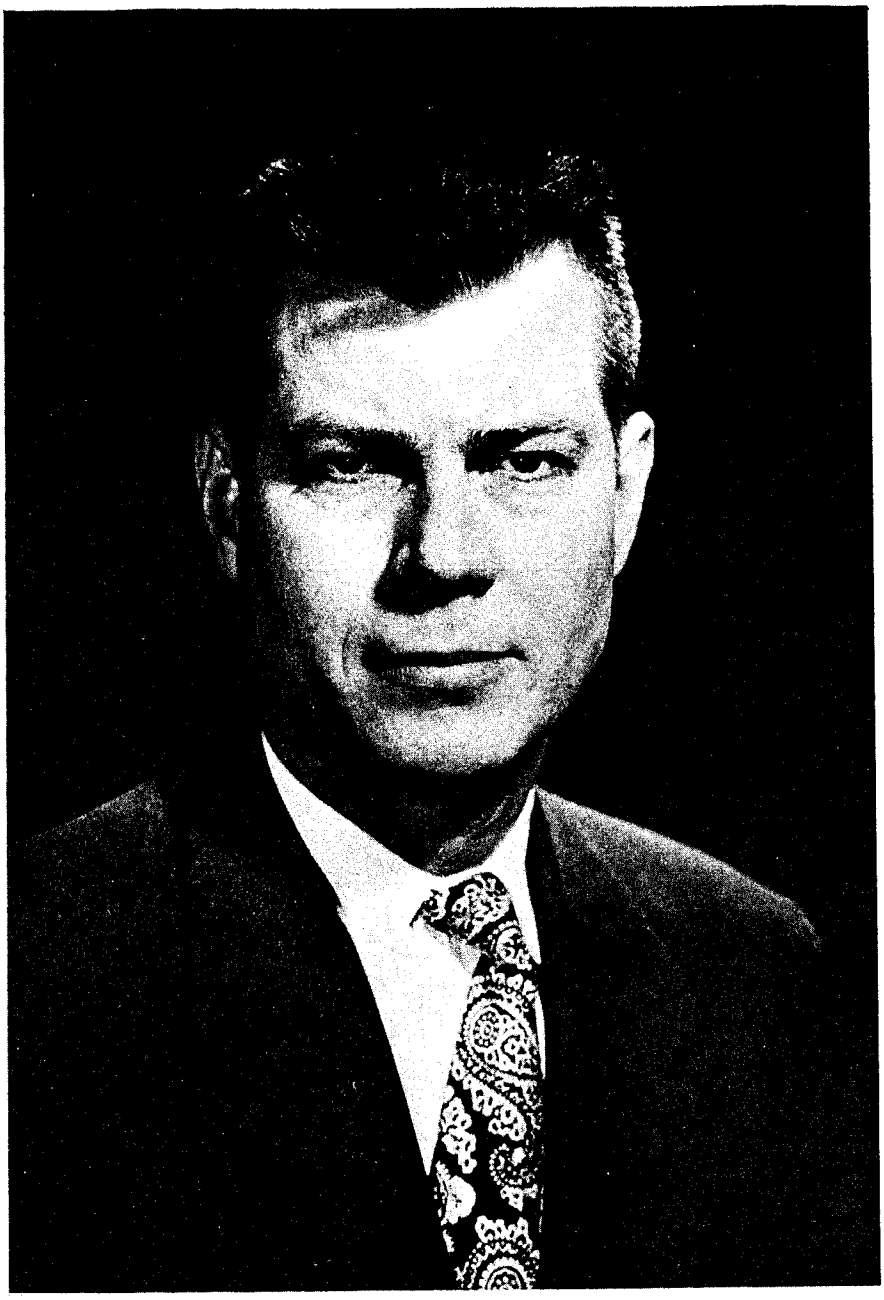
Colonel Sidney Martin

Cheyenne Area Engineer
30 June 1958 - 12 July 1961



Joseph C. Patterson

Acting Area Engineer 30 May 1958 - 30 June 1958
Assistant Area Engineer 1 July 1958 - 2 Oct 1960



William T. Black
Supervisory Construction Engineer, General
July 58 - June 61

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F. E. WARREN MB - SQUAD III

SECTION I
DESCRIPTION OF PROJECT - MAPS

The Squadron III launch facilities are of the semi-hard (designed for 25 lbs per sq inch over-pressure) type. They were built on a 1 x 9 concept, with single launchers at each of 9 sites (identified as Sites 1 through 9 on the site location map). Each of these launch facilities consists of a launcher and a launch operations building built with roofs approximately at ground level and connected by a tunnel.

The main launcher facilities were built by the Eby Construction Comapny of Wichita, Kansas. Work began on 7 December 1959; earliest scheduled completion for a site was 1 January 1961 with scheduled completion dates for additional sites at 15 day intervals extending to 1 May 1961. The contractor stayed a little ahead of schedule on the over-all contract. The original current working estimate for Squadron III was approximately $28,300,000 and the estimated final cost is $33,504,000. For a detailed cost growth study of the project, see Section 5.

ATLAS MISSILE DATA

The United States' first ballistic missile project, the SM-65 ATLAS, has entered the final phase of its development program. It is powered by a cluster of liquid propellant rocket engines, burning liquid oxygen and RP-1, a kerosene-like hydrocarbon fuel, and is designed to deliver a thermonuclear warhead 6,325 statute miles.

The propulsion unit consists of two large booster engines in the

first stage, one sustainer engine and two small "vernier" rockets in the second stages. All five rockets are ignited prior to launching. After a few minutes of flight during which time the missile is propelled well into its trajectory the two booster engines and associated equipment are jettisoned to reduce the load. The sustainer engine continues to accelerate the missile until a velocity of approximately 16,000 MPH is reached. The "vernier" rockets are then used to trim the velocity to the exact value required. After the vernier guidance is discontinued, the missile will follow a purely ballistic or unguided course to the target area.

As the vernier is shut down, the nose cone becomes disassociated from the rocket framework. The remaining framework is destroyed by aerodynamic heating.

The rocket control is accomplished by the guidance system which essentially employs radioinertial guidance through the early portion of the rocket's flight. This is basically a radio control system.

The missile structure consists of thin gauge stainless steel and the missile contains approximately 300,000 parts not including the ground support equipment.

DESIGNATION:	SM-65
PRIME CONTRACTOR:	CONVAIR, Ramo-Wooldridge
STATUS:	Development Production
RANGE:	6200 miles (approx.)
VELOCITY:	16,000 mph max.
FRAME:	
Stages:	($1\frac{1}{2}$)

Manufacturer:	CONVAIR
Length (Overall), ft:	75 (approx.)
Diameter (Body), ft:	10
Weight (Gross), lb:	243,000
Material (Major):	Steel
GUIDANCE:	
Manufacturer:	GE/Burroughs
Type:	Radar-Doppler Command
POWER PLANTS:	
First Stage (Booster)	
Manufacturer:	Rocketdyne
Propellants:	Liquid Oxygen and Kerosene
Type & Number:	Regenerative Liquid (2)
Thrust, lb:	300,000
Sustainer:	60,000 lb.
WARHEAD:	
Type:	Nuclear

GEOLOGY, SOILS AND FOUNDATION REPORT

F. E. WARREN AIR FORCE BASE, WYOMING

AUXILIARY SITE "J"

INTRODUCTION:

This report contains Geology, Soils and Foundation Engineering data pertaining to F. E. Warren Air Force Base, Wyoming, Auxiliary Site "J". This site is located in Section 4, Township 11 North, Range 61 West, Weld County, Colorado, five miles north of Grover, Colorado.

The data presented herein include regional and local geology, report on foundation conditions, recommendations as to foundation design for the proposed structures and appurtenances, results of laboratory tests of soil and foundation strata, results of field percolation tests, and logs of exploratory borings. These data were obtained from studies made of surface exposures and subsurface core samples, field tests, laboratory analyses of subsurface samples and borrow soils and field and office geological and engineering studies.

GEOLOGY

GENERAL:

The F. E. Warren Air Force Base, Auxiliary Site "J" is located in the west-central portion of the Denver basin, a structural basin, located in eastern Colorado, southeastern Wyoming, western Nebraska, and northwestern Kansas. The surface axis of the basin, in rocks of Tertiary Age, centers at Julesburg, Colorado, in the far north-eastern corner of the state. The axis of the structural basin in Cretaceous and older rocks centers along a line between Denver, Colorado, and

Cheyenne, Wyoming.

Auxiliary Site "J" is located in the extreme north-central portion of Weld County, Colorado, 5 miles north of Grover, Colorado, and 6 miles east of Hereford, Colorado. The area in the immediate vicinity of the site is devoted to agriculture, predominantly dry farming for growing wheat. No surface drainage courses of any consequence are located in the vicinity of Auxiliary Site "J".

REGIONAL GEOLOGY:

Structural Geology:-Structurally, the Denver basin has its center along an axis from Denver, Colorado, to Cheyenne, Wyoming. The surface axis of the basin, in rocks of Tertiary Age, centers near Julesburg, Colorado, in the extreme northeastern corner of the state. For the most part, sediments exposed on the surface within the confines of the basin are Upper Cretaceous and Tertiary in Age.

The Denver basin is asymmetrical. It has a gentle eastern flank from the Chadron Arch and the Las Animas Arch to its center. Its western boundary is abrupt in the mountain front adjacent to its synclinal axis. The present structural configuration of the basin is the result of a long series of tectonic adjustments. The epeirogenic and orogenic adjustments have taken place continuously from pre-Cambrian time to the present.

Sedimentary Geology:-Sediments penetrated by core borings at Auxiliary Site "J" are formations of lower Tertiary Age. Tertiary time was inaugurated by major orogenic movements that broke up the Cretaceous seas and formed the mountain ranges of northern New Mexico, central Colorado, and southeastern Wyoming. The mountains

that were formed at this time were surrounded by numerous inland lakes. These lakes existed through most of Tertiary time and became the catchment areas of several hundred to more than three thousand feet of sediments. The Tertiary sediments vary from lacustrine to eolian and from conglomerates to siltstones and claystone, corresponding to the oscillation of water depths, and correlative with the advance and retreat of the lake shores and changing climatic conditions.

Characteristic of the Tertiary sediments is the apparent lack of consolidation resulting in reasonably high porosity and light unit weight. This condition can probably be ascribed to the deposition of the sediments as sheets in very shallow waters along with disturbance by wind and resulting interbedded eolian deposits.

Coincident with the later part of the orogeny of the Denver and Julesburg basins and following the deposition of the Tertiary sediments, which were derived from the newly forming mountains, the entire basin was tilted toward the east. With this tilting the area assumed the configuration in which it is found today.

Stratigraphy:- The Tertiary sediments in the general area can be divided into four natural lithographic groups, each representing separate and distinct cycles of sedimentation. These groups are the White River, Arikaree, Hemingford, and Ogallala.

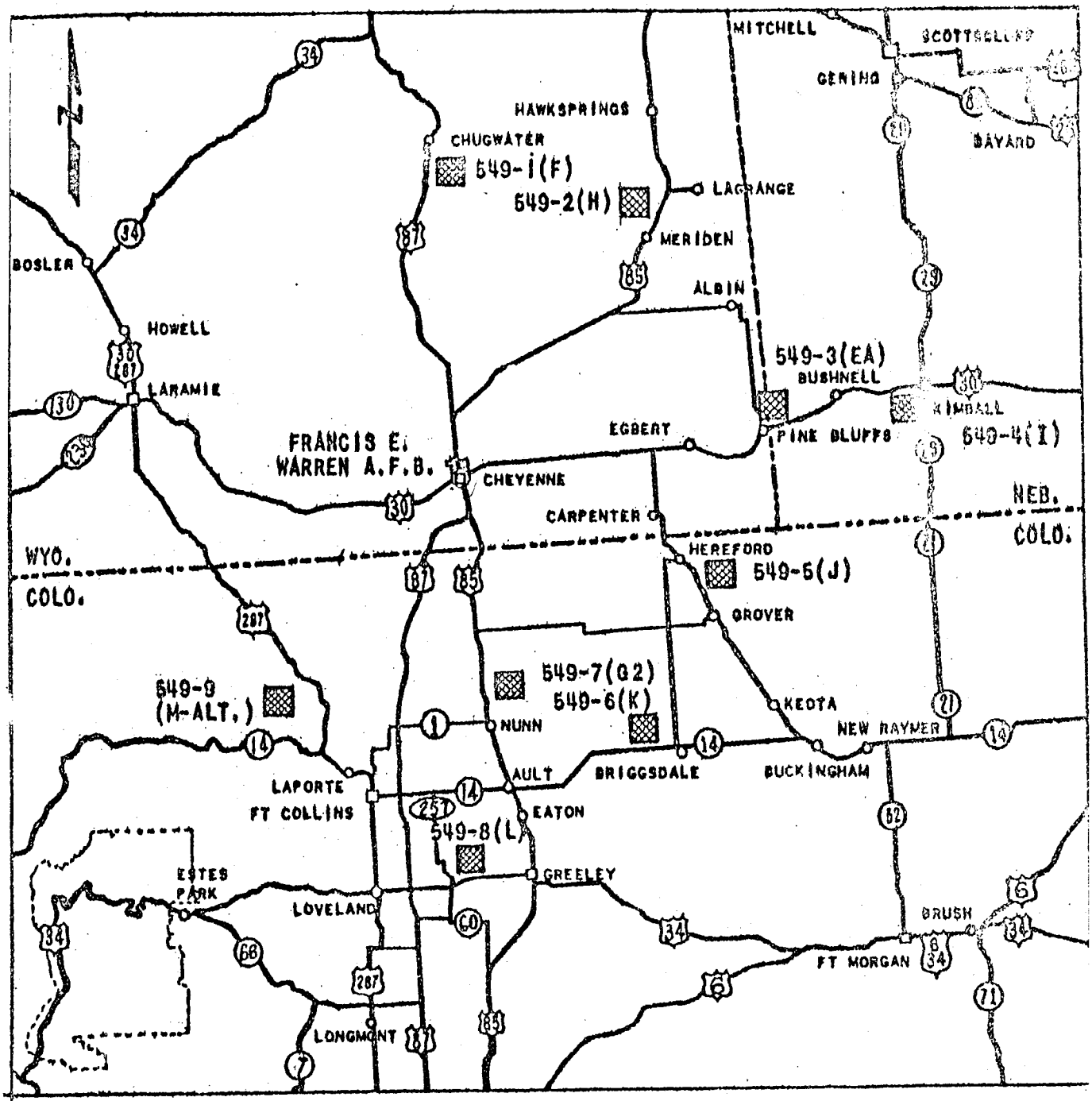
Auxiliary Site "J" is in the basal Tertiary, White River group, Brule formation. In northeastern Colorado, this formation consists of clays, silty and sandy claystones, and weak siltstones and sandstone. The Brule formation ranges from 300 feet to more than 600

feet thick in northeastern Colorado.

