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EARTHWORK CONSTRUCTION IN SUPPORT OF A MARINE AMPHIBIOUS FORCE --ETC(U)
JAN 78 P S SPRINGSTON

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A Marine Amphibious Force (MAF) level Marine Air/Ground Task Force (MAGTF) will generate multiple, large-scale horizontal construction projects totaling thousands of cubic yards of earthwork. Even with Naval Construction Force (NCF) support, a landing force commander may be confronted with simultaneous critical earthwork requirements that would exceed the engineering capability of the MAF. A hypothetical earthwork construction case is defined by a set of limiting assumptions. Within the boundaries set by these

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assumptions, facility construction activity estimates are calculated and arrow networks are drafted. The Critical Path Method (CPM) is utilized to predict project earliest finish dates and resource allocation. The presented data (networks, resource requirements, project durations, etc.) will be of use to researchers and planners in the area of amphibious logistic support. Specific Initial Operating Capability dates for facilities will vary with operational requirements; thus, a general discussion of the projections was substituted in lieu of specific conclusions of whether facility construction was in pace with tactical and operational requirements.

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CONTENTS

GLOSSARY OF TERMS

AAFS	Amphibious Assault Fuel System
ABFC	Advanced Base Functional Component
ALSA	Amphibious Logistic Support Ashore
AMSS	Advanced Multi-purpose Surfacing System
AOA	Amphibious Objective Area
ASP	Ammunition Supply Point
BSA	Beach Support Area
CESE	Civil Engineer Support Equipment
CESO	Civil Engineer Support Office
CPM	Critical Path Method
EAF	Expeditionary Airfield
FACSO	Facilities Support Office
FEBA	Forward Edge of Battle Area
FLOLS	Fresnel Lens Operated Landing System
FOMAT	Foam Core Fiberglass Reinforced Structural Surfacing Material
FSSG	Force Service Support Group
LRU	Low Rate Unit of the AMSS
LSA	Logistic Support Area
MAF	Marine Amphibious Force
MAGTF	Marine Air/Ground Task Force
MARCORPS	U.S. Marine Corps
MARDIV	Marine Division

Glossary of Terms (continued)

MAW	Marine Air Wing
MHE	Material Handling Equipment
MOGAS	Motor Gas
MOMAT	Mobile Matting (Surfacing)
MSR	Main Supply Route
NAVFAC	Naval Facilities Engineering Command
NCF	Naval Construction Force
NCFSU	Naval Construction Force Support Unit
NCR	Naval Construction Regiment
NMCB	Naval Mobile Construction Battalion
NRL	No Resource Leveling
PEMS	Project/Equipment Management System (concept)
POL	Petroleum, Oils and Lubricants (usually fuel)
RL	Resource Leveling
SATS	Short Airfield for Tactical Support
SIXCON	Modular Fuel System
ST	Short Ton
TAFDS	Tactical Air Fuel Dispensing System
V/STOL	Vertical/Short Take-off and Landing
WSG	Wing Support Group

INTRODUCTION

The Amphibious Logistic Support Ashore (ALSA) System presents the structure for systematically analyzing the capability of a Marine Air/Ground Task Force (MAGTF) to provide consistent and efficient flow of material, equipment, services, and supplies for combat troops. The ALSA System, which encompasses the engineering, construction, maintenance, transportation, and service functions of the MAGTF, is functionally divided into six component subsystems. The Horizontal Construction Subsystem of ALSA consists of all procedures, materials, technology, and hardware required by MAGTF engineer units to furnish the earthwork structures and prepared surfaces used in Marine Corps amphibious shore-side operations [1].

Future amphibious landing operations will include containerized cargo, container transporters, and materials-handling equipment as well as conventional and V/STOL aircraft. The earthwork and prepared surfaces provided by the MAGTF engineers must be able to support these heavy wheel loads over beach exit routes, Logistic Support Areas (LSAs), Main Supply Routes (MSRs), and Expeditionary Airfields (EAFs), and within ammunition and fuel dumps. A Marine Amphibious Force (MAF) level MAGTF could generate multiple, large-scale horizontal construction projects totaling thousands of cubic yards of earthwork. Time will be severely constrained for the landing force commander, who may be confronted with simultaneous earthwork requirements for airfield, roadway, and LSA construction; and for grading, ditching, and drainage support for other facilities in the objective area.

The scope of the construction effort will necessitate the assignment of Naval Construction Force (NCF) units to augment the construction capability of the Division and Force Engineer Battalions of the MAF. Even with NCF support, it is debatable whether the engineering capability of a MAF will be sufficient to enable concurrent starting of all equal priority earthwork projects and timely completion of the projects.

The efficiency of horizontal construction projects influences the effectiveness of MAGTF combat elements. This report presents a critical point study of the ALSA Horizontal Construction Subsystem and, thereby, the earthwork construction capability of a MAF level MAGTF. Within limiting assumptions, construction estimates and schedules are formulated, and project starting and completion dates and equipment requirements are analyzed. The extent to which the landing force commander would be constrained by horizontal construction is ascertained for this hypothetical case.

PROCEDURE

Major horizontal construction projects that would be generated by a MAF are listed and defined in Appendix A. General assumptions concerning the tactical situation, weather, work hours, etc. were equally applied to all project estimations. Specific assumptions concerning project scope, design, and terrain were established for each project (Appendix B) to facilitate construction activity estimates. Equipment specifications and performance characteristics for selected items of MARCORPS and NCF earthmoving equipment were compiled (Appendix C) for inclusion in equipment production formulas. The projects were subdivided into their component construction activities, and, using the production formulas, estimates were completed for activity durations and assigned resources (equipment). Individual project durations were estimated through employment of Critical Path Method (CPM) techniques to isolate the critical path and expected duration for each project.

Overall project scheduling was accomplished with a bar graph that depicts project start/end dates and the assigned military construction unit. Projects were scheduled in accordance with the priority guidelines established in Table 1 [2]. Lower priority projects were not scheduled until all first priority projects were under construction and sufficient resources were available.

Finally, the scheduling and various aspects of each project are discussed. Shortcomings within the Horizontal Construction Subsystem of ALSA are identified and explained in detail.

GENERAL ASSUMPTIONS

Since, by definition, a MAF is a highly mobile force capable of assaulting a hostile shore, there is an infinite array of possible combinations of climate, topography, weather, and enemy action that might be encountered. To impart consistency to the estimation of the numerous construction activities included within this report, it was necessary to formulate limiting assumptions that would serve as a datum for estimates. The assumptions were intended to present reasonable constraints; therefore, extremely adverse or beneficial conditions of topography, haul distances, etc. were avoided.

Table 1. Priority Ratings for Horizontal Construction Project

Project Description	Priority
Landing Beach Preparation (ramps, surface preparation/stabilization, beach roads, exits, etc.)	1
POL Storage (AAFS/TAFDS)	1
Expeditionary Airfield(s)	1
MSR Construction	1[a]
Emergency Rehabilitation of Access Roads and Bridges	1
Open Storage (LSAs)	1[b]
Ammunition Storage	2
Construction Force Augmentation (rock crushing, asphalt plant, etc.)	2
Housing (begin construction for priority personnel and continue to completion)	2[c]
Aircraft Maintenance Facilities (earthwork)	3
Hospitals (supporting earthwork)	3
Drainage Control and Dustproofing	3
Road and Bridge Construction (other than MSR and emergency rehabilitation)	4
Base Maintenance	4

[a]Not included in Reference 2.

[b]Upgraded from Reference 2.

[c]Downgraded from Reference 2.

The general limiting assumptions were as follows:

- Approximately 14 hrs of daylight are available. Earthwork and surfacing (except where noted) are limited to 12 hrs/day. Night earthwork operations are not feasible as a result of enemy threat and inefficiency of equipment. Labor/time estimates are not to be adjusted for detrimental effects of enemy action, weather, or equipment breakdown.

- Site topography is assumed to be gently sloping to level ground covered by medium overgrowth consisting of brush and small trees less than 4 in. in diameter. Topsoil and some undesirable organic matter generally occur in the upper 12 in. of the soil strata and overlie fairly competent soils. Suitable areas are available for borrow pits and quarries. No ripping or blasting of rock are required for horizontal construction projects.

• There is no threat to the landing force from either NBC warfare or aerial attack.

• The MAF has landed in a predominantly undeveloped area with marginal, or no, logistic facilities (roads, airfields, etc.).

• Three NMCBs are assigned to the MAF. Each NMCB is accompanied by its organic equipment allowance and several items of augment equipment (Appendix C).

BASE LAYOUT

A naval advanced base may be needed to support unified area defense and/or launching and support of unified military operations [2]. Seizure and establishment of an advanced base could be a primary mission of a MAF landing. Through the process of providing logistic support to the combat elements of the MAF, an advanced base will inevitably be established in the rear area. The extent of this base development will depend upon the mission of the MAF, whereas the configuration of the base will be influenced by tactical considerations, topography, and economics.

The advanced base supporting the MAF ashore will be designed to provide efficient logistic and tactical support to MAF combat elements. Minimum prerequisites for the base include:

1. Dependable main supply routes linking beach support areas (BSAs), logistic supply areas, ammunition storage points (ASPs), and combat troops.
2. Logistic supply areas for the storage, breakout, and retrograding of containers and the storage of breakbulk supply items.
3. Ammunition supply points with protective earth revetments for the storage of sufficient quantities of ordnance to supply three Marine Air Groups and one Marine Division.
4. POL storage (AAFS), distributing, and issuing systems (TAFDS, SIXCON).
5. Berthing, messing, administrative and work areas, and facilities to support 8,800 combat service support personnel assigned to the MAF Force Troops and 15,000 personnel assigned to the Marine Air Wing (MAW) [3].
6. Expedient airfields to support the MAW. (Without benefit of existing facilities, at least three expeditionary airfields and several V/STOL and VTOL pads would have to be constructed to move the MAW ashore. A multitude of support facilities associated with these airfields must be

available for the airfields to achieve a sustained operational capability.)

A conceptual layout of an advanced base (Figure 1) was necessary to define the scope of the horizontal construction projects. Effort was not directed either toward formulating a theoretical topographical model of the AOA, or at designing a hypothetical base to fit within any specific topographic restraints. The major support facilities illustrated in Figure 1 were sited with reference only to functional utility and safety.

SCHEDULING ANALYSIS

Activity durations and associated resources were estimated and then plotted in an arrow network (CPM) for each project. The CPM network enabled the interrelationships of the various work activities of a project to be clearly evident. Each work element (activity) was represented by an arrow with the tail of the arrow representing the start of the activity and the head of the arrow, the completion of the activity. With the association of time estimates with the activities, the longest path through the network represented the project duration. Every activity on the longest path was duration critical, i.e., any delay in completion of the activity would delay completion of the project. The remaining activities were not duration critical, since there was more time available in which to complete them than was required. The critical path method is explained in more detail in References 4 and 5.

Earliest and latest start and finish dates for each activity were calculated to determine which critical activities had some float (slack) in their starting dates. A computer program, REAL***, was used extensively to determine the critical paths of the project networks and to analyze resource (construction equipment) allocation [6]. REAL*** provided earliest activity start dates and activity durations. The program also listed the quantity of slack available to each activity and the resources assigned to the activity.

The program provided two critical path solutions, i.e., for critical path considering activity durations and for the critical path considering the twin restraints of activity durations and activity resources. In the latter case, a resource leveling routine was called which endeavored to maintain resource usage within specified limits. The resource leveling routine will be more fully explained in the expeditionary airfield (EAF) scheduling discussion.