GEOLOGY OF AUXILIARY SITE "J":

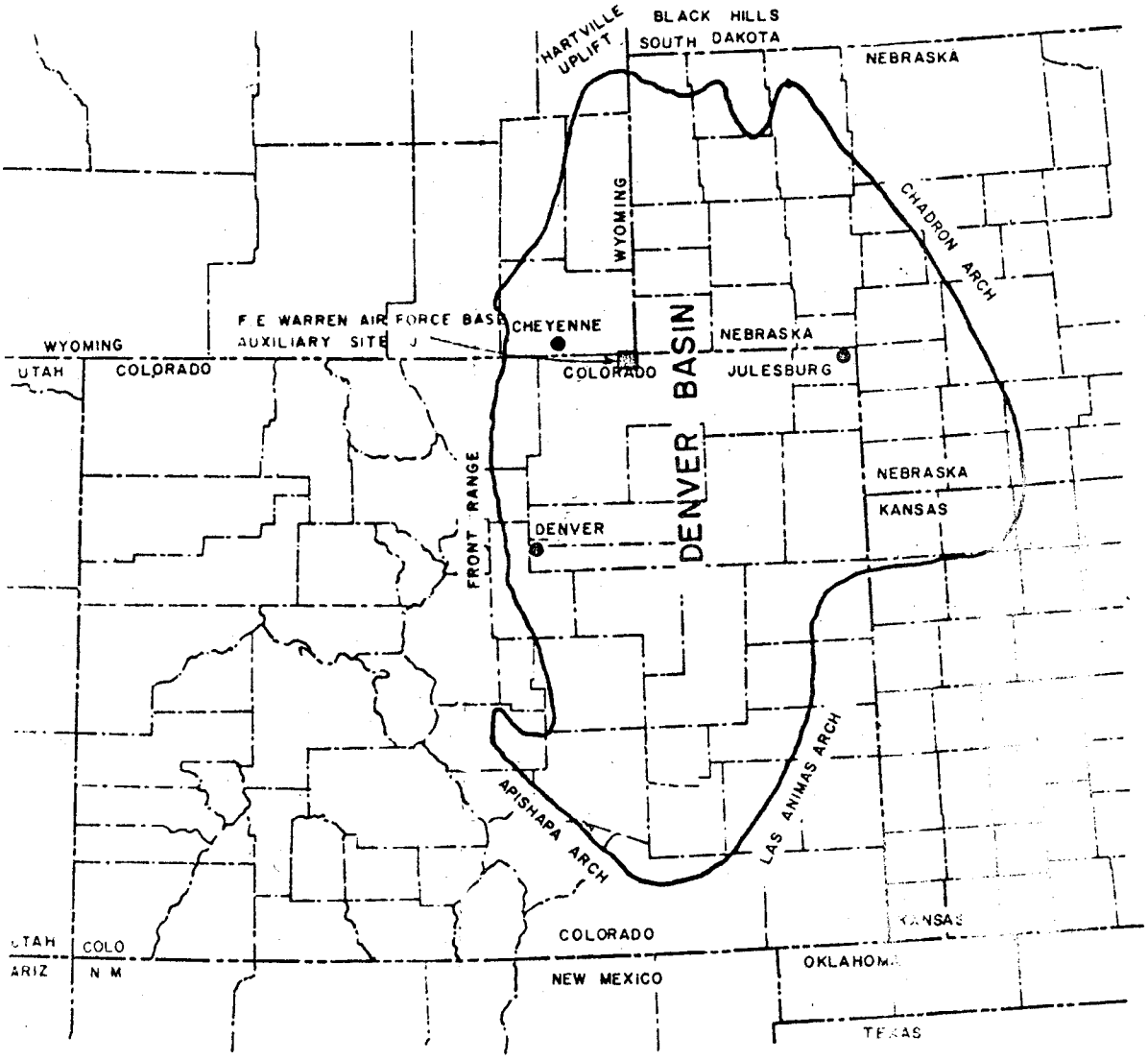
General:- Nearby outcrops and core samples lifted at the site indicate that bedrock is the middle portion of the Brule sediments. The formational boundaries were selected on the basis of lithology. No attempt has been made to differentiate between the upper and lower formations of the Brule sediments.

Vertical and horizontal fractures were encountered by the core borings in the upper portion of the Brule sediments. These fractures were quite numerous to a depth of fifty feet. It has been reported that the same fractures in the general area "are known to be as much as 1-foot wide and a mile long".



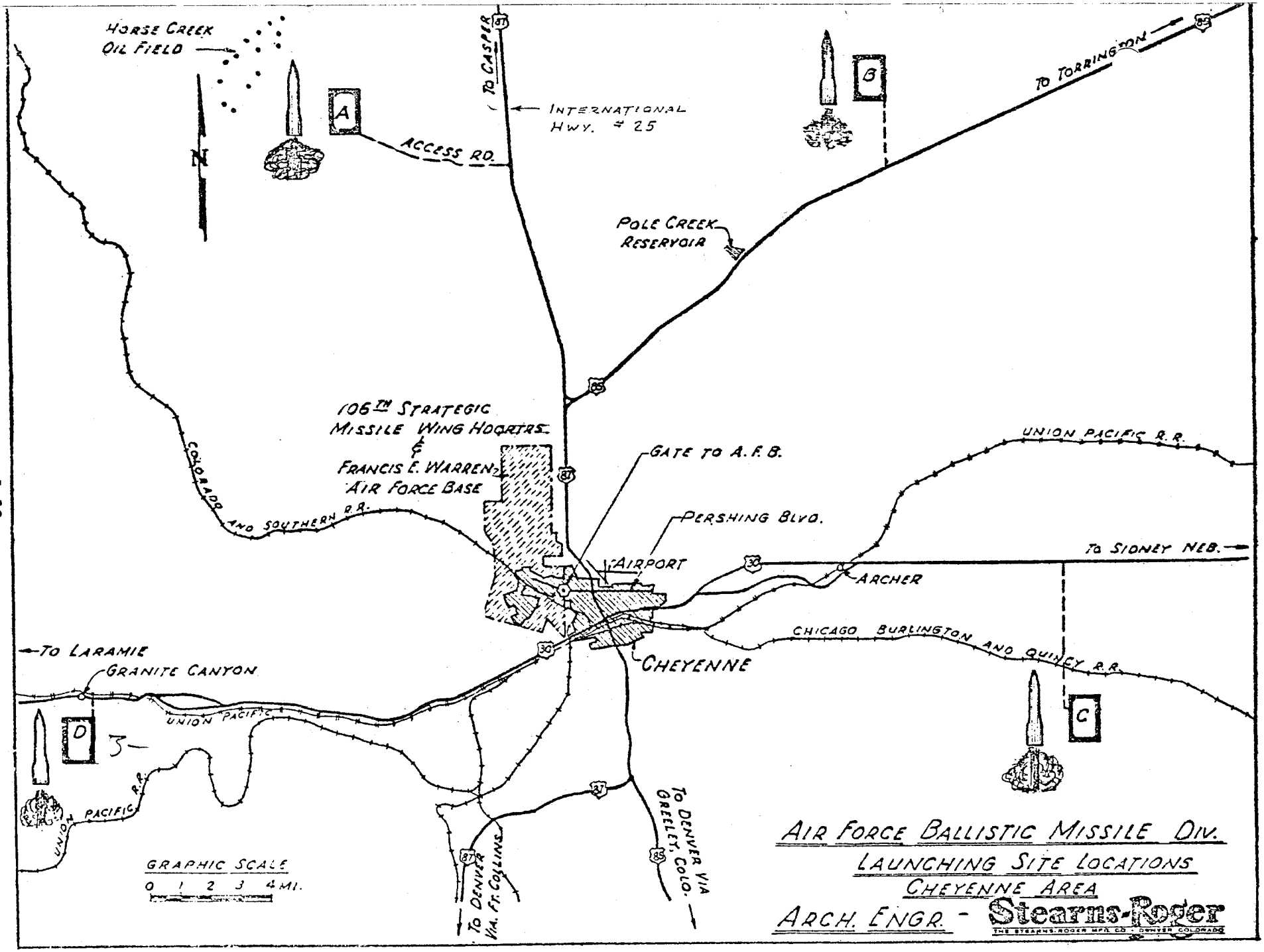
AIR FORCE BALLISTIC MISSILE DIV.
LAUNCHING SITE LOCATIONS
WARREN A.F.B. AREA

ARCH. ENGR. - Stearns-Roger



MAP SHOWING POSITION OF DENVER BASIN AND LOCATION OF AUXILIARY SITE J IN RELATION TO THE DENVER BASIN AND JULESBURG BASIN.

F. E. WARREN AIR FORCE BASE WYOMING
AUXILIARY SITE


HORSE CREEK OIL FIELD
A
ACCESS RD.
TO CASPER
INTERNATIONAL HWY. # 25
B
TO TORRINGTON
POLE CREEK RESERVOIR
106TH STRATEGIC MISSILE WING HDQRTRS. & FRANCIS E. WARREN AIR FORCE BASE
COLORADO AND SOUTHERN R.R.
GATE TO A.F.B.
PERSHING BLVD.
UNION PACIFIC R.R.
TO SIDNEY NEB.
AIRPORT
ARCHER
CHICAGO BURLINGTON AND QUINCY R.R.
CHEYENNE
TO LARAMIE
GRANITE CANYON
UNION PACIFIC R.R.
D
C
UNION PACIFIC R.R.
TO DENVER VIA GREELEY, COLO.
TO DENVER VIA FT. COLLINS
GRAPHIC SCALE
0 1 2 3 4 MI.
AIR FORCE BALLISTIC MISSILE DIV.
LAUNCHING SITE LOCATIONS
CHEYENNE AREA
ARCH. ENGR. - Stearns-Roger
THE STEARNS-ROGER MFG. CO. - DENVER, COLORADO

SECTION 2
DESIGN - PLANNING - GENERAL PLAN OF CONSTRUCTION
F.E. WARREN AFB - SQUADRON III

The F.E. Warren AFB Atlas ICBM Squadron III consists of nine (9) single launchers at nine (9) widely scattered sites in the vicinity of Southeastern Wyoming, Northeastern Colorado, and Wester Nebraska. Each launch site or station is complete within itself, with Launch Operations Building, Power Plant and Switchgear, Service Building, Propellant Loading System, and all necessary equipment and appurtenances, and support utilities. Sturctures are of steel and concrete, and each station is semi-hard, or partially underground, with backfill cover. Structures are tunnel connected.

The main launcher contract for F. E. Warren AFB, Squadron III, was awarded the Martin K. Eby Construction Company on 4 December 1959 and work started 11 December 1959. Progress on the job as a whole was satisfactory.

DESIGN

The plans and specifications were definite and "biddable" as to the construction requirements at the time the bids were taken. This is supported by the examination of the bids received and the Government estimate. At the time bids were taken, the plans and specifications, though containing more errors than found in such documents prepared under normal procedures, were sufficiently complete and definite to permit preparation of firm bids.

AIR FORCE PLANNING
Launch Facilities, Squadron III, FE Warren AFB

1. Original planning contemplated a 3 x 3 launcher squadron similar to Squadron II at Warren.

2. Instructions received 4 September 1958 to proceed with surveys for Sites E, F and G with alternate site for E.

3. New sites selected for F and G 21 October 1959.

4. Work on Site E dropped per 14 November 1959 conference.

5. Preliminary foundation reports and topo completed for all above sites.

6. Siting meeting 25 March 1959 in Cheyenne established foundation investigation and mapping requirements for 1 x 9 sites. Thirteen sites investigated including E-A of the previous 3 x 3 concept. Reports requested complete by 10 May 1959.

7. Preliminary foundation reports submitted in increments from 28 April 1959 to 14 May 1959. Mapping furnished from 27 April to 8 May 1959.

8. Working points of 9 of 13 sites investigated staked 1-3 May 1959. Final foundation report to include deep holes and seismic studies as type of installation had not been determined. No direction to proceed recieved.

9. In conference held AFRCE, MRR 14 May 1959, schedule for design of Schilling AFB transferred to Warren AFB. Facility to be "coffin-type". Layouts of 7 sites furnished. Layout of 8th site was contingent on gaining right-of-entry to complete survey data and 9th site to be resited.

10. Schedule furnished in conference provided preliminaries complete 1 June 1959, projects 24 July 1959, award 1 October 1959, complete first site 1 December 1960 with follow-on sites completed at 15-day intervals with last site 31 March 1961. Final topography and soils reports required on "crash basis" to meet design schedule.

11. Site H layout finished on 20 May 1959. New site M-1 located on 21 May 1959.

12. Final topography finished by 31 May 1959 ahead of deadline date of 10 June. Soils reports finished from 15 June to 16 July 1959 with deadline of 15 July 1959.

13. Preliminaries received for review on 15 June with joint review conference held 19 June. Submittal very incomplete due to timing. BMD announced at conference that plans and specifications would be adapted from the Forbes AFB project, that only those changes absolutely essential to construct job would be made. "We don't want to build a better mousetrap; we just want to build another mousetrap."

Specifications submitted with preliminary were adapted from Fairchild project which had been furnished the A-E by BMD in error, so specific comment effort on specifications review was of little value. BMD stated that propellant loading system skids were to be GFE from LAD contract with Blaw-Knox. Generators, air conditioning and valves were to be same as Squadron II for standardization.

14. Final project documents received for review 21 August 1959, a slippage of three weeks from schedule. Joint review conference held 2 September. Comments were voluminous because of minimum

work done in adapting plans and specifications from Forbes AFB. The A-E was given until 24 September to correct finals. No change was made in completion dates.

15. Backcheck review disclosed specifications had not been properly corrected which resulted in additional delay in advertising.

16. Corrected stencils received 10 October with revised completion (turnkey) dates of first site 1 February 1961 and last site 1 June 1961. The late delivery caused conflict with reproduction and advertising of Ellsworth Titan project and caused additional delay in advertising.

17. Project advertised 23 October 1959 with bid opening scheduled 24 November 1959 but delayed to 2 December 1959 because of protest on proprietary generator specification.

18. Modifications Nos. 6 and 8 incorporating revised criteria, BMD Associate Contractors comments and their A-E's continued coordination check corrections, have been most involved modifications to date. No. 6 involved 77 specification changes, 181 revised drawings and 4 new drawings. No. 8 revised water treatment facilities, added electronic equipment platforms and elevated floor system and made general revisions to 107 drawings.

LAUNCH FACILITIES
SQUADRON III
F. E. WARREN AFB

	Orig. Sched.	14May59 Resched.	20May59 Resched.	3Aug59 Resched.	Actual
Final Des to Omaha	1Aug59		19Aug59	4Sep59	100ct59
*Advertised				16Sep59	230ct59
Open Bids				160ct59	2Dec59
Award Contract		10ct59		260ct59	4Dec59

*Following addenda were issued under bid invitation:

Addendum No. 1 issued 23 Oct 59 consisting of following:

Specification Revisions	23
Descriptive dwg revisions	53
New dwgs added	28

Addendum No. 2 issued 13 November 1959 consisting of:

Specification revisions	284
Descriptive dwg revisions	369

Addendum No. 3 issued 16 November 1959 consisting of:

Specification revisions	107
Descriptive dwg revisions	63

Addendum No. 4 issued 17 November 1959

Specification revisions	83
Descriptive dwg revisions	91

Addendum No. 5 issued 18 Nov 59 consisting of:

Specifications revisions	5

Addendum No. 6 (Telegraphic) issued 17 November 1959 consisting of:

Specification revisions	7

Addendum No. 7 (Telegraphic) issued 20 Nov 59 consisting of:

Specification revisions 2

Addendum No. 8 (Telegraphic) issued 24 Nov 59 consisting of

Deferring bid opening

Addendum No. 9 (Telegraphic) issued 27 Nov 59 consisting of:

Specification revision 10

SECTION III
F. E. WARREN SQUADRON III
SIGNIFICANT PROBLEMS
DA-5914

1. Steel Delivery:

a. Description. The first problem encountered early in the the job was obtaining information relative to sources of steel and scheduled delivery dates. The contractor furnished a list of steel suppliers, but did not furnish firm delivery dates.

b. Action Taken. He was subsequently directed to furnish firm delivery dates immediately. Due to the status of the steel industry immediately after the strike, this was impossible, but the contractor furnished this schedule as soon as he could.

2. Wide Dispersal of Sites:

a. Description. The fact that there are nine widely separated work sites, all 40 or more miles from the Area Office, was a difficult problem. Radio contact with some of the more distant sites was not always possible. Different types of material at each site required many separate solutions to general problems. The fact that 5 sites are in Colorado, 3 in Colorado, 3 in Wyoming and 1 in Nebraska required the contractor to deal with many different local unions and tried to keep peace with all of them.

b. Action Taken. The area set up weekly staff meetings and specifically encouraged the various Resident Engineers to freely discuss problems and their solutions in hopes that it would help others. In addition, the Assistant Chief of the Operations Branch constantly visted the sites to discover problem areas on advanced sites and sent out multiple letters to all 9 Residents when necessary. The

Area also employed a full time labor relations man to help with labor problems.

3. Strikes:

a. Description. Strikes caused the following delays: (1) Ironworkers at Site 5 on 6 April 1960, 6 calendar days delay. (2) Ironworkers at Sites 6 and 8 on 11 April 1960, 23 calendar days delay at each Site. (3) Ironworkers at Site 7 on 11 April 1960, 1 day delay. (4) Cement Finishers Strike at Sites 1, 2, 3 and 4 on 1 June 1960 caused 1 day delay at each site. (5) Electricians strike at Sites 1, 2, 3 and 4 on 13 June 1960 caused 1 day delay at each site.

b. Action taken. Contract Modification No. 26 was prepared to reimburse the contractor for the premium time for going on a 58-hour week to recapture the time lost as a result of these strikes.

4. Performance of Mechanical Subcontractor:

a. Description. A very difficult problem was the performance of the mechanical subcontractor. He was very uncooperative in furnishing schedules of all sorts, awarded contracts to manufacturers whose performance on past missile jobs was far less than satisfactory, and in general did not provide proper management and very little material control.

b. Action Taken. It was necessary to exert constant pressure on the prime because he seemed willing to accept any type of excuse from his subcontractor for failure to accomplish work or to obtain supplies when needed.

5. Realistic Schedules:

a. & b. Description and Action Taken. This office demanded schedules from the contractor, insisted that they be realistic, and

instituted corrective action whenever delivery appeared to be slipping behind schedule.

6. Apparent Low Strength Concrete:

a. Description. There were many instances where tests of concrete cores and cylinders indicated low 28-day concrete strength.

b. Action Taken. The contractor was directed to perform additional curing, increase the cement content of the concrete, add pozzolith and Aquarex Admixtures and in some cases wash the aggregate. The Resident Engineers were directed to institute rigorous inspection procedures to see that the contractor followed all specification requirements as well as all above mentioned directives. In general, the concrete strengths improved considerably after the above corrective measures were instituted.

7. Skid Delivery:

a. Description. The prime contractor stated that the PLS skid assemblies delivery and installation schedule as given in the specifications was such that the connecting of the skid assemblies to the various process vessels and the subsequent backfill operation would be delayed considerably.

b. Action Taken. The contractor requested a more suitable delivery schedule for these skid assemblies. The skid manufacturer (Blaw-Knox) indicated that he might be able to beat the 1 September 1960 delivery date for this first set of skids, but subsequent to that, the Blaw-Knox plant was struck and his ability to beat the 1 September 1960 delivery date was impaired, however, all skids were delivered on time or ahead of schedule.

8. Omission of Vertical Stirrups.

a. Description. Vertical stirrups at columns D-2, D-3, E-2 and E-3 in the floor slab of Site 4 Operations Building and at Cols B-3 and C-3 in the roof of the Site 7 Operations Building were omitted.

b. Action Taken. The problem was referred to the Using Agency and they in turn furnished their design for corrective action which consisted of adding capitols and bases to the columns in question. Correction was performed at contractor's expense.

9. Possible Settlement of Gaseous Storage Vessels:

a. Description. The using agency was advised of a possible problem that may develop due to settlement of gaseous storage vessels. These vessels are more or less rigidly connected to the Launch and Service Building by piping and any settlement of the vessels may have serious effect on connections and piping.

b. Action Taken. The contractor proposed a modification contemplating a one point support of the vessels to prevent settlement. Because this type of support will introduce local stress in the vessels, this office recommended an alternative proposal to provide flexibility in the piping by the use of flexible joints. The using agency decided that no serious problem existed and that the original design was adequate.

10. Lack of Coordination in Contract Drawings:

a. Description. Probably due to the lack of time available, contract drawings were issued without proper coordination of the structural, mechanical and electrical portions.

b. Action Taken. In some of the simpler discrepancies, it was possible to clarify the problem by letter, but in some cases a modification had to be prepared when either a charge to or a credit to the

Government occurred.

11. Control Sytem Testing:

a. Description. Blaw-Knox declined to negotiate a bid for performance of CST on Squadron III. The using agency sent the CST package to this office for implementation.

b. Action Taken. This office recommended that CST for Warren III be by separate negotiated lump sum contract to assure obtaining a qualified contractor who was capable of successfully completing on schedule this last test before the launcher was turned over to the Using Service. Bids were taken and Lockheed Aircraft was successful bidder.

12. Graver Tank Company Tanks:

a. Description. Graver Tank Company was unable to obtain test samples on the Heat Exchangers and Slug Tanks that would pass the particle size requirements as set up in the specifications.

b. Action Taken. The Using Agency agreed to waive the strict adherence to the 150 micron particle size requirement on cold testing of the liquid nitrogen/helium heat exchanger and contamination of this vessel by particle sizes in excess of 150 microns as introduced by nitrogen would not be considered cause for rejection. This permitted increased progress on 50 percent of Graver production for Squadron III.

13. Delays in PLS and Mechanical:

a. Description. Slowdown in production due in part to poor management on the part of Wallace Process Piping Company. (M.K. Eby - subcontractor).

b. Action Taken:

(1) All skids and valves were examined and approved and/or

necessary cleaning performed.

(2) Wallace submitted plan thru Eby to improve management on sites by providing experienced management at site level, radio directed transportation of materials from warehouses to sites and maintenance of close inventory of materials on sites and in warehouses.

VELAN VALVES

Velan valves were changed by Blaw Knox as a result of operational tests performed by the Air Force on Velan Valves furnished for Warren II and Offutt Squadrons. Copes-Vulcan valves were modified by a kit to overcome a problem similar to that of the Velan valves.

Skid design changes in June 1960 added additional valves and these changes had to be accomplished in the field.

In addition, a number of valves were installed into the skids with the pressure on the opposite side of the seat than originally designed. Responsibility for this has not been clearly fixed; but confusion apparently occurred as the result of a conference among Air Force, Corps of Engineers, and contractor respresentatives in Pittsburgh in which the Air Force representative stated that certain valves were found wrong in the Winger contract and they should be reversed in this contract.

PROPELLANT LOADING SYSTEM SKIDS

In fairness to all concerned it should be pointed out that through all phases time was extremely limited and that this applied as much to the design time of the Air Force as to the time required by Corps of Engineers operations. As a result of this shortened time there was a compression from a normal research and development production cycle to an attempt to enter production from a concept stage. In more usual procedures a development prototype would have been built, tested, and the design revised. In this case, all went on concurrently; consequently, many revisions were required not only to drawings and specifications but also to concepts of how to do the job. In many cases, design improvements have not been made because of the unwarranted loss of time that would be required.

Particularly important in causing delay was the concept of using off-the-shelf commercial valves in a system with rigid cleanliness re= quirements. There are special valves made for such systems, but they are exceedingly expensive and were not required by specifications. Other in- compatibilities between cleaning requirements and design were found in the use of carbon steel which rusts, and the use of screwed joints and fittings which have a tendency to gall and produce metallic particles. Screwed fittings and joints are also incompatible with the high pressures.

Throughout the contract the closest coordination was maintained with AFBMD in solving mutual problems.

Why do Propellant Loading System Skids require recleaning at Installation Site?

1. The propellant loading system skids require some recleaning or blow down when received at the construction site for the reasons given below. It should be realized that the maximum particle size in a "clean" skid is 150 micron, barely visible to the eye.

a. The specifications provided for both the method and processes which should be used in cleaning component parts. It is really apparent that the methods provided in the specifications were inadequate to give the degree of cleaning required in the sections of the specifications.

b. An examination of the Technical Provisions of the specifications revealed that, in general, commercial standards of quality and practices are all that is required for materials and workmanship. There were no particular requirements for special construction as normally would be required for chemical process systems requiring similar standards of cleanliness. Thus, commercial type valves, strainers and filters were used in the design without any consideration being given to the necessity for controlled and highly polished surfaces required for this special type work. Sand cast valves, in particular, are sources of particles larger than permitted.

c. Inspection was by Contractor personnel, Corps of Engineers inspectors and selected testing laboratories. In all cases all three inspectors certified to cleanliness of components after factory cleaning and sealing. Thus, reinspection and recleaning should not have been a requirement at the factory, if the components were cleaned when sealed.

However, approximately 90% of components were rejected because of contamination when reinspected at the Blaw-Knox Company before assembly. Some components were recleaned 8 to 10 times only to be rejected at time of assembly in the skids. From this it was conceived that the specifications were inadequate to provide the system required in the end product and that the process of shipment itself produces particles.

d. The specifications were deficient as to materials, processes of cleaning and required inspection techniques. The interior of the system contained many small holes, crevices, imperfect surfaces in castings, sand in castings, graphite, imbedded particles and metallic particles which it was possible to lossen at any time during the assembly, shipping, transportation or final checkout at the propellant loading systems. In addition, the approved materials for gaskets, packing, castings, etc, were not entirely free from shredding small particles which caused contamination.

e. For degreasing of components vapor degreasing was the only approved method of cleaning except for fuel valves. This method produces only a vapor of insufficient velocity to remove particle contamination. The method of checking contamination is a combination of black light and wipe tests. The configuration of many components are such that neither test will guarantee clean components as both can be applied only on a random basis since not all surfaces can be reached.

f. The No. 2 Fuel Skid was constructed of carbon steel. A requirement of the specifications was to clean carbon steel to the basic metal, then dip in kerosene and seal the system with a purge. In the few minutes required to process the component after cleaning, the carbon steel

showed signs of oxidation. After the parts were dipped in kerosene the oxidation continued but at an accelerated rate because kerosene not only contains water, but has a great affinity for water and removes it from the air. Early in the manufacturing process, AFBMD was made cognizant of the problem. However, there was no alternate solution given by them until approximately one month later. The alternate solution was a nitrate solution in which all the chemicals were given in proportion. The Blaw-Knox Company found that in using this solution the skids continued to be contaminated with rust, and in addition, the solution produced crystalline deposits which contaminated the system with particles greater than 150 microns. The Air Force was advised that the materials should be changed from a carbon steel to stainless steel.

g. It was found that after heat treating, a precipitation, chromium carbide, appeared on the surface of ASTM A-373, Type 304 steel used for the manufacture of expansion joints. Wipe and black light tests indicated contamination. It was further found that immediately after cleaning contamination did not exist to any degree, but a recheck after 24 or more hours showed additional precipitation of chromium carbide to the surface of the material. This precipitation was beyond the allowable limits of the specifications. Later checks of Type 304 stainless materials near welded areas or heat treated areas showed signs of chromium carbide precipitation. Thus a system assembled immediately after cleaning could be judged clean. However, after completion of all tests and sealing, additional precipitation occurred and on a new test, the system would be judged contaminated. As shown by field tests, the problem would be partially eliminated by use of stainless 347 steel which has

an inhibitor but costs considerably more money. Basic ME handbooks state that 304 stainless steel should not be used where welding is required. Since this specification had been used before the skids were finally satisfactory, the Air Force decided no change should be made.

h. In the shop assembly of the components due to the nature of the design, it was found necessary to weld in the assembly area without recleaning. This resulted in some contamination.

i. Upon shipping to the field, numerous sections of light weight piping connected to heavy assemblies were either vibrated loose or broke off, causing systems to lose purge, thus introducing contamination to the system. The basic design was inadequate for shipment of the units.

j. In checking out the final system, the various assemblies were given extreme shocks in cold testing which caused considerable movement of the various piping and flanges. This movement caused friction or shredding of packing, gaskets and other soft material, and loosened particles from the valves.

k. There were numerous change orders issued due to new design criteria or conflict of designs between skid assembly and the field fabrication which required additional valves, additional piping, cutting of piping, reversal of valves and valve fittings, all of which were necessary to accomplish on site without controlled shop conditions.

Why were the Propellant Loading System Skids Delayed in Completion?

1. Propellant Loading System Skids were delayed in completion primarily because a research and development effort prior to production was

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Why were the Propellant Loading System Skids Delayed in Completion?

1. Propellant Loading System Skids were delayed in completion primarily because a research and development effort prior to production was

required to overcome deficiencies of design and specifications. A resume of some of the delays which tend to prove the above statement are as follows:

a. The basic design specifications and drawings were given to the Los Angeles District with a lead time just sufficient to print and prepare for distribution without time for review. The Invitation to Bid was sent out on 17 April 1959, and the date for opening was set for 14 May 1959. This did not give the bidders sufficient time to evaluate the complexity or magnitude of the job. The date of award was 20 May 1959, and was considered extremely close to the date of opening in that approval was required by the Department of Defense before award could be made.

b. During the time of advertising there were four addenda issued, the last one being 7 days before the opening of bids. Of the four addenda, two contained technical changes requiring 101 design changes.

c. The Blaw-Knox Company was the low bidder and was brought into a conference with personnel of AFBMD, LAFO-OCE and the Los Angles District, at which time the company was advised of the difficulties of the job and the absolute necessity for meeting contract delivery dates. At that time it was stated by the contractor's representative that the dates were tight but could be met if change orders were held to a minimum. The contractor stated that he intended to make 1/10-inch scale models of each of the skid assemblies to determine poor design and complications that would occur in assembly before he arrived at that point, in order that he could meet his contract commitments.

d. Approximately 15 June 1959 the main office of the contractor reviewed both the supply contract for the furnishing of the propellant loading system skids and the field contracts which they had accepted for

construction. The Vice-President and the General Manager of the Power Piping Division, who bid these contracts, were immediately discharged and replaced by people from other divisions. The new personnel assigned to the project required a period of orientation.

e. In early June a conference was held at the Blaw-Knox plant to review the models which had been constructed in order to eliminate poor design and improve the possibility of making skid assemblies without continual refabrication of various parts of the assembly. There were approximately 40 modifications and design changes necessary after reviewing the scale models. AFBMD finally furnished information that would allow the contractor to proceed on 16 August 1959, approximately 30 days after the review.

f. On 2 June 1959 a great many design changes were received from AFBMD through LAFO-OCE for inclusion into the skid construction, all of which required engineering time and reordering of materials, such as changing of materials, C_v values, flow rates, pressure drop on valves, etc.

g. Changes as described above continued to occur at approximately 2 to 3-week intervals. These changes in many instances were not firmed up and had to be modified or removed at a later date. The changes as received were in such a condition that many contacts by this office direct with AFBMD were necessary to resolve the Air Force's desires. Because of the many Air Force Agencies concerned the final resolution of changes frequently involved AFBMD, Space Technological Laboratory, A. D. Little in Boston, and Convair at San Diego. Thus, a great deal of time was consumed in acquiring the desired information to properly make a change.