The estimates for the various project activities were formulated as described in Appendix B. Estimates were derived considering the equipment performance characteristics given in Appendix C.

Expeditionary Airfield (EAF)

Figure 2 presents the arrow network for construction of a short airfield for tactical support (SATS) and the immediate conversion of the SATS to an EAF with a TAFDS area. Two hypothetical cases of EAF construction were considered - Case 1, construction by NMCB organic equipment; and Case 2, construction by NMCB augment equipment. Organic equipment was assigned to EAF 2 and augment equipment to EAFs 1 and 3. The critical path for Case 1, not considering resource leveling (NRL), consisted primarily of the hauling and filling activities with the MRS scrapers (Figure 2). The critical path for Case 2 (NRL) consisted of the finish grading and compacting activities and a mat laying activity (Figure 2). The different critical path of Case 2 was a result of the larger load capacity and shorter cycle time of the CAT 637 scrapers (augment) compared to the MRS I110, S110 scrapers (organic).

The resource allocation routine attempted to maintain resource usage at a specified level, while not exceeding predetermined resource critical limits and specified activity durations. Neither activity durations nor activity resource assignments were changed by the program. Where several parallel activities exhibited varying amounts of float time, their start dates were adjusted to limit the resource usage to the desired quantity as far as practicable. For example, in the EAF network (Figure 2), clearing of Areas 1 through 5 are parallel activities that require crawler tractors. These activities could be started simultaneously; however, this would necessitate an initial heavy outlay of crawler tractor resources followed by relatively low usage until the next set of parallel activities was encountered. It is more economical, and possibly crucial to timely project completion, to maintain a steady resource level throughout the project by optimizing resource usage.

Table D-1 includes a list of EAF network activity descriptions, and Table D-2 presents a list of resource assignments and activity durations for Case 1, EAF construction. Tables D-3 through D-6 contain data from the solution of the Case 1 network with (Tables D-5 and D-6) and without (Tables D-3 and D-4) employment of resource leveling. The effects of the resource leveling routine are readily apparent upon comparison of resource usage in Tables D-3 and D-5.

Comparison of critical activities listed in Tables D-4 and D-6 also yields interesting information. Without consideration of resource leveling, there was a single critical path (activities with zero float) through the network; however, with resource leveling, activities that were previously noncritical became critical and the critical path developed several branches. The critical path was extended when activities lost their slack as a result of scheduling demands. Thus, where resource allocation exceeds or equals supply, resource critical activities are added to the critical path, and the project is vulnerable to delay from loss of equipment.

Tables D-7 through D-11 contain the solution data for the Case 2 network. Again, application of the resource leveling routine causes a diversification of the critical path.

Ammunition Supply Point (ASP)

The CPM arrow network for a 5,000-ST ASP is given in Figure 3, and the network activity descriptions, durations, and resource assignments can be found in Table D-12. Roadway stripping activities and one roadway shaping activity were on the critical path for the NRL network solution (Tables D-13 and D-14). Where resource leveling was applied (Tables D-15 and D-16), many activities that were not duration critical were found to be resource critical, e.g., roadway clearing, revetment clearing, and revetment construction activities. These activities were added to the critical list as a result of heavy requirements for crawler tractors and scrapers.

An ASP would probably be located in hilly terrain to benefit from the natural protection of the hillsides. If this were the case, then the difficulty of roadway construction would be increased beyond that represented by this analysis. Negotiable road grades would have to be maintained and gullies bridged with earth and culverts. In this situation, a beneficial tradeoff can be obtained by extending the duration of the revetment construction activities through construction of additional berms (revetments) to barricade the front of the stock piles. Barricading would permit shorter intermagazine distances and, thus, would reduce the extent of the ASP road system.

Main Supply Routes (MSR)

The CPM arrow network for the MSR system is given in Figure 4, and the network activity descriptions, durations, and resource assignments are listed in Table D-17. Stripping activities involving MRS scrapers, clearing of MSR 2, and shaping of MSR 4 (Tables D-18 and D-19) were on the critical path (NRL), which was 21 days in duration. With resource leveling, clearing of MSR 3 was added to the duration critical activities (Tables D-20 and D-21) because the allocation of TD20 crawler tractors with semi "U" dozers was at the critical limit. However, one TD20 crawler tractor with an angle dozer was available during this period; therefore, clearing of MSR 3 cannot be considered critical, although the overall crawler tractor demand was at a near critical level during most of the project.

Bulk Fuel Farms

Table D-22 provides a listing of the activity durations and activity resource assignments that were employed in the solution of the arrow network (Figure 5) for the construction of 12 AAFS (60 tank farms) for bulk fuel storage. The berm construction activities for AAFS 1, 2, 3; AAFS 4, 5, 6; and AAFS 7, 8 comprised the critical path (Table D-23) for both the NRL and RL cases. The critical path was not changed by application of resource leveling; however, the critical path did become resource critical as well as duration critical.

Logistic Support Area (LSA)

The critical path of the arrow network (Figure 6) for construction of the LSA was calculated to be 12 days. The critical path, without resource leveling, consisted of (1) clearing and stripping activities for Area 1, (2) hauling and filling activities for Areas 1 and 2 and the Truck Loading Area, and (3) the AMSS surfacing activity of Area 2.

Application of the resource leveling routine revealed that the remaining hauling and filling activities and the AMSS surfacing activities were resource critical. Several clearing and stripping activities (1-3, 3-6, 1-4, and 4-11) were identified as critical, because the starts of resource critical filling activities were dependent upon completion of these activities.

Tables D-24 through D-28 contain the resource usage and critical path data for the resource/time and time solutions of the LSA network.

Cantonments

Specific cantonment layouts were not available (Appendix B); thus, activity scheduling was performed with a bar chart rather than a CPM arrow network. The bar chart (Figure 7) depicts the time phasing of the basic construction activities and lists the construction equipment associated with each activity.