h. In August 1959 the cool-down weight of L-12, a large valve

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h. In August 1959 the cool-down weight of L-12, a large valve

was changed twice after manufacturing had started, and AFBMD had stated a third change was considered. The manufacturer finally determined that he could not make the valve to the final new weight determined, and a new supplier had to be found.

i. Shortly before the skids were needed for delivery test data began to arrive in dribbles, and numerous telephone calls were received stating that the specified test procedures were inadequate and C_v values specified did not agree with the calculated C_v's. This office asked for all data available on tests in order to evaluate same, and immediately advised LAFO-OCE and AFBMD that this was a trouble area. It wasn't until the middle of November that the difficulty was pin-pointed. It was necessary to modify the specifications and rerun the C_v's in many instances. It was necessary in some instances for the sub-contractors to rebore their parts .002-inch to make them come within the specifications. In many instances the C_v stipulated was impossible to attain through a straight 1-foot section of pipe much less an intricate valve configuration at the required pressure drop. During November and December the Los Angeles District had a competent mechanical engineer at the Blaw-Knox plant in an effort to settle all problems relative to acceptance or rejection of flow rates of valves on other manufacturing problems. Because the specification made a solution impossible it was necessary to call together representatives of A. D. Little, AFBMD, Los Angeles District and the contractor to establish the rules for acceptance. At that time many of the valves were finally accepted though not strictly complying with the specified C_v. The mechanical engineer of the Los Angles District went from plant to plant setting up with plant personnel and making the

necessary tests, immediately accepting valves if they complied with the new criteria. In some valves and many strainers the pressure drop allowed by specifications was totally unrealistic. For example, one 10-inch strainer was specified to have a pressure drop less than would be developed in one foot of pipe of the same diameter. In these instances the valve or strainer was accepted if it had approximately the same pressure drop as other manufacturers' similar type of equipment.

j. The specifications permitted the contractor the option of using supplier-cleaned components or cleaning components himself. He elected to use supplier-cleaned components. When assembly was started it was found that the systems could not be readily built as the individual components, though previously tested, did not pass the cleaning requirements. After tests, it was determined that certain supplier-cleaned components could not be shipped without contamination. Some components were returned to the manufacturers and others were cleaned under the supervision of the manufacturers at the Blaw-Knox plant, thus creating considerable delay in assembly. The No. 2 skid was delayed for a considerable period of time while a decision was reached as to what would be acceptable, knowing that the carbon steel would rust and contaminate the skid immediately after conclusion of cleaning.

k. During final assembly it was found necessary to relocate lines, add additional supports, change type of supports, reroute small lines, and in many ways modify the basic design. This was immediately accomplished as the problem was presented. However, time was consumed in doing so. During cool-down tests and pressure tests it was found necessary to make additional changes to the system in order to produce a satisfactory end

product. One of the basic changes required was found in final tests and took considerable time to resolve. The specifications required that screwed fittings in which gauges and instruments are fitted require solder joints between instrument and fitting and fitting and pipe. It was found that by use of solder it was very difficult to make a joint hold without leaking under the extreme pressure imposed upon it. The problem was placed before AFBMD and this office was told to continue soldering, that this had been done on all previous jobs without any difficulty. After two weeks of trying different methods of soldering, it was found that on previous contracts, contractors had been allowed to backweld with stainless steel, and all joints which would not have to be broken in the field are now backwelded; thus, the only soldered joints left were the actual gauges and instrument fittings themselves. The use of solder, in addition to slowing the completion of the job, adds to the contamination problem in that during installation and removal of the fittings particles of lead flake off. It is impossible to keep these particles out of the system.

1. On 6 October 1959 this office was required to change two important solenoid valves in the system. The contractor was immediately instructed to procure them as they were part of the control panel and would require time after procurement to install in the panel before installation in the skid assembly. These solenoids were changed and rechanged six different times and were not finalized until March 1960.

2. Certain specification deficiencies occurred in connection with the on-site work which have created contractual problems.

a. The specifications stated that the contractor would not be

required to furnish more than one factory representative per three sites. In fact, he had to furnish six for the first three sites.

b. Conflicts in the location of site piping and skid piping have occurred.

c. There were gaps between the skid contract and the site contract.

Why are Propellant Loading Systems damaged upon receipt at sites?

1. The propellant loading systems are damaged when received at the site for the following reasons:

a. The basic design of the propellant loading system was for a force of 3g's. There was no consideration given in the design to the forces caused by vibration over long periods of time in shipment nor the harmonic vibration which would be set up in truck and train transportation. This harmonic vibration caused copper tubing to break due to work hardening, copper tie strips holding lines were caused to break because of work hardening and various screwed fittings to loosen.

b. In numerous instances the basic design did not consider large, top-heavy valves whichwould twist out of alinement while moving in the shop or loading. Large valves and other fittings were installed on copper lines and light weight stainless steel lines where their very weight for long periods of time would cause a sag in the line. During travel the lines sagged because of weight and jolting vibrations and broke in numerous instances. Considerable damage was done to gages in the panel board because of extreme vibration. The entire gage board is supported on vibration dampers that are only designed for 3 g blast for short

duration rather than the vibration of truck trailer and train transportation for 12 days.

c. Additional damage occurred by negligence of the transportation carrier. A number of skids exceeding normal railroad clearances were damaged enroute in the Chicago Area. The width and height of skids were taken into consideration in transportation, and the routing was such that the skids would not strike any bridge or tunnels enroute. However, in traveling in the Chicago area care was not taken in the yards and apparently the skids were routed in the yards under bridges which were too low, thus causing severe damage.

d. In order to accelerate delivery of skids, an attempt was made to ship single skids on a special low bed trailer with special protection for vibration. This type shipment was immediately given up after receipt of the first shipment because of the extreme damage sustained.

e. Some damage also occurred in the final truck trailer shipment of skids between the main road and the actual installation site.

f. In attempting to eliminate damage occurring in transportation approximately 80 permanent supports were added to each set of skids by the Corps of Engineers to overcome deficiencies in the basic design.

g. The distance from the point of manufacture determines the amount of intransit damage. The greater the distance from Pittsburgh the greater the damage. This has been proved by comparing damage to shipments to Fairchild and Forbes Air Force Bases.

3. The Form 290 transfer date for Warren III was 21 April 1961 as compared to a revised contract completion date of 10 June 1961. The task of completing this major ICBM construction site fifty days ahead of

schedule was due to the contractor's above-average supervision and management of the sub-contractors, plus excellent coordination between the Corps of Engineers and the Air Force. A team had been forged with a single desire by all those taking part in this vital project to do a good job on or ahead of schedule and thus made such results possible. This team composed of laborer, skilled mechanic, technician, architect, engineer, supervisor and executive, each contributing a wealth of experience, made a great contribution to the defense of the free world.

SECTION 4
HISTORY PRIME CONSTRUCTION CONTRACT
NEWSPAPER ARTICLES

NEW MISSILE SQUADRON WILL MAN ADDITIONAL ATLAS SITES, TRIBUNE, CHEYENNE, WYOMING, JUNE 7, 1959. The Air Force has announced a complete new missile squadron of 750 to 1,000 men will man nine new Atlas missile launchers planned for the Warren Air Force Base complex.

The new launchers, dispersed as far as 60 miles from Cheyenne, will be "semi-hardened" and equipped with self-guiding Atlas intercontinental ballistics missiles.

The new construction is estimated at between $20,000,000 and $30,000,000 and will bring total construction costs of the Warren missile project to about $70,000,000.

Col. E. A. Swanke, chief of the Air Force Ballistic Missile Division field office at Warren, estimated the new construction time would add about 15 months to the period required to build, install and check out the Warren complex.

That would mean Convair Astrounautics and its subcontractors, who will bring the missile base into operational status, probably will remain here into early 1962.

The additional construction is not expected to mean that Convair will need significantly more employes at Cheyenne, but that the estimated 2,000 persons who will take part in the operation will remain more than a year longer. It will also mean a larger construction force will be needed for a similar period.

Swanke said the nine new launch sites, which will mean the

Warren unit will be armed with 24 Atlas missiles when completed, will be equipped with missiles with "all-inertial guidance systems" which plot trajectory and keep the missile on course automatically.

The other 15 missiles at Warren will be controlled from ground facilities at their four launching sites.

Because the guidance system is self-contained, Swanke said, the launchers can be widely dispersed. One of them is near Kimball, Neb. Others are near Greeley and Fort Collins, Colo.

The new launch sites also can be "semi-hardened" because of the self-guidance principle. The term "hardened" refers to the launcher's ability to withstand a nuclear attack.

In this case, the launchers will be sunk flush with the ground with only a roof visible which will be rolled back to allow the missiles to fire.

Site E, the first of the nine new launchers, will be located 40 miles east of Cheyenne, near Pine Bluffs; site F, will be 35 miles north; site G, 22 miles south; site H, 38 miles northeast, near Meridan; site I, 60 miles east, near Kimball, Nebr; site J, 30 miles east by south; site K, 40 miles southeast; site L, 50 miles southnear Greeley; and site M, 35 miles southwest, about 10 miles from Fort Collins.

Col. Swanke said considerably less land will be required for the nine new sites -- less than a quarter section each -- than for the four multiple-launching pads now under construction.

Site A, first of the Warren complex, near completion northwest of Cheyenne, requires a section and one half. Sites B, C and D

take up about three-quarters of a section each.

Swanke said the government will lease rather than buy the land for the nine new sites.

The third missile squadron at Warren will bring total forces at the air force base to about 5,000 men.

Swanke said the Air Force planned to call for bids on the nine new sites together, rather than contracting them separately.

GE DEPARTMENT IN CHARGE OF MISSILE RE-ENTRY UNIT, Oct. 2, 1959.

The organization responsible for the development of the re-entry vehicle used on the Atlas missiles at Warren Air Force Base, is the Missile and Space Vehicle department (M&SVD) of General Electric, Robert Jordan is the base manager for the local office.

In June, 1955, M&SVD, Philadelphia, Pa., began work under contracts for development of re-entry vehicles (nose cones) for the Atlas ICBM and the Thor IRBM. Both Thor and early operational Atlas' used basically the same nose cone.

Under extensions of these contracts, GE is continuing development of advanced type re-entry vehicles. One of these advanced types will be installed on Atlas missiles at Warren AFB.

The re-entry vehicle, an independent system in itself, is the forward-most part of the ballistic missile. Its purpose is to house, protect and transport a payload during both missile flight and re-entry.

The rocket booster thrusts the re-entry vehicle at a prescribed velocity along a desired path.

At a predetermined point the rocket engines shut off and

the re-entry vehicle separates from the missile body to continue a ballistic trajectory through space at speeds of 15,000 miles per hour or more. The apogee, or highest point of this flight, is measured in the hundred of miles. Actual re-entry into the earth's atmosphere is the prime test of the vehicle. At this point it must withstand destructive forces never before encountered by an airborne system. The temperature of the air at the front end of the vehicle rises to 10,000 degrees F. which is hotter than the surface of the sun.

When a space vehicle is slowed up by re-entry into the earth's atmosphere the shock is equivalent to a car slamming into a solid brick wall at 60 mph.

Missile nose cones are subjected to the same battering forces that work on meteors, but while meteors burn out or break up, nose cones must remain intact and functional.

This is the job of the Missile and Space Development department of General Electric.

The liaison engineer at the Warren Field Office is Elsworth Gerrels. The field representative is Ned Branine.

KANSAS FIRM LOW BIDDER ON NINE NEW MISSILE LAUNCHERS. Cheyenne, Wyoming, Dec. 3, 1959. An apparent low bid of $22,143,981 was submitted Wednesday by the Martin K. Eby Co. of Wichita, Kans., to build nine new Atlas missile launching sites in Colorado, Wyoming, and Nebraska.

The new sites to be added to the Warren Air Force Base complex will be located at various points within 60 miles from the Cheyenne base.

Diversified Builders, Inc., of Paramount, Calif, was second with a bid of $22,156,000.

Completion dates for the nine new launchers range from Jan. 1 to May 1, 1961. The Army Corps of Engineers said the contract would be awarded in the near future.

Engineering officials said this could range from a few days to a week or more. It is expected to take somewhat longer to get the contract signed this time because of the size of the project.

Although the bid opening was postponed nearly a month from the original date, the Engineers said completion dates for the new launchers have not been set back.

The launchers will be of "semi-hardened" construction -- armored with concrete and designed to fire self-guiding Atlas intercontinental ballistic missiles.

Eby, lowest of five bidders, also was slightly under the government estimate of $22,336,630.

The sites for the new Atlas launchers:

--40 miles east of Cheyenne, near Pine Bluffs, Wyo.

-- 35 miles north, near Chugwater, Wyo.

-- 22 miles south, near Rockport, Colo.

-- 38 miles northeast, near Meridan, Wyo.

-- 60 miles east, near Kimball, Neb.

-- 30 miles southwest, near Ft. Collins, Colo.

-- 40 miles southeast, near Briggsdale, Colo.

-- 40 miles southeast, west of Greeley, Colo.

-- 35 miles southeast of Cheyenne.

The Fuller Co. has completed Atlas Site A and its six

launchers, which are being brought to operational status by Convair Astronautics, builders of the Atlas, and Air Force subcontractors.

STRIKE CALLED AT MISSILE SITES, Thursday, March 24, 1960. A giant protest demonstration by about 1,000 union workers at Atlas missile sites under construction around Cheyenne brought work to a virtual standstill.

George Calvert, operations manager for Convair Astronautics at site A northwest of the city, said only maintenance and technical work was continuing.

Gilbert Schryver, security officer for Convair, said about 150 pickets had taken up positions at sites A, B, C and D and at the main gate of Warren Air Force base at the western edge of the city.

Early reports said some men were crossing the picket line but apparently too few crossed to keep the main construction work going.

Norman Dean, business agent for the electrical workers union, said the action was taken because some prime contractors at the sites were paying wages below those set by the department of labor.

Ed Casteel, business agent for the operating plasterers cement masons union, said "everybody is concerned about this". He said only the most essential work was going on.

The electrical workers kicked off a protest strike last week following charges that certain electrical work was being done at site A by technical personnel of Convair and its subcontractors.

That dispute was resolved sufficiently to permit a return to work after two days of picketing.

The new walkout is the first to affect all missile sites. Previous labor troubles have stemmed from site A alone.

The Warren air force base missile complex includes facilities for launching 24 intercontinental ballistics missiles. The sites are spotted up to 60 miles from Cheyenne. The primary sites form a rough ring around the city.

STEPS FOR ACTIVATING ATLAS LAUNCHING SITES EXPLAINED, Cheyenne, Wyoming, March 7, 1961. Convair-Astronautics, Division of General Dynamics Corp., today revealed more details on the events that led up to turning over of three Atlas ICBM launching sites by the Air Force Ballistic Missile Division to the Strategic Air Command, Saturday.

The three sites joined other operational Atlas ICBM launch complexes already on alert here at Warren AFB, and at Vandenberg AFB, Lompoc, Calif. A third complex, Warren III, is under construction and on schedule, it was announced.

The Atlas missile is the free world's first operational ICBM and is produced for the Air Force by Convair-Astronautics, Division of General Dynamics Corp., at its San Diego, Calif., facilities. Convair builds the airframe, the autopilot system and other components, assembles the missile and conducts both captive and flight test programs for the Air Force.

Working with the Ballistic Missile Division of the Air Force, Convair's role in activating Atlas ICBM launch complexes like those at Warren AFB is to establish the technical criteria, supervise ground support equipment installation, check out equipment and turn over to the Air Force the facilities equipped with an Atlas ICBM.