Cantonment construction was assigned to the FSSG Engineer Battalion and was scheduled for starting upon completion of the other high priority MARCORPS projects (Figure 8). Cantonment construction involves a significant clearing requirement to facilitate siting of troop shelters. There were insufficient crawler tractor resources to permit concurrent scheduling. For this reason, crawler tractors were considered to be resource critical.

EQUIPMENT ALLOCATION

Projects were assigned to the NMCBs and the FSSG Engineer Battalion according to their construction capabilities. After analysis of the critical path solutions and the resource allocation tables, the projects were scheduled on a bar graph (Figure 8) that depicts project start/end dates and the responsible military unit. With known project time frames and project resource allocation versus time, it was possible to summarize equipment requirements for the various projects.

Equipment allocation was calculated for crawler tractors, scrapers, road graders, compactors, and the AMSS LRUs, and was plotted over a 50-day time frame (Figures 9 through 19). Whereas resource allocation at the individual project level was presented in the resource allocation tables, resource allocation information for the overall horizontal construction effort was summarized by Figures 9 through 19.

The landing force commander cannot rely on having all of his construction resources available for commitment. A percentage of his equipment resources will be required for use in contingencies and for replacing deadlined equipment. Mechanical failure, maintenance servicing, and enemy action may deplete an equipment allowance by 10% or more.

This report does not consider construction of all vital horizontal projects during the first 50 days of a MAF amphibious landing. Only the major horizontal construction projects were analyzed. Smaller, though equally critical projects, such as VTOL and V/STOL pads, fortifications, road maintenance, clearing and earthwork for critical facilities, and drainage projects, were omitted. To budget for these excluded projects, it is recommended that at least 10% of the equipment resources be kept in reserve. Therefore, it is concluded that the landing force commander (of this study) should not plan to allocate more than 80% of his equipment allowance. The remaining 20% would, thus, be available to counterbalance unforeseen enemy action, equipment deadlining, and unscheduled projects.

Crawler Tractor Allocation

Clearing operations precede all other earthwork; thus, crawler tractor allocation, shown in Figures 9 through 12, was heaviest during the first 30 days of the amphibious landing. In each figure, the crawler tractor allocation exceeds the recommended 80% planned commitment level. In Figures 10, 11, and 12, there are zero reserves, and allocation equals the total allowance of crawler tractors.

Road Grader Allocation

The NMCB grader allocation for the construction assignments did not exceed 61% of the total allowance of 18 road graders (Figure 13). Road grader allocation on projects assigned to the Engineer Battalion of the FSSG depleted the recommended reserves and equaled the available supply during the period of D+10 to D+11 (Figure 14). However, the NMCB reserves were sufficient during this period to alleviate the temporary MARCORPS deficiency.

Self-Propelled Vibratory Roller Allocation

The NMCBs had sufficient vibratory roller resources to meet compaction equipment requirements. The only compaction equipment listed in the Engineer Battalion Tables of Equipment that was suitable for earth compaction was a towed sheepsfoot roller (TAM No. B1800). This roller is relatively slow and inefficient compared to the self-propelled compaction equipment (ECC 4634/21) of the NCF, and is suitable only for compaction of cohesive materials. The Engineer Battalion's requirements for compaction equipment were combined with those of the NMCBs to obtain the graph plotted in Figure 15. From Figure 15, it can be observed that the compaction equipment allocation exceeds the supply available from the NMCB allowances during the period of D+9 to D+11; furthermore, the recommended 80% allocation level is exceeded from D+9 to D+11.

Scraper Allocation

Within both NCF and MARCORPS units, the scraper allocation equaled and/or exceeded the allowance levels within the first 30 days after D day. Scraper allocation by the FSSG Engineer Battalion slackened after D+15; thus, these scrapers were available after D+15 to alleviate shortages within the NMCBs. The three NMCBs and, particularly, the FSSG Engineer Battalion have significant 5-ton dump truck resources (36 and 74, respectively) to augment scrapers in hauling operations; however, extensive dump truck hauling would increase loader and grader allocation to critical levels.

From D+7 to D+15 the scraper requirements of the LSA and bulk fuel farm projects exceeded the FSSG Engineer Battalion scraper allowance. This would necessitate (1) hauling fill in dump trucks and stripping with dozers, (2) delaying start of a project, e.g., the ASPs, or (3) reducing the quality of construction of a project, e.g., eliminate stripping roads in ASP 1 or stripping of the LSA. The landing force commander would be faced with a difficult decision. Employing dump truck and crawler tractor resources would certainly be detrimental to smaller projects which required these resources. Elimination of overburden stripping would cause premature roadway or surfacing failures, thus necessitating costly rework.

DISCUSSION

A MAF could experience difficulty in providing and allocating the construction equipment assets that would be necessary to complete critical horizontal construction projects within the first 50 days subsequent to D-day. Transient equipment deficiencies, which are capable of delaying projects, could develop with respect to crawler tractors, scrapers, and compactors. Depending upon the requirements of the operational plan and tactical situation, the IOC of critical facilities may arrive past acceptable deadlines. The bar graph of Figure 8 was used to prepare Figure 20, which depicts the state of rear support area development on D+6, D+16, D+30, and D+45. It should be noted that POL facilities are completed by D+12 even though all three expeditionary airfields are not operational until D+45. Thus, V/STOL aircraft would be the sole users of aviation fuel until the tactical fighter fuel demand grew from D+25 (EAF 1) through D+38 (EAF 2) and D+45 (EAF 3). It is stressed that the types of insufficient equipment and the magnitude of equipment or facility IOC shortcomings in an actual situation would be dependent on the similarity of the situation to the limiting assumptions of this report.

Numerous factors could influence the engineering support within the AOA. The size, type, and functional utility of captured facilities would have a pronounced effect on the magnitude of the programmed construction effort. Likewise, the quality of construction would influence the project durations and, thus, facility operational dates. MARCORPS efforts would be focused toward construction of an "initial" quality. Calculations in this report for airfield earthwork and container transporter trafficable surfaces include estimates for stripping of deleterious materials and grading to form a slope or crown for drainage purposes. These activities could be omitted to expedite construction and conserve resources in the short term. Omission of these activities significantly increases the probability of paying a stiff penalty at a later date - possibly still during the assault phase. Unstripped areas would be prone to shear failure and pumping under repeated loadings. Subgrade failure would necessitate costly maintenance (resource and time) of an extensive road system; also flight operations would be curtailed (resource, time, and tactical penalties) to remove airfield matting and rework apron or runway subgrades. Higher quality, "temporary" construction of critical facilities, in particular roads and airfields, may prove to be extremely cost-effective in the long term with respect to the landing force mission.

Another factor that could significantly affect the horizontal construction magnitude is the siting of major facilities and installations. Tactical considerations arising from a nuclear, aerial, or artillery threat could increase spacing between facilities, thereby adding to the road system and horizontal support requirement. Terrain conditions impact on horizontal construction in a similar manner. Rugged topography would require cutting and filling to maintain roadway alignment and grades that are negotiable by container transports. Difficult soil conditions, e.g., rock, marsh, high water table, etc., would also impede horizontal construction.

Equipment shortfalls could be diminished by (1) improving equipment production efficiency, (2) incorporating a project/equipment management method to manage horizontal construction projects, (3) adding new equipment to allowances, e.g., self-propelled vibratory rollers to the FSSG Engineer Battalion allowance, and (4) reinforcing engineering units with additional equipment to meet the specific situation. The latter alternative has a significant disadvantage - shipboard space would be severely restricted, and any addition of construction equipment would exclude other priority tactical equipment.

A project/equipment management system (PEMS) would be an invaluable asset to the landing force commander. In the proposed PEMS concept, all project/equipment planning and scheduling would be performed under the supervision of a single individual, e.g., the MAF engineer, who would supervise project estimates and the formulation of CPM networks for large projects. After project priorities were established, the various CPM networks could be solved with the aid of a computer and projects scheduled to achieve an optimum allocation of construction equipment.

The PEMS, which would consist of a software system, would require a compatible command/administrative structuring of the construction units. Independent and joint project tasking would be prerequisites; moreover, the MAF engineer would have to be continuously aware of the real time and projected equipment status for the construction units. Examples of requisite project tasking are:

Independent tasking:	EAF No. 1 to NMCB ONE
Joint tasking:	LSA to FSSG Engineer Battalion with grading support from NMCB TWO
Joint tasking:	EAF No. 3 to NMCB THREE with equipment and manpower support from NMCBs ONE and TWO

The PEMS is envisioned as a possible subroutine of the AOA Real Estate Management project presently under study by CEL.

Several areas require further study and definition before equipment, project, and real estate management in an amphibious environment can be effective. These areas include:

Facility Design There are no MARCORPS designs for a container-capable LSA or for an ASP capable of handling and storing containerized ammunition. The Army is currently funding two studies - Container Port Construction Study and Containerized Ammunition Study - that address problems associated with these two facilities [7,8]. The Army studies should be investigated for relevancy to an amphibious environment, and designs should be prepared for an LSA and an ASP that would satisfy the MARCORPS amphibious criteria. The most serious MARCORPS shortcoming is judged to be in the area of storing and handling containerized munitions.

Containerized Storage of Munitions Army studies of containerized munitions have been directed towards (1) developing interior restraint systems for ammunition-stuffed Milvans, (2) investigating the effects of containerized storage (up to 2 yr) on ammunition quality, and (3) developing methods of buffering high explosive (Class 7) munitions with less active (Class 5) munitions within the holds of containerships. The Milvan Temperature and Humidity Tests [9] concluded that the ammunition test items (2.75-in. rockets, HE M374A1 81MM mortar rounds with fuzes) stored for 2 yr in various types of containers and in various climates did not produce any adverse effects. These tests demonstrate that containerized storage of munitions in an AOA is feasible with respect to munition quality.

Data from the Milvan Container Stowage Tests [10] are available and could be useful in determining safe separation distances for earth-buffered container magazines. Nineteen tests (detonations) were conducted at the Tooele Army Depot in Tooele, Utah. Holes were excavated and sized to the proper dimensions to simulate the below water portion of a containership hold. In the tests, MILVAN shipping containers stuffed with typical types of Class 7 and Class 5 ammunition items were placed below ground level in the simulated holds in the same configuration as would exist in the hold of a cargo ship. The purpose of the tests was to determine the percent of containers that would contribute damaging blast overpressures should any one of the mass-detonating munitions-stuffed containers be initiated. The tests indicate that two Milvan containers (stuffed with munitions of Class 5 or less) positioned side by side between Milvan containers stuffed with Class 7 or above munitions would be an effective shield for reducing or controlling propagation.

It should be emphasized that the Army studies of containerized ammunition have not solved the MARCORPS shortcoming in this area - particularly with respect to containerized munitions handling and storage within an ASP. The Army has, however, compiled extensive data that could serve as a baseline for further exploratory work. Specifically, MARCORPS needs are for:

1. Revetted storage of containerized ammunition to minimize intermagazine quantity and distance requirements and, thus, ASP size, perimeter, and extent of road system.

2. Tailoring of specific ASP and magazine/revetment designs to the categories and quantities of ammunition and explosives expected to be expended in an amphibious landing.

These needs have not been addressed by Army studies.

Quantity and distance criteria have been established for the open storage (without revetments) of ammunition in an advance base situation [11]. Such storage, however, increases the probability of loss of life, equipment, and ammunition, and should be used for as brief a term as possible.