Convair's integrating job in activating Warren, the Air Force's newest missile stronghold; missile sites 2 through 4, was directed by K. W. Jeremiah, Convair base operations manager. L. Russ Medlock is responsible for activating Warren AFB missile sites 5 through 13, Warren III.

Building America's missile bases has been heralded as the single most important defense task in the nation today. The overall job at Warren AFB and at other bases, calls for precision workmanship, and the close day-to-day cooperation of Convair, its subcontractors, Project Atlas Associate contractors, the United States Air Force, Army Corps of Engineers and its subcontractors. The task welded together people from all walks of life and diverse backgrounds into the team that made the events of today possible.

Warren II complex has been turned over to the Air Force because of the millions of manhours of work, running the complete gamut of weather conditions, thousands of telephone calls and telegraph messages, millions of air and road miles travelled, the inevitable temporary separations of families, and the sheer dedication of the joint military and industrial project Atlas team.

Saturday's activities at Warren AFB will be repeated many times over as America is on the move to prepare its first line of defense against the holocaust of possible nuclear war.

This is how a typical Atlas missile complex is activated . . . after construction is finished on each launch pad and its support buildings, Convair's Astronautics receives BOD -- Beneficial Occupancy Date.

At this time Convair technical personnel and subcontractors begin installing tons of intricate ground support gear. Convair personnel then supervises the laying of thousands of pieces of communications and power supply cabling, connector boxes and associated gear.

During this period the missile launcher equipment arrives with the liquid nitrogen, and liquid oxygen tanking systems, hydraulic equipment, RP-1 fuel tanks, and the various electronic consoles for checking out and keeping track of the missile's "health".

While this activity is taking place, other crews are busily checking out the huge Atlas launcher with a "whalebone" mockup of the missile. The wooden whalebone simulates the dimensions and structural shape of the actual "bird".

The next major step after equipment installation is the validation phase in which initial checking must take place to determine whether all the equipment is in working order, including the launcher check, gas and pneumatic systems.

The third step in base activation involves installing the missile into the launcher. The launch control equipment is checked and rechecked to verify its capability. Then the automatic check-out equipment is tested for performance.

The final integration task is countdown minus the hot firing of the engines. Atlas missiles at operational bases will never be fired except in case of all-out war. System integration also includes a full check-out of the missile's propellant utilization systems, liquid oxygen flow and tanking and other related tasks.

While the mechanical and electronic teams are at work, another huge task is being carried out behind the scenes -- the world of paperwork. Technical manuals, purchase orders, parts inventories, status reports, all have to be kept up to date, and these are just a few of the documentation duties that have to be performed.

One document, the Air Force Technical Order, more commonly called the AFTO, represents the complete history of every part on the premises from the time that it was made until it is turned over to the Air Force, must be kept by Convair-Astronautics employees. The AFTO contains about 350,000 handwritten entries.

Upon successful completion of all of these tasks, Convair notifies the Air Force for the final step -- demonstration. Each system and major systems for all the facilities and the missile itself must be demonstrated to the complete satisfaction of the Air Force surveillance team.

Sell-off by Convair begins on the day when the final papers are next step for Convair.

THEY'RE READY NIGHT AND DAY AT CHEYENNE BASE, Wyo. State Tribune, Cheyenne, Wyo., April 18, 1961. On a windy mesa north of here, range country desolate as great parts of the world will be if the "birds" ever start flying, sprawls one of America's operational missile sites.

Inside thick concrete huts the gleaming stainless steel Atlas missiles rest on their sides, the nuclear warheads screwed in place.

If your security clearance is sufficient -- and if you have the desire -- you can reach up and pat the warhead. It is far more potent than the bomb which killed 78,000 at Hiroshima.

A couple hundred yards away, in another concrete bunker, an Air Force captain and a lieutenant, pistols strapped to their waists, sit behind panels where the pressing of a grey "start" button can send these monsters on a half-hour, 6,000-mile trip into enemy territory.

At this base they are ready, day and night, to start shooting from six pads.

If war with Soviet Russia ever comes and that button is pressed, the handful of soldiers at Warren Air Force Missile Squadron No. 1 will not know what targets they shot at.

And they probably would never find out if they hit. For this lonely outpost would be a prime target of Communist rockets.

It is a fearsome duty. The missilemen have, as their sole professional reason for being, a job they hope to God they never have to do.

The deadly seriousness of a "missile gap" strikes home after a visit to this base.

A year ago it was still in construction.

The only intercontinental ballistics missiles in operational readiness were three Atlas rockets standing in vulnerable exposure in gantries along the Pacific at Vandenberg Air Force Base in California.

Khrushchev passed them less than a quarter-mile distant in his train trip up the West Coast in 1959. He may have been amused, because his Soviet Union had far more.

What Russia did not have was the enormous nuclear bomber force of the Strategic Air Command. And not having such a force, Russia

had pushed with tremendous emphasis on missiles until the peril to America became evident to even the most dense.

Since that time, just a year ago, U. S. missile sites have begun to sprout across the entire western half of the continent.

Besides the six pads at this base, there are nine at Warren II now operational. Nine more were turned over to SAC less than three weeks ago around Omaha. There are at least three new Atlas pads at Vandenberg.

So today the United States has at least 30 operational missile launching pads where a year ago it had three.

But this is only the tiniest beginning. The Air Force is building a missile network so staggering in size and cost that it dwarfs any previous military crash program in history.

All but one of the 14 Atlas complexes will be west of the Mississippi. They will be in California, Wyoming, Nebraska, Washington, Kansas, Oklahoma, Texas, New Mexico and New York.

They must be widely dispersed. One single complex nearing completion embraces an area bigger than Connecticut.

13 ATLAS SITES ARE COMPLETED, Wyo. State Tribune, Cheyenne, Wyo., April 28, 1961. The Martin K. Eby Construction Co., prime contractor for nine of the 13 Atlas Missile sites in the Warren Air Force base complex, announced Friday it would turn over the last of the nine sites to the Air Force before Monday.

"We are very proud of this May 1 completion because it represents on time completion of a very important phase of our nation's defense. It means that no slippage has occurred in our

total construction program despite the impact of numerous major changes in our construction plans made necessary by important improvements in the missile," a Eby spokesman said.

Construction of the sites began in 1958.

A total of 24 Atlas launching pads are included in the complex, with Site 1, northwest of Cheyenne, containing six pads.

Five of the 13 sites are located in Colorado and the other site is at Kimball, Nebr.

The sites will be turned over to the Strategic Air Command, which has three missile squadrons under the 706th Strategic Missile Wing at Warren.

SECTION 5
ATLAS "E", F.E. WARREN - SQUADRON III

1. REVIEW OF PAST COSTS. The initial CCE for construction of Squadron III, F. E. Warren, was $28,300,000. A total of 98 change orders were issued for a total of $3,733,446. Negotiated claims amounting to $1,893,802 resulted in 15 more change orders for a total of 113 on this Squadron. Acceleration amounted to $1,333,000 which is considered an influencing factor on costs for this base.

2. INFLUENCING FACTORS. The following factors will be discussed to evaluate their influence on the final costs of this Squadron.

a. Geography, climate and weather.

b. Acceleration

c. Labor

d. Contractor management

e. Subcontractors

f. State and local tax requirements.

g. Cost indexes.

h. Joint occupancy

i. Area Engineer - SATAF relationship

2(a) Geography, climate and weather.

(1) Location

The nine (9) missile sites of Squadron III are located north, east and south of Cheyenne Wyoming within a radius of sixty (60) miles of that city. Sites 549-1, 549-2 and 549-3 are located

in Wyoming, Site 549-4 in Nebraska, and Sites 549-5, 549-6, 549-7, 549-8 and 549-9 in Colorado. The sites are located in rolling terrain with the most westerly site (549-9) adjacent to the east foothills of the Rocky Mountains of Colorado. All sites are accessible by good roads and are fifteen miles or less from rail sidings. The support facilities are located at Warren Air Force Base, Cheyenne, Wyoming. See Tab 1.

(2) Weather

Since the sites are scattered through the States of Colorado, Nebraska and Wyoming, it is impossible to make a general statement as to the weather at the sites. Tab No. 3 contains a tabulation of precipitation and temperatures for Ft. Collins, Colorado, Kimball, Nebraska, and Chugwater, Wyoming. It is considered that the information shown for these sites presents the representative picture for the different areas involved.

(3) Latent Conditions

One minor field change in the amount of $1,000 was necessary due to latent conditions, namely, removal of lignite under a water storage tank. There were no other latent conditions encountered during construction.

2(b) Acceleration.

During the course of construction, the contractor was directed to add additional personnel and work additional shifts and equipment in order to meet the specified completion date in lieu of being granted time extensions for additional work added and for excusable delays encountered as a result of weather and strikes. This acceleration amounted to approximately $1,333,000 or 4.8% of the

final contract amount.

2(c) Labor.

A breakdown of the labor expended on Contract DA-5914 is as follows:

Regular Time		Overtime	
Hours	Cost	Hours	Cost
1,488,735	$5,018,585	260,850	$1,292,340

See Tab No. 4 for detailed breakdown.

Availability. In most instances the labor supply was inadequate resulting in the necessity for importing craftsmen from outside the local area. The influx of workers presented a problem in that the imported mechanics, in most instances, out numbered the local mechanics in the local Unions. This resulted in loss of control of the local Unions by the local craftsmen. The cooperation by the local craftsmen was essentially excellent throughout the life of the contract. However, the imported craftsmen were responsible for the majority of the walk-outs on the project. This situation was aggravated at a later date when the Associate contractors started working on the jobs.

2(d) Evaluation of Contractor's Management

The Contractor's management performance was rated above average. This was the contractor's first experience in missile launcher construction; however, his electrical and mechanical subcontractors had prior missile construction experience at Cheyenne, Wyoming. The contractor performed the concrete, reinforcing steel, structural steel and forming and subcontracted the major portion of the remaining work.

The prime contractor and certain subcontractors worked additional personnel and overtime hours to progress certain critical phases of the job more rapidly to insure meeting contract completion dates. A portion of these costs were absorbed by the prime contractor and subcontractors and a portion absorbed by the Government because of Government incurred delays and modifications.

2(e) Evaluation of Subcontractors

The contractor had twenty (20) first tier subcontractors and twelve (12) second tier subcontractors. See Tab 5 for list of subcontractors and work performed by each. In addition to the subcontractors listed, there were numerous lower tiered subcontractors that performed specialty work and supplied materials, equipment and special services.

The performance of the subcontractors was satisfactory. The prior experience of the electrical and mechanical subcontractors proved to be of great value in meeting completion dates in view of the number of modifications issued and the delays caused by the Government's failure to deliver liquid nitrogen to the various sites as needed for testing and delays caused by the failure of certain Government furnished equipment and/or components to function properly. The mechanical work involved approximately 50% of the contract and was the work affected most by modifications and Government incurred delays. The mechanical and electrical subcontractors were able to overcome in part the delays incurred because of the experience of many of their supervisors and craftsmen gained on previous missile construction, by increasing the size of crews where applicable and by working multiple shifts and/or overtime. All delays could not be

overcome and the contractor was granted time extensions by modifications to the contract. The prime contractor and subcontractors could not make most efficient use of equipment and personnel because of the acceleration effort required to offset delays incurred through no fault or negligence on their part. This increased costs substantially.

2(f) State and local tax requirements.

Colorado and Wyoming both impose state sales taxes. In addition, the contractor would experience labor unemployment and insurance taxes. However, these latter would be experienced under normal circumstances and so would not be considered to affect the cost growth.

2(g) Cost Index.

It has not been possible to compile a complete index on the cost index for materials under Contract DA-5914. However, a review of the original labor costs and the final labor costs indicates an increase of approximately 11%.

As noted previously, the 9 sites are located in 5 different counties in 3 different states. The determination of the original wage rate of $3.01 per hour was made by taking an average of the wage rates for the 12 most common categories in each county. No consideration was given to a weighted percentage for these various categories. The final average wage rate of $3.35 per hour was determined by taking an average of the rates for the same 12 categories based on rates paid at the end of the job. This percentage is approximately the same as the increase shown for the same period of time in averages determined by Engineering News Record over the same period

of time. These wage rates are not meant to show an actual dollar value for labor costs but only to show the approximate magnitude of increase. The cost of lumber during the same period of time on a national average has decreased by approximately 2%. Various other supplies are so diversified in nature that it is practically impossible to arrive at a percentage difference in prices.

2(h) Joint Occupancy

From prior experience on Squadrons I and II at Cheyenne, Wyoming, the Area Engineer and SATAF Commander agreed that joint occupancy should be avoided if at all possible. Joint occupancy could not be avoided on Squadron III; however, it was required only in Room 101 of the Launch and Service Building at Sites 6, 7, 8 and 9 and the Launch Operations Building at Site 7. The work of the construction contractor and subcontractors was coordinated with the work of the Air Force contractors in such a manner that no delays or additional costs were incurred.

2(i) Area Engineer - SATAF Relationship

Relationship between the Area Engineer Office and SATAF was excellent throughout the project. As the construction contract neared completion, SATAF recognized that changes issued at this time resulted in exceptionally high costs and created delays that could not be overcome by acceleration efforts on the part of the contractor and his subcontractors. SATAF, therefore, had the changes accomplished by their contractors.

Transfer of facilities to the Using Service with clearance of deficiencies was accomplished with a minimum of delay and differences. The amicable relationship of all personnel involved in

such action greatly facilitated coordination and completion of inspections.

3. BASIC CONTRACT DATA

(1) Design criteria. Basic design criteria were established by the Air Force. The original contract amount was $22,143,981. Date work started - 7 December 1959. A list of major features is as follows:

Launch Operations Building	9 Each
Launch & Service Buildings	9 Each
Propellant Loading Systems	9 Each
Utility Systems	9 Each

(2) Bidding information. A tabulation of the bids and the Government estimate for this contract is as follows:

Martin K. Eby Wichita, Kansas	$22,143,981.00
Diversified Builders Paramount, California	22,156,000.00
Geo. A. Fuller Co. Los Angeles, California	23,185,695.00
Kiewit-Riedesel-Brown Omaha, Nebraska	25,331.727.00
H. B. Zachry Co. San Antonio, Texas	29,223,000.00
Government Estimate	22,336,630.00

(3) Support Facilities.

Contract No.	Description
DA-6064	Liquid Oxygen Disposal Area
DA-6467	Liquid Oxygen Facilities Addn.
DA-6593	Control System Testing
DA-6852	Facility Changes.