Equipment Characteristics and Efficiency Factors Production formulas for calculating equipment production have received widespread use within industry; however, applying these formulas to military construction is difficult because they require knowledge of equipment performance characteristics and operator efficiency. There is no single reference for specifications and performance characteristics of NCF and MARCORPS construction equipment, and operator efficiency factors are often obtained in a subjective manner. Reference 12 contains some information on military construction equipment performance characteristics and operator efficiency; however, this information is incomplete and is not totally adaptable to MARCORPS needs. A detailed study of MARCORPS and NCF equipment performance characteristics and operator efficiencies would provide valuable data for use in estimating construction equipment production in support of an amphibious landing.

Trafficable Surfacing The four ASPs defined in this report contain 28 mi of roadway. The principle MSR system constitutes an additional 16 mi of roadway, and the LSA surfacing requirement is on the order of 14 acres. AM2, M8A1, AMSS, MOMAT, and FOMAT are surfacing systems currently envisioned for use during an amphibious operation. Study is needed to determine the cost - with respect to time, money, and equipment - of using these and other, more conventional surfacing systems.

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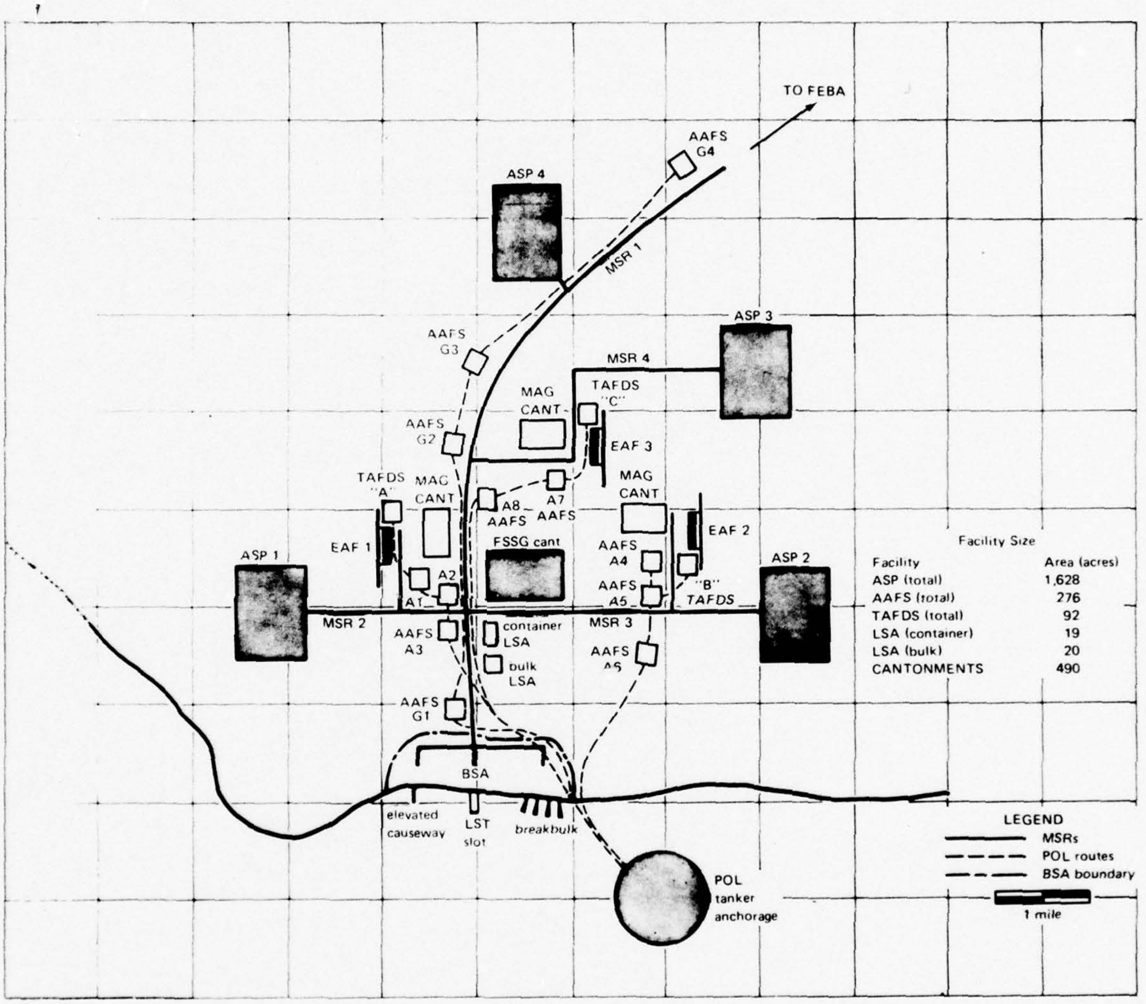

Figure 1. MAF rear support area.