(4) Construction Schedule: Contractor schedules his work to commence 11 December 1959. The original completion date was 1 May 1961. Beneficial occupancy dates of work at the various sites was as follows:

	Launch Operations Bldg	Launch & Service Bldg
Site 1	12 April 1961	21 April 1961
Site 2	24 March 1961	13 April 1961
Site 3	15 March 1961	18 April 1961
Site 4	23 February 1961	11 April 1961
Site 5	10 February 1961	23 March 1961
Site 6	30 December 1960	30 January 1961
Site 7	26 January 1961	2 February 1961
Site 8	12 Deeember 1960	18 January 1961
Site 9	23 January 1961	7 February 1961

Final transfer of the facility to the Air Force was on 26 May 1961. The original bid for each site was as follows:

Site 1	2,427,109
Site 2	2,427,109
Site 3	2,427,109
Site 4	2,477,109
Site 5	2,477,109
Site 6	2,477,109
Site 7	2,477,109
Site 8	2,477,109
Site 9	2,477,109

In an effort to remain on schedule the contractor worked most crafts on a multiple shift basis as well as working overtime on Saturdays,

Sundays, and Holidays. In addition, the contractor was required to accelerate the work to overcome excusable delays. The propellant loading system skids were obtained by the Los Angeles District under a contract with Blaw-Knox. These skids were furnished as Government-furnished equipment under this contract. The original CCE for this Squadron was as follows:

Basic Construction Cost	$22,600,000
Land	200,000
Contingencies	2,800,000
Government Costs	2,700,000
Total CCE	28,300,000

4. CONTRACT MODIFICATIONS

The following facets as they pertain to modifications will be discussed. Essentially, all modifications were as a result of changes initiated by the Air Force. A breakdown of these changes into design, definitization, criteria changes, field changes, modifications to support contracts, claims and acceleration is as follows:

(1) Approximately $1,123,000 was spent for definitizing facility design. This included the addition of miscellaneous steel plates, anchors, inserts, addition of structural steel equipment platforms in the Launch and Service buildings and the Launch Operation building, deletion of all segregated storage magazines, substitution of rigid paving for flexible, addition of nitrogen purge for PLS during installation, revisions to stainless steel and carbon steel piping, addition of testing requirements for valves, and for extensive changes to equipment in the Launch Operation Buildings

and Launch and Service buildings.

(2) The other changes requested by the Using Service amounted to $2,524,000. The major portion of these changes involved relocation of air-conditioning units, revisions to water treatment systems, revisions to platforms, changes to pump-house sites, addition of horizontal thrust rollers for overhead roof on missile shelter, addition of a source of supply of helium for the liquid oxygen slug tank blanket with the necessary rearrangement in structural steel piping in valves, rearrangement of electrical wiring, addition of filter units in heating systems in the Launch Operation and Launch and Service buildings and revisions to the water supply system at two sites, revised grounding of the electrical system, and refabrication of helium piping.

(3) There were no modifications issued solely as a result of interference.

(4) One field change was necessary in order to correct latent conditions, namely, removal of lignite under a water storage tank for $1,000.

(5) Modifications to the Support contracts amounted to $85,000, of which $65,000 involved changes on the control system testing contract.

(6) Claims allowed on this contract amounted to approximately $991,000. (86 claims presented for $4,888,000 including acceleration). Protests on unilateral adjustments and modifications resulted in an increased payment of $549,000. Payment in the amount of $185,000 was allowed for the installation of additional electrical grounding. Numerous other claims resulted in the payment

of the remaining $257,000.

(7) Acceleration costs resulted in the payment of approximately $1,333,000. This payment was made in lieu of granting allowable time extensions in order to meet the specified need date on the project. All modifications and claims have been negotiated and are physically complete.

A constant review of the latest labor union agreements and the minimum rate listes issued by the Secretary of Labor was made in computing Government estimates for modifications. Cost estimates for Contract DA-5914 and all other contracts at the F. E. Warren MB were prepared in accordance with latest recognized estimating procedures. Costs data were secured from trade magazines, catalogs, local labor agreements, and professional engineering counsel handbooks. In addition, the estimators made personal visits to the construction sites to observe the conditions under which the work was performed. As a result of experience gained during the construction of Squadrons I and II at F. E. Warren MB, the Corps of Engineers' personnel were able to base their estimates on previous experience. Fifteen modifications were as a direct result of the settlement of claims. Twenty-two other modifications were composed partially of settled claims. The final amount allowed for payment of claims, including acceleration, under this contract was $1,893,802. An additional amount of $431,000 allowed for acceleration under individual modifications is not included in this figure but is in 4(2) above. See Tab No. 6 for a resume of claims and modifications over $200,000.

Breakdown of Modifications by Costs

0 - $50,000		$50,000 - $200,000		$200,000 +	
No.	Total Amount	No.	Total Amount	No.	Total Amount
41	$370,235	6	$538,709	6	$2,824,502

The contractor filed a total of 86 claims amounting to $4,888,000. The following tabulation shows the action which was taken on these claims.

Status	No.	Under $200,000	No.	Over $200,000	No.	Total Value
Settled	59	$725,512	3	$1,168,290	62	$1,893,802
Withdrawn	19	$245,222	2	$ 532,594	21	$ 777,816
Denied	3	$ 75,937	0	- -	3	$ 77,937

5. GOVERNMENT COSTS

Total Government Costs for Squadron III are estimated to be $2,522,342 which represents 7.6% of the total CWE of $33,156,991. As a result of experience gained during construction of Squadrons I and II, it was possible to reduce Government costs on this project below the original estimate. In addition to Government personnel used for inspection, the following private firms were used for various aspects:

United Testing Laboratory

DMJM&A

Zep-Aero

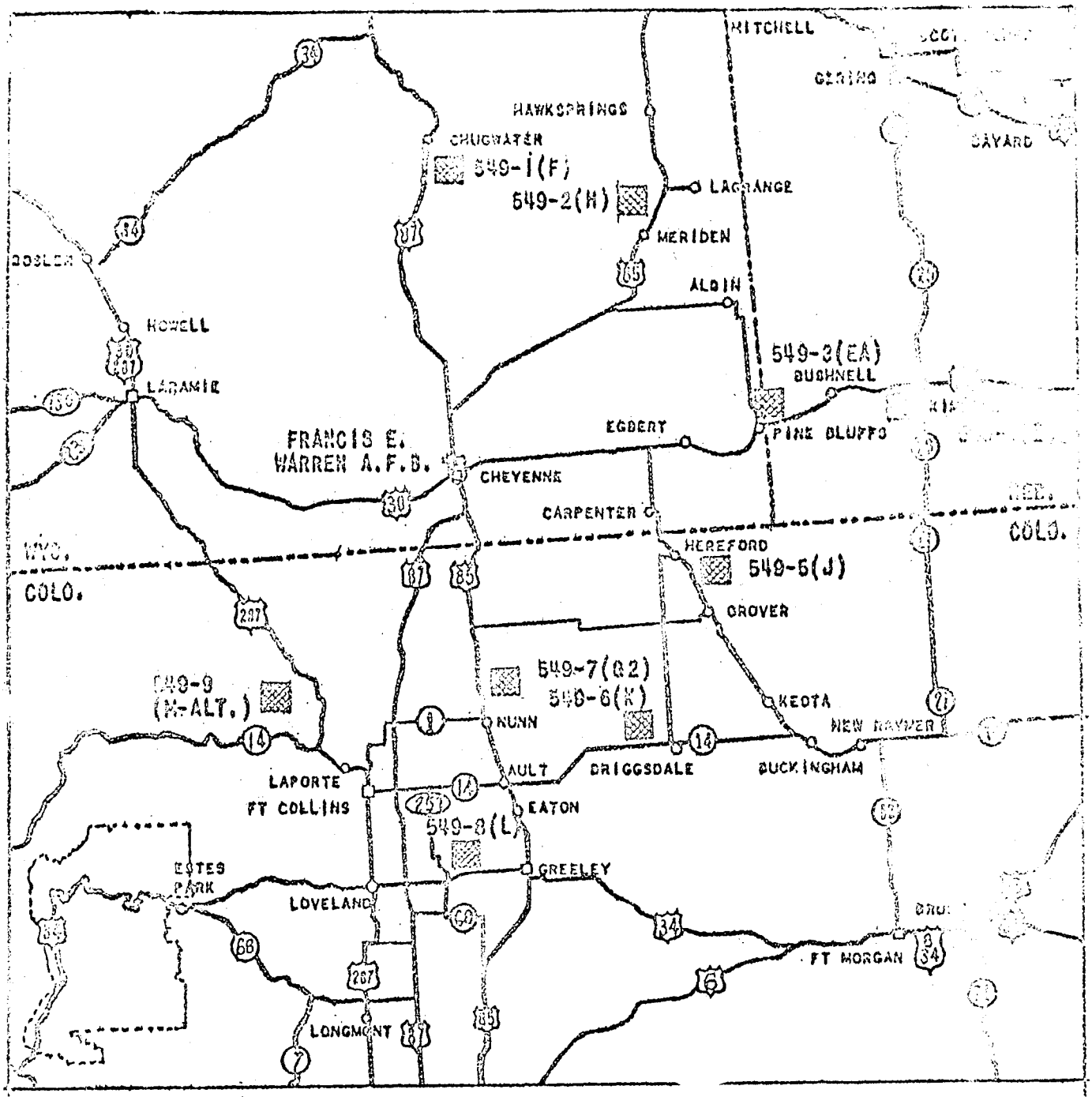
It was necessary to utilize Architect-Engineer for preparation of certain estimates during peak periods because Government estimators were not available in the required numbers. However, Government personnel were assigned on TDY from various other District Offices where possible. See Tab 7 for a monthly listing of Government costs.

6. CONTINGENCIES

The contingency fund is established at the time award of the contract to provide funds for unforeseen minor changes and necessary adjustments in Government costs during the life of the contract. At time of award of Warren III, the maximum contingencies allowed were established at 10%. Contingency funds presently on hand are $121.

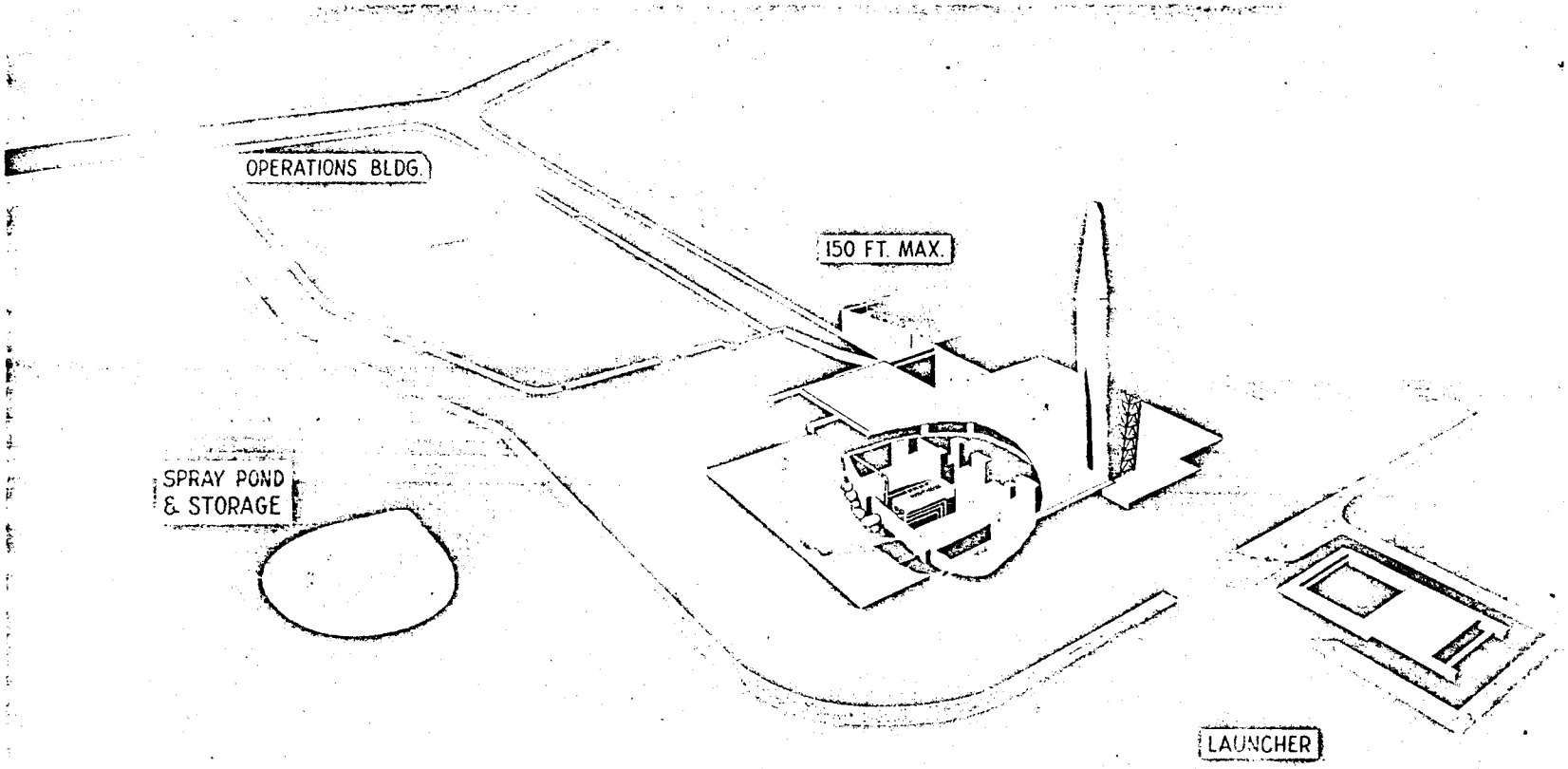
The existing CCE of Warren III is as follows:

Basic Construction	$24,797,480
Land	209,800
Modifications (Negotiated)	3,733,446
Claims (Settled)	1,893,802
Unawarded Work	-
Contingencies	121
Government Costs	2,522,342
Total Buy-Out Cost	33,156,991


MITCHELL
GERING
SAVARD
HAWKSPRINGS
CHUGWATER
549-1(F)
549-2(H)
LAGRANGE
MERIDEN
ALDIN
HOWELL
LARAMIE
549-3(EA)
BUSHNELL
EGBERT
PINE BLUFFS
FRANCIS E.
WARREN A.F.B.
CHEYENNE
CARPENTER
NEB.
COLO.
WYO.
COLO.
HEREFORD
549-5(J)
GROVER
549-9
(M-ALT.)
549-7(G2)
549-6(K)
KEOTA
NUNN
NEW RAYMER
AULT
BRIGGSDALE
BUCKINGHAM
LAPORTE
FT COLLINS
EATON
549-8(L)
GREELEY
ESTES
PARK
LOVELAND
FT MORGAN
LONGMONT
10
20
30 MILES
GRAPHIC SCALE
LAUNCHING SITE LOCATIONS
AIR FORCE BALLISTIC MISSILE DIV.
LAUNCHING SITE LOCATIONS
WARREN A.F.B. AREA
ARCH. ENGR. -

ATLAS

ALL INERTIAL HORIZONTAL-HARD SQDN.*



*ONE OF NINE IN A SQUADRON

TABULATION OF PRECIPITATION AND TEMPERATURES CHUGWATER, WYOMING

Precipitation 25 Year Period 1931-1955

Normal
59-61

Dec 59	Jan 60	Feb	Mar	Apr	May	June	July
.66	.55	.57	1.05	2.14	2.42	2.47	2.47
T	.48	.94	.95	.80	1.83	1.98	.27

Aug	Sept	Oct	Nov	Dec 60	Jan 61	Feb	Mar
1.11	1.26	.90	.62	.66	.55	.57	1.05
.48	1.00	.71	1.26	.64	.16	.47	2.69

Apr	May	June	July	Aug	Sept	Oct
2.14	2.42	2.47	2.47	1.11	1.26	.90
1.38	5.63	2.34	2.16	.67	1.20	.34

Temperatures 25 Year Period

Normal
59-61

Dec 59	Jan 60	Feb	Mar	Apr	May	June	July
30.1	27.5	29.3	33.9	43.8	52.5	61.8	69.7
33.6	27.6	23.1	35.6	46.6	53.1	64.8	70.7

Aug	Sept	Oct	Nov	Dec 60	Jan 61	Feb	Mar
68.0	58.8	48.4	36.1	30.1	27.5	29.3	33.9
69.3	60.7	39.5	36.9	28.4	32.7	34.7	36.8

Apr	May	June	July	Aug	Sept	Oct
43.8	52.5	61.8	69.7	68.0	58.8	48.4
41.8	53.0	63.1	67.9	68.9	53.8	46.3

TABULATION OF PRECIPITATION AND TEMPERATURES KIMBALL, NEBRASKA

Precipitation 25 Year Period 1931-1955
Normal
59-61

Dec 59	Jan 60	Feb	Mar	Apr	May	June	July
.54	.42	.49	1.10	1.91	2.78	2.80	2.40
.21	.74	.76	.50	1.18	2.84	3.28	1.78

Aug	Sep	Oct	Nov	Dec 60	Jan 61	Feb	Mar
1.90	1.31	68	.64	54	.42	.49	1.10
.71	.90	1.44	.73	.72	.06	.18	2.39

Apr	May	June	July	Aug	Sept	Oct
1.91	2.78	2.80	2.40	1.90	1.31	.68
.91	6.58	4.55	5.82	.55	2.71	.45

Temperatures 25 Year Period
Normal
59-61

Dec 59	Jan 60	Feb	Mar	Apr	May	June	July
29.7	27.0	30.0	35.4	45.7	55.7	65.4	72.8
34.4	25.8	23.7	35.0	48.5	55.7	64.6	72.0

Aug	Sept	Oct	Nov	Dec 60	Jan 61	Feb	Mar
70.8	61.4	50.0	36.7	29.7	27.0	30.0	35.4
70.0	61.9	50.3	37.4	29.0	30.7	34.4	37.0

Apr	May	June	July	Aug	Sept	Oct
45.7	55.7	65.4	72.8	70.8	61.4	50.0
42.6	53.3	66.0	70.4	70.7	54.6	47.7

TABULATION OF PRECIPITATION AND TEMPERATURES FT. COLLINS, COLORADO

Precipitation 25 Year Period 1931-1955
Normal
59-61

Dec 59	Jan 60	Feb	Mar	Apr	May	June	July
.42	.36	.50	.93	1.78	2.68	1.88	1.17
T	.37	.53	.84	.88	2.50	.72	.80

Aug	Sept	Oct	Nov	Dec 60	Jan 61	Feb	Mar
1.57	1.29	.99	.50	.42	.36	.50	.93
.03	.39	2.11	.28	.56	.21	.64	3.38

Apr	May	June	July	Aug	Sept	Oct
1.78	2.68	1.88	1.17	1.57	1.29	.99
1.00	7.06	1.83	4.27	4.00	4.00	1.17

Temperatures 25 Year Period
Normal
59-61

Dec 59	Jan 60	Feb	Mar	Apr	May	June	July
29.9	26.6	29.8	36.3	46.8	55.3	64.5	71.2
34.2	25.2	25.0	35.5	49.3	55.4	67.0	70.9

Aug	Sept	Oct	Nov	Dec 60	Jan 61	Feb	Mar
69.0	60.7	49.7	36.8	29.9	26.6	29.8	36.3
69.8	62.5	50.2	37.7	30.2	29.2	35.1	36.5

Apr	May	June	July	Aug	Sept	Oct
46.8	55.3	64.5	71.2	69.0	60.7	49.7
45.7	56.0	65.2	69.7	70.0	54.7	48.2

CHEYENNE AREA OFFICE
CONTRACTOR'S PAYROLL DISTRIBUTION
CONTRACT NO. DA-25-066-Eng-5914

	REGULAR TIME		OVERTIME	
MONTH	HOURS	COST	HOURS	COST
1959				
Dec	1,850	5,210	140	390
1960				
Jan	18,230	66,685	2,795	11,860
Feb	37,015	111,970	1,810	7,120
Mar	55,425	170,235	6,000	24,380
Apr	70,060	214,520	5,140	20,615
May	95,630	295,515	7,020	29,105
Jun	100,780	316,875	14,545	65,585
Jul	142,610	470,105	40,680	180,770
Aug	136,585	455,400	32,980	154,555
Sep	121,505	391,225	15,830	69,970
Oct	151,265	511,400	22,765	109,970
Nov	149,065	534,590	32,295	179,245
Dec	119,870	431,080	16,765	94,120
1961				
Jan	131,585	487,990	27,285	157,900
Feb	87,395	319,265	22,325	128,650
Mar	37,250	129,745	7,250	34,580
Apr	25,260	83,240	4,150	19,170
May	6,030	19,035	935	3,770
Jun	1,325	4,500	140	585
TOTALS	1,488,735	$5,018,585	260,850	$1,292,340

F.E. WARREN III

DA-25-066-eng-5914

OPERATIONAL BASE COMPLEX - MISSILE SITES 549-1 thru 549-9

MARTIN K. EBY CONSTRUCTION COMPANY, INC. - PRIME CONTRACTOR

FIRST TIER SUBCONTRACTORS TO EBY

American Fence Company	All fencing work
Applied Coatings, Inc.	Waterproofing and painting
Construction Specialties	Acoustical units
Fischbach & Moore, Inc.	Electrical
Wallace Process Piping Co.,Inc. & Assoc.	Mechanical
Sterling Paving Company	Paving
Pittsburgh Plate Glass Company	Glass and glazing
B. Davis Furniture Company	Flooring Covering
Crouse Ready-Mix, Inc.	Concrete - Sites 3 and 5
San Ore Construction Co., Inc.	Earthwork and paving
Gerald F. Eiden Company	Plasterers
Sam Fox Sheet Metal Company	Sheet metal
Plains Construction Company	Earthwork
Ross Construction Company	Earthwork
Alamo Construction Company	Earthwork
H. R. Neusbaum Company	Mechanical
Carter's Lawn & Tree Service	Seeding
Simpson Electric Company	Electrical Wiring for Corps of Engineers' sheds
R. & H. Trucking Company	Aggregate Hauling
Harsch-Anderson Lumber Co.	Roofing

FIRST TIER SUBCONTRACTOR TO FISCHBACH & MOORE, INC.

Johnson Service Company	Mechanical and testing

FIRST TIER SUBCONTRACTOR TO SAN ORE CONSTRUCTION CO.

Knisely-Moore Construction Company	Paving

FIRST TIER SUBCONTRACTORS TO WALLACE & ASSOCIATES

Plains Construction Company	Earthwork
Powers Regulator Company	Mechanical
Holden and Holden Company	Well Pumps
Parker Engineering	Painting Tanks
Acme Company	Mechanical
Frazier Grossman Company	Mechanical
Carl Herbst Plumbing & Heating Co.	Mechanical
Devers-Henry, Inc.	Equipment w/Operator
Ross Construction Company	Earthwork
Alamo Construction Company	Earthwork

WAGE SCALES

(CRAFT) Asbestos Worker

(UNION) Local #28, Denver, Colorado

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.70 - $4.00	Same

OVERTIME:

2 x Basic Rate: All Overtime.

TRAVEL:

12-18 miles from Denver or Laramie	$1.50 per day
18-24 " " " " "	$3.00 per day
24-30 " " " " "	$4.50 per day
Over 30 " " " " "	$8.00 per day

FRINGE BENEFITS: Actual subsistence if away from home overnight.

Health & Welfare	$0.10 per hour worked
Pension	$0.20 per hour worked

WAGE SCALES

(CRAFT) Carpenter

(UNION) Local 469 Cheyenne, Wyo., (Sites 1, 2, & 3)

Local 2141 Scottsbluff, Nebr., (Site 4)

Local 418 Greeley, Colo. (Sites 5 thru 8)

Local 1340 Ft. Collins, Colo. (Site 9)

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$2.75 - $3.35	Same

OVERTIME:

1 1/2 x Basic Rate:

Over 8 hours per day: All Sites

Saturdays: All Sites

Sundays: Wyoming Sites (1,2 & 3)

Holidays: Wyoming Sites (1,2 & 3)

2 x Basic Rate:

Sundays: Nebr. & Colo. Sites (4 thru 9)

Holidays: Nebr. & Colo. Sites (4 thru 9)

TRAVEL: Greeley, Colo - 20 miles or over - 1 hr journeyman pay (sites 5 thru 8)

Ft. Collins, Colo. - 20 miles or over - travel time 1 way (Site 9)

FRINGE BENEFITS:

Health & Welfare: None

Vacation: None

Pension: None

WAGE SCALES

(CRAFT) Cement Mason

(UNION) Local 299 Cheyenne (Sites 1 thru 4)

Local 577 Denver (Sites 5, 6 &8)

Local 399 Ft. Collins (Sites 7 & 9)

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.10 - $3.75	Same

OVERTIME:

1 1/2 x Basic Rate:

Over 8 hours per day: Colo. (Sites 5 thru 9) up to 8:30 PM Monday thru Friday

Wyoming & Nebraska (Sites 1 thru 4)

Saturdays: Wyoming and Nebraska (Sites 1 thru 4) up to 4:30 PM

2 x Basic Rate: Colo. (Sites 5 thru 9) after 8:30 PM Mon thru Fri

Over 8 hours per day

Sundays: All Sites

Holidays: All Sites

Saturdays: Wyoming and Nebraska (Sites 1 thru 4) after 4:30 PM

TRAVEL: Sites 1 thru 4 - $0.10 per mile round trip from Cheyenne over 12 miles

Sites 5, 6 & 8 from Denver		Sites 9 from Ft. Collins	
15 miles	$3.54/day	15 miles	$3.10/day
50 miles	5.50/day	50 miles	5.00/day
65 miles	8.00/day	65 miles	7.00/day

FRINGE BENEFITS:

Health & Welfare:	None
Vacation:	None
Pension:	None

WAGE SCALES

(CRAFT) Electrician

(UNION) IBEW Local 415 Cheyenne (Sites 1 thru 4)

IBEW Local 68 Denver (Sites 5 thru 9)

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.68 - $4.05	Same

OVERTIME:

1 1/2 x Basic Rate:

over 8 hours per day: Sites 1 thru 4 between 4:30 PM - 8:30 PM, Mon thru Fri
Sites 5 thru 9

Saturdays: Sites 1 thru 4 up to 4:30 PM Sat

Sites 5 thru 9

2 x Basic Rates:

Over 8 hours per day Sites 1 thru 4 after 8:30 PM Mon-Fri

Saturdays: Sites 1 thru 4 after 4:30 PM Sat.

Sundays: All sites

Holidays: All sites

TRAVEL:	Sites 1 thru 4	Sites 5 thru 9
	Over 9 miles $2.00 per day	Over 20 miles $0.10/mile
	Plus $0.30 mile one-way	Plus time @ 30 mph
	$9.00 maximum	Plus subsistence @ $9.00/day

FRINGE BENEFITS:

Health & Welfare:	All sites 1% gross pay
Vacation:	Sites 5 thru 9 4% gross hourly pay
Pension:	None

WAGE SCALES

(CRAFT) Ironworkers

(UNION) Local 494 Laramie (Sites 1, 2, 3, 4, 5, 7 & 9)

Local 24 Denver (Sites 6 & 8)

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.55 - $3.75	Same
OVERTIME:		
2 x Basic Rate:	All overtime	
TRAVEL:	Sites 1 - 5, 7 & 9	Sites 6 & 8
	$2.50 per day	$3.50 per day
	over 50 miles	over 50 miles
	$5.00/day plus subsistence	$7.00/day plus subsistence

FRINGE BENEFITS:

Health & Welfare:	None
Vacation:	None
Pension:	None

WAGE SCALES

(CRAFT) Laborer

(UNION) Local 1219 Cheyenne Sites 1, 2 & 3

Local 1140 Omaha Site 4

Local 720 Denver Sites 5 thru 9

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$2.00 - $2.22	Same
OVERTIME:		
1 1/2 x Basic Rate:		
Over 8 hours per day:	All Sites	
Saturdays:	All Sites	
Sundays:	Sites 1 thru 3	
2 x Basic Rate:		
Sundays:	Sites 4 thru 9	
Holidays:	All Sites	
TRAVEL:	None	
FRINGE BENEFITS:		
Health & Welfare:	None	
Vacation:	None	
Pension:	None	

WAGE SCALES

(CRAFT) Operating Engineer

(UNION) Local 326 Cheyenne (Sites 1 thru 3)

Local 571 Omaha (Site 4)

Local 9 Denver (Sites 5 thru 9)

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.25 - $3.70	Same
OVERTIME:		
1 1/2 x Basic Rate:		
Over 8 hours per day:	All sites except Site 4	
Saturdays:	All sites except Site 4	
Sundays:	Sites 1 thru 3	
Holidays:	Sites 1 thru 3	
2 x basic rate:		
Sundays:	Sites 5 thru 9	
Holidays:	Sites 5 thru 9	
All Overtime:	Site 4	
TRAVEL:	None	
FRINGE BENEFITS:		
Health & Welfare:	None	
Vacation:	None	
Pension:	None	

WAGE SCALES

(CRAFT) Painter, Brush

(UNION) Local 571 Cheyenne Sites 1, 2, 3, 4 & 5

Local 974 Greeley Sites 6, 7 & 8

Local 264 Ft. Collins Site 9

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.00 - $3.35	Same

OVERTIME:

1 1/2 x Basic Rate:

All Overtime

TRAVEL:	Sites 1 - 5 2 hrs. @ journeyman rate plus $0.08 per mile	Sites 6 & 7 2 hrs. @ journeyman rate	Sites 8 & 9 No travel time

FRINGE BENEFITS:

Health & Welfare:	None
Vacation:	None
Pension:	None

WAGE SCALES

(CRAFT) Roofer

(UNION) Local 41, Denver All sites

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.45	Same

OVERTIME:

1 1/2 x Basic Rate:

Over 8 hours per day: All sites

Saturdays: All sites

2 x Basic Rate:

Sundays: All sites

Holidays: All sites

TRAVEL: $0.10 per mile. Actual subsistence if required to be away from home over night. Travel time at journeyman rate before 8:00 AM and after 4:30 PM outside city limits.

FRINGE BENEFITS:

Health & Welfare: $0.10 per hour

Vacation: None

Pension: None

WAGE SCALES

(CRAFT) Sheetmetal Worker

(UNION) Local 207 Cheyenne Sites 1 & 2

Local 9 Denver Sites 3 thru 9

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.55 - $3.90	Same

OVERTIME:

1 1/2 x Basic Rate:

Over 8 hours per day: Sites 1 & 2 up to 10:00 PM Monday thru Friday

Saturdays: Sites 1 & 2 up to 10:00 PM Saturday

2 x Basic Rate:

Over 8 hours per day sites 1 & 2 after 10:00 PM Monday thru Saturday

Sundays: All sites

Holidays: All sites

TRAVEL: Sites 1 & 2 straight time plus $0.10 per mile from Cheyenne city limits.

Sites 3 thru 9 $0.07 per mile from Denver plus toll charges plus time based on 40 mph.

FRINGE BENEFITS:

Health & Welfare: $0.075per hour sites 1 & 2

Vacation: $0.10 per hour deducted from gross pay sites 3 - 9

Pension: None

WAGE SCALES

(CRAFT) Steamfitter

(UNION) Local 192 Cheyenne Sites 1, 2 & 3

Local 464 Omaha Site 4

Local 208 Denver Sites 5, 6, 7, 8 & 9

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$3.60 - $3.95	Same

OVERTIME:

1 1/2 x Basic Rate:

Over 8 hours per day: Sites 1 thru 4

Saturdays: Sites 1 thru 4, all; Sites 5 thru 9 8:00 AM - 4:30 PM

2 x Basic Rate:

Over 8 hours per day: Sites 5 thru 9

Sundays: All Sites

Holidays: All Sites

Saturdays: Sites 5 thru 9 except 8:00 AM - 4:30 PM

TRAVEL:

Sites 1 - 3: 15 - 30 miles 2 hrs travel or subsistence of not less than $7.00; over 30 miles $0.10 per mile.