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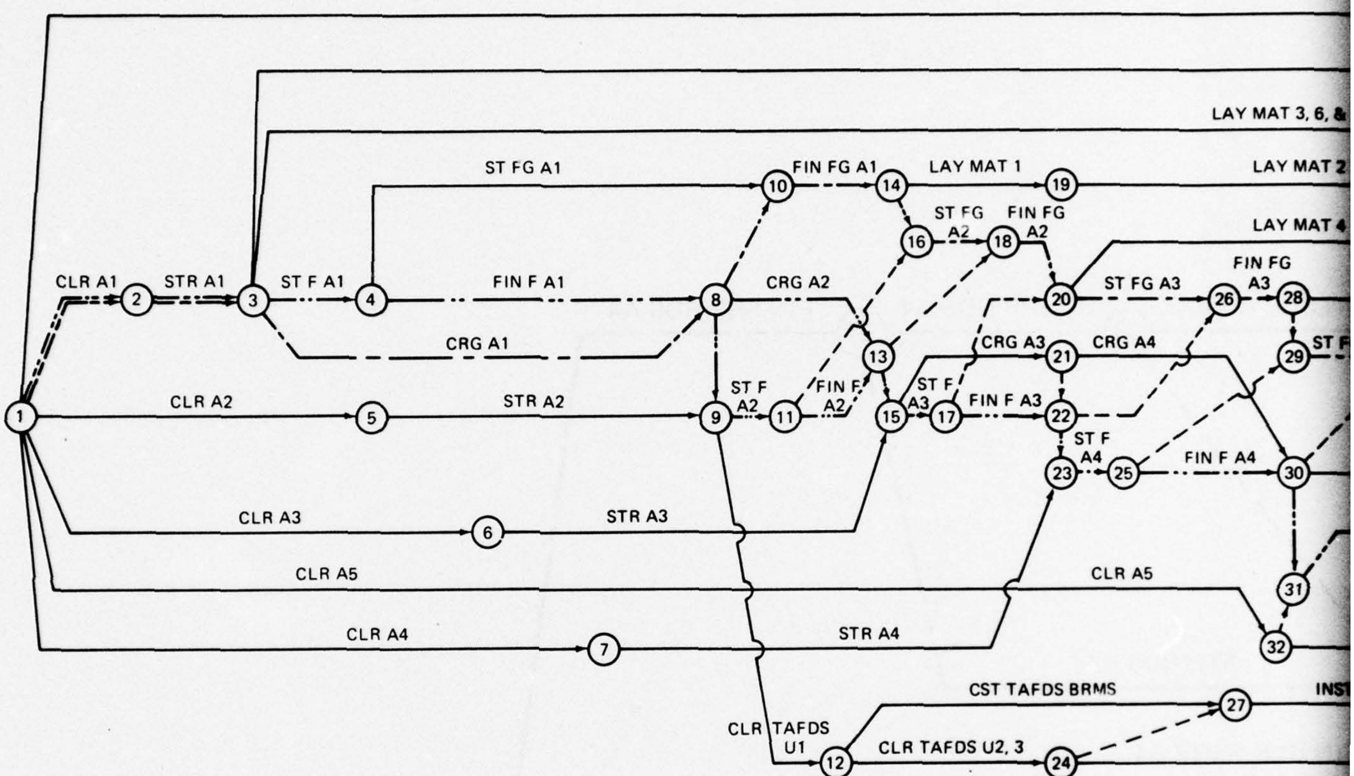