Site 4: $7.00 per day

Sites 5 thru 9: Over 15 miles from Ft. Collins or Greeley $0.045/hr/mi
One-way with $7.00 maximum

FRINGE BENEFITS:

Health & Welfare: Site 4: $0.075 per hour

Sites 5 - 9 $0.10 per hour

Vacation: Site 4 $0.08 per hour; Sites 1 - 3 85% 8 hr day/mon

Pension: None

WAGE SCALES

(CRAFT) Teamster

(UNION) Local 307 Cheyenne, Sites 1, 2 & 3

Local 950 Scottsbluff, Site 4

Local 13 Denver, Sites 5, 6, 7, 8 & 9

	PREVAILING RATE	PAID BY CONTRACTOR
WAGE RATE:	$2.40 - $3.10	Same

OVERTIME:

1 1/2 x Basic Rate:

Over 8 hours per day:	All Sites
Saturdays:	All Sites
Sundays:	All Sites except Site 4
Holidays:	All Sites except Site 4

2 x Basic Rate:

Sundays:	Site 4
Holidays:	Site 4

TRAVEL: Subsistence when away from home station.

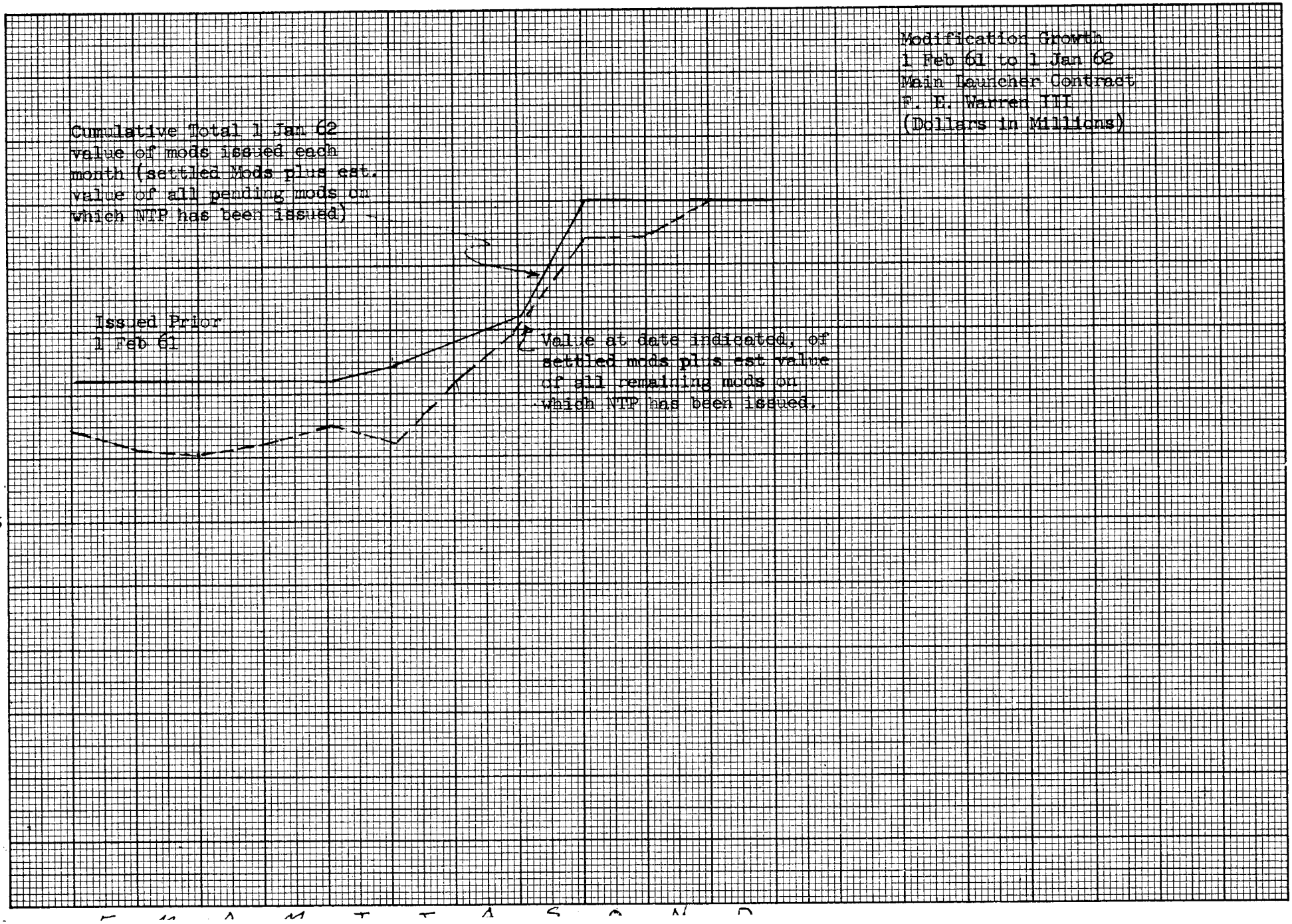
FRINGE BENEFITS:

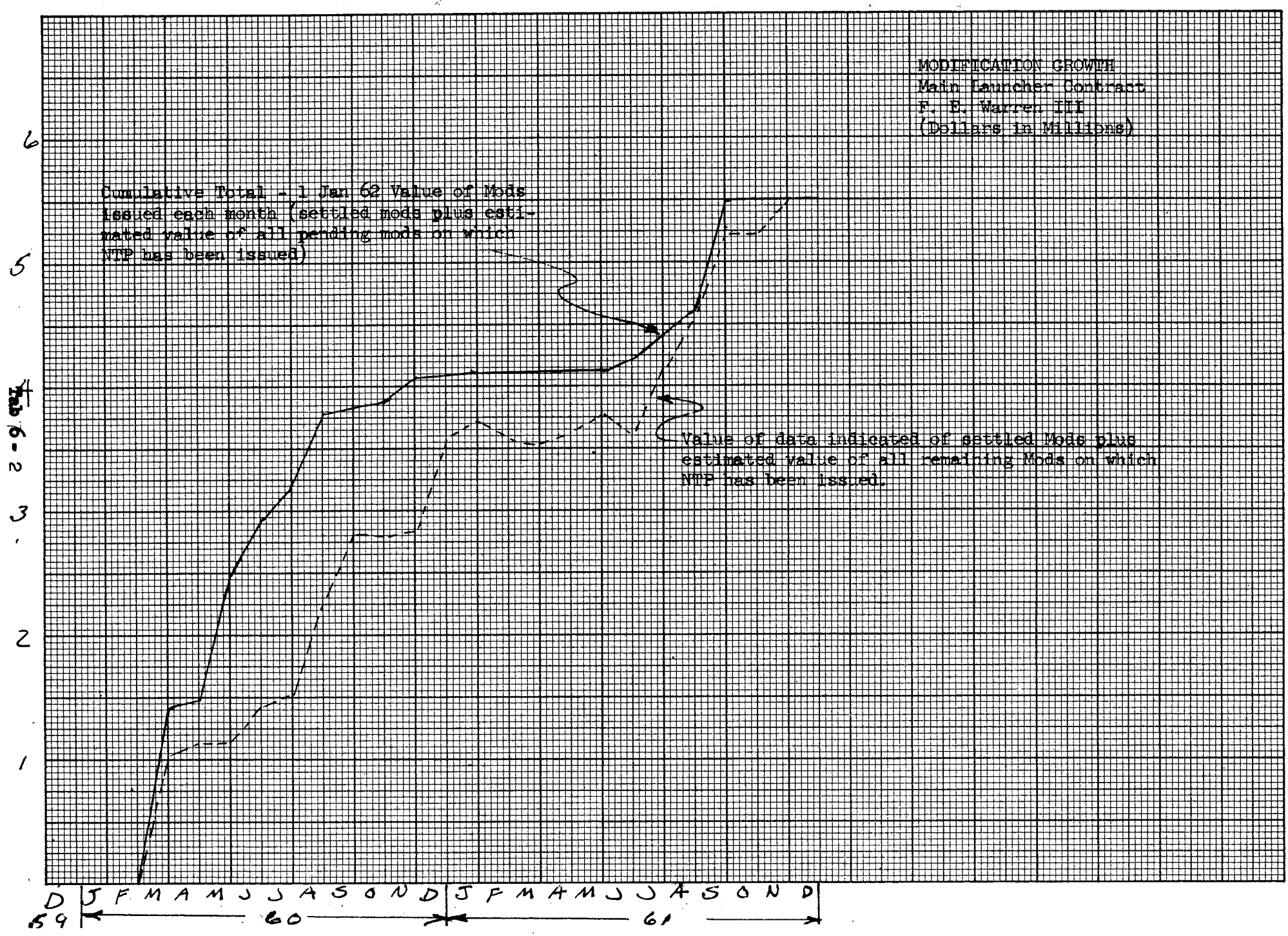
Health & Welfare:	None
Vacation:	None
Pension:	None

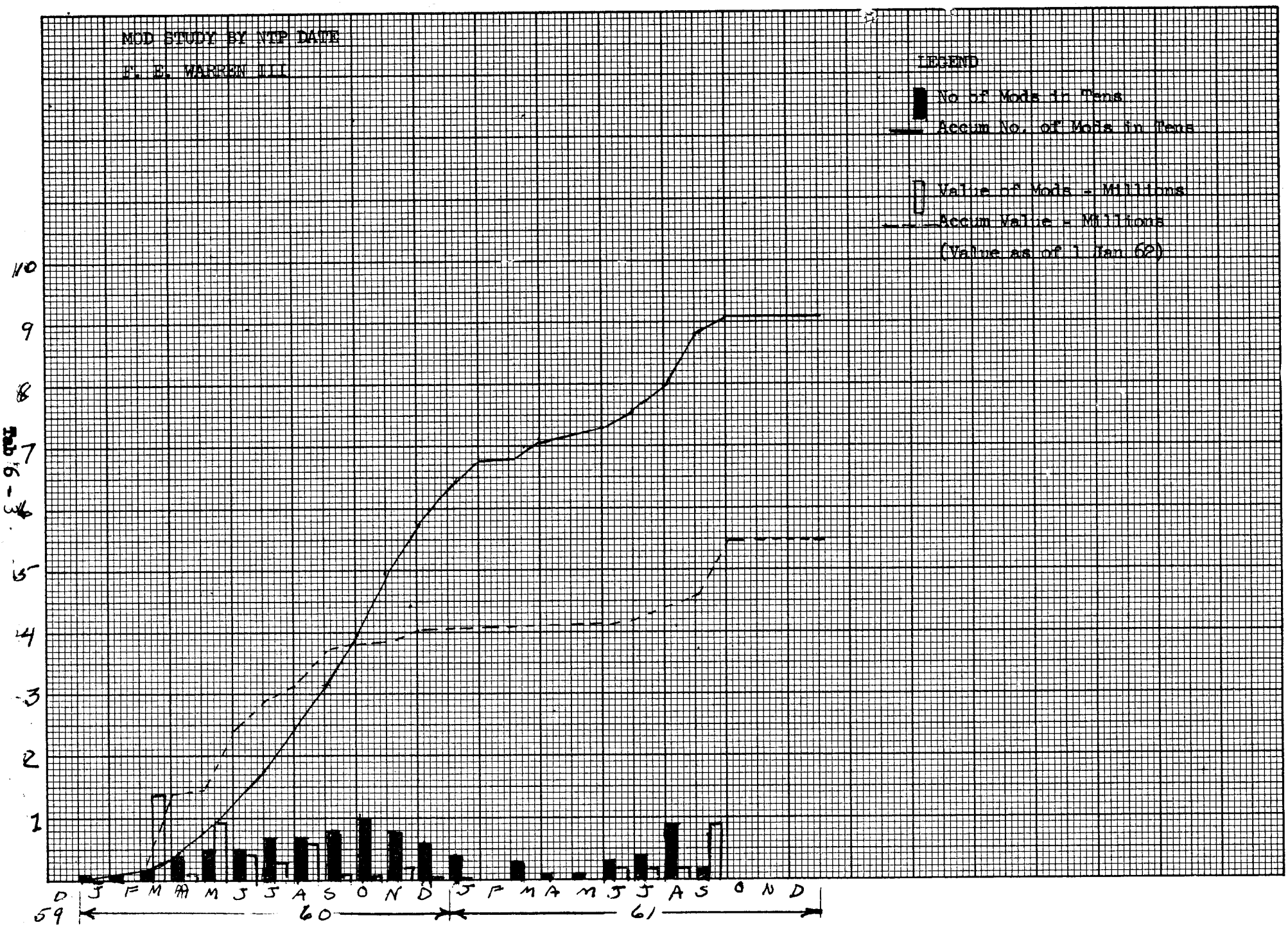
F. E. WARREN III

COUNTY STATE	Larimer Colo.	Weld Colo.	Kimball Nebr.	Laramie Wyo.	Platte Wyo.	TOTAL	AVERAGE	
Asbestos Worker	3.65	3.65	3.65	3.65	3.65	18.25	3.65	3.85
Carpenter	2.90	2.90	2.50	3.05	3.05	14.40	2.88	3.05
Cement Mason	3.00	3.44	2.50	2.75	2.75	14.44	2.88	3.43
Electrician	3.90	3.90	2.50	3.43	3.25	17.28	3.44	3.87
Iron Worker	3.55	3.55	3.55	3.55	3.55	17.75	3.55	3.65
Laborer	2.49	2.27	1.77	2.12	2.12	10.77	2.15	2.11
Operating Engineer	3.00	3.00	2.80	2.47	2.47	13.74	2.75	3.42
Painter Brush	2.50	2.50	2.25	2.85	3.25	13.35	2.67	3.18
Roofer	3.30	3.30	2.20	3.30	3.30	15.40	3.08	3.45
Sheetmetal	3.75	3.75	2.30	3.45	3.45	16.70	3.34	3.74
Steamfitter	3.80	3.80	2.50	3.40	3.74	17.24	3.45	3.77
Teamster	2.55	2.55	1.65	2.28	2.55	11.58	2.31	2.75
							36.15	40.27

Average Wage - Initial..... 3.01 Final.. 3.35


Modification Growth
1 Feb 61 to 1 Jan 62
Main Launcher Contract
F. E. Warren III
(Dollars in Millions)
Cumulative Total 1 Jan 62
value of mods issued each
month (settled Mods plus est.
value of all pending mods on
which NTP has been issued)
Issued Prior
1 Feb 61
Value at date indicated, of
settled mods plus est value
of all remaining mods on
which NTP has been issued.
6
5
4
3
2
1
I - 9 GRL


MODIFICATION GROWTH
Main Launcher Contract
F. E. Warren III
(Dollars in Millions)
Cumulative Total - 1 Jan 62 Value of Mods issued each month (settled mods plus estimated value of all pending mods on which NTP has been issued)
Value of data indicated of settled Mods plus estimated value of all remaining Mods on which NTP has been issued.
6
5
4
3
2
1
Feb 62
D J F M A M J J A S O N D J F M A M J J A S O N D
59
60
61


MOD STUDY BY NTP DATE
E. E. WARREN III
LEGEND
No of Mods in Tens
Accum No. of Mods in Tens
Value of Mods - Millions
Accum Value - Millions
(Value as of 1 Jan 62)
10
9
8
7
6
5
4
3
2
1
D J F M A M J J A S O N D J F M A M J J A S O N D
59
60
61