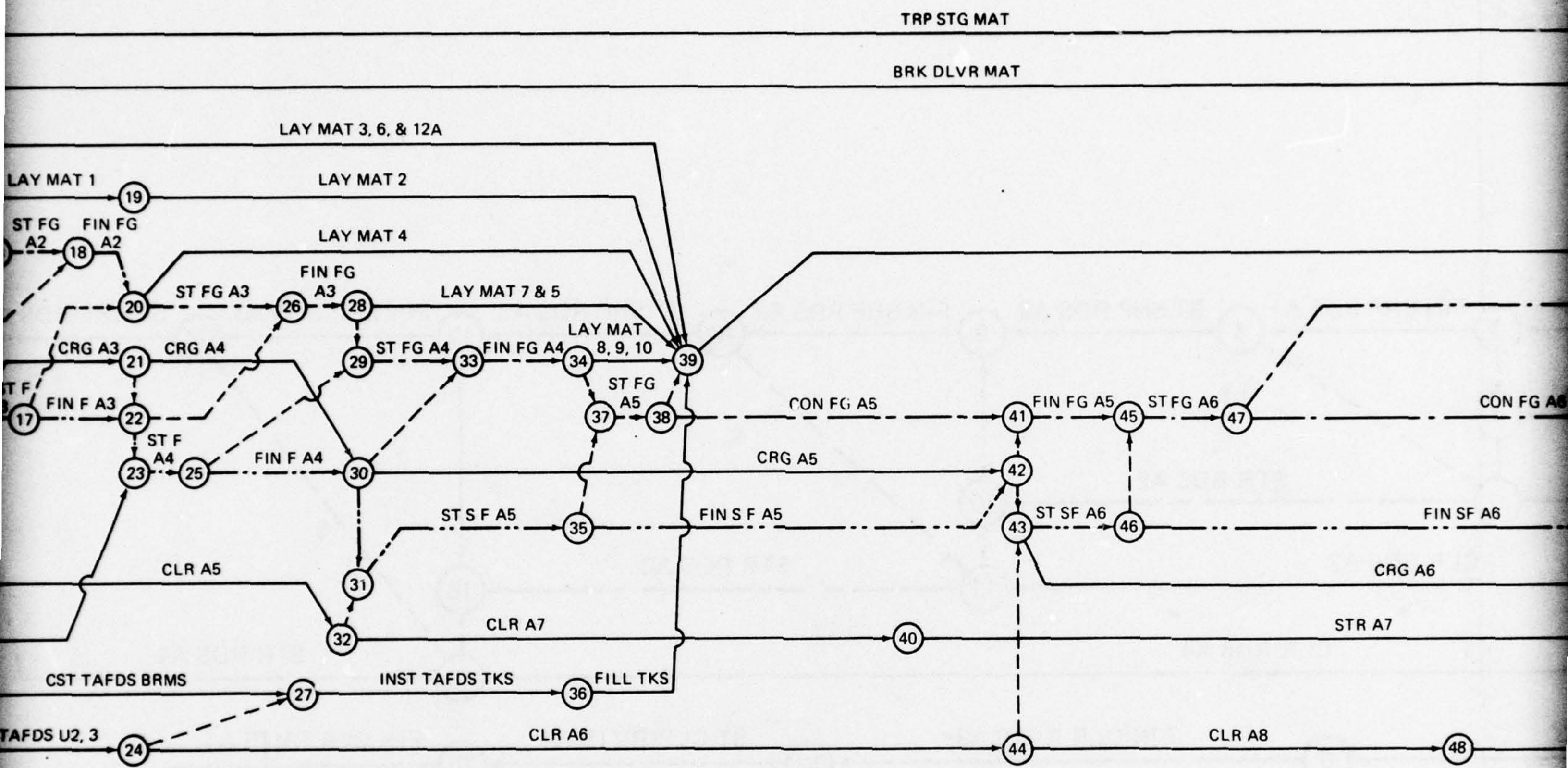
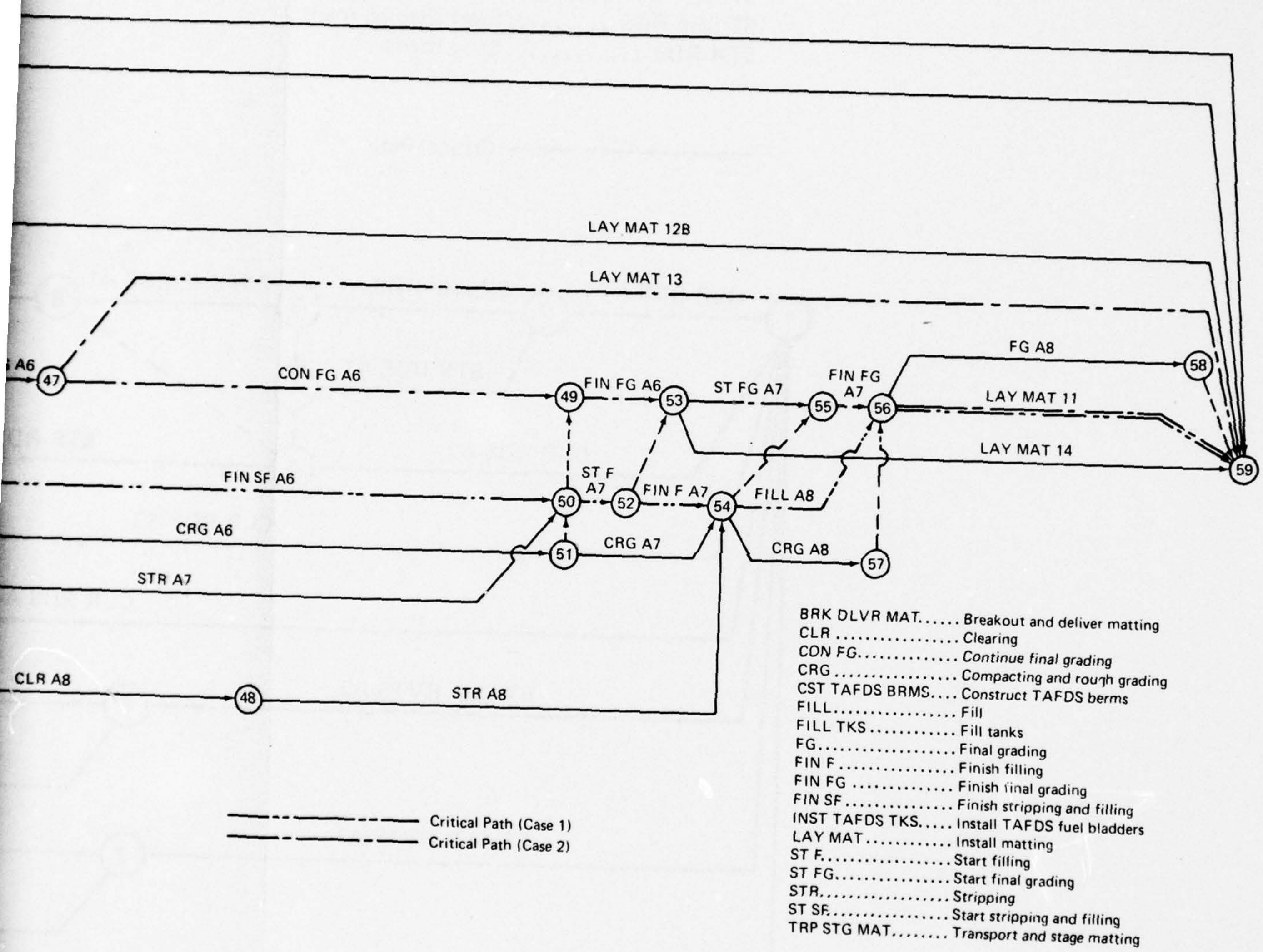


Figure 2. Arrow network for EAF construction.


LAY MAT 12B
LAY MAT 13
A6
47
CON FG A6
49
FIN FG A6
53
ST FG A7
55
FIN FG
A7
56
FG A8
58
LAY MAT 11
LAY MAT 14
59
FIN SF A6
50
ST F
A7
52
FIN F A7
54
FILL A8
CRG A6
51
CRG A7
CRG A8
57
STR A7
CLR A8
48
STR A8
Critical Path (Case 1)
Critical Path (Case 2)
BRK DLVR MAT...... Breakout and deliver matting
CLR .... Clearing
CON FG.............. Continue final grading
CRG .... Compacting and rough grading
CST TAFDS BRMS.... Construct TAFDS berms
FILL................. Fill
FILL TKS .... Fill tanks
FG................... Final grading
FIN F .... Finish filling
FIN FG .... Finish final grading
FIN SF .... Finish stripping and filling
INST TAFDS TKS..... Install TAFDS fuel bladders
LAY MAT .... Install matting
ST F................. Start filling
ST FG................ Start final grading
STR.................. Stripping
ST SF................ Start stripping and filling
TRP STG MAT........ Transport and stage matting

CLR PERIM .... Clear perimeter
CLR RDS .... Clear roads
FIN CLR RVTS .... Finish clearing revetments
FIN CST RVT BRMS .. Finish constructing revetment berms
FIN SHP RDS .... Finish shaping roads
ST CST RVT BRMS ... Start constructing revetment berms
ST CLR RVTS .... Start clearing revetments
ST SHP RDS .... Start shaping roads
STR RDS .... Strip roads

— - — - — Critical Path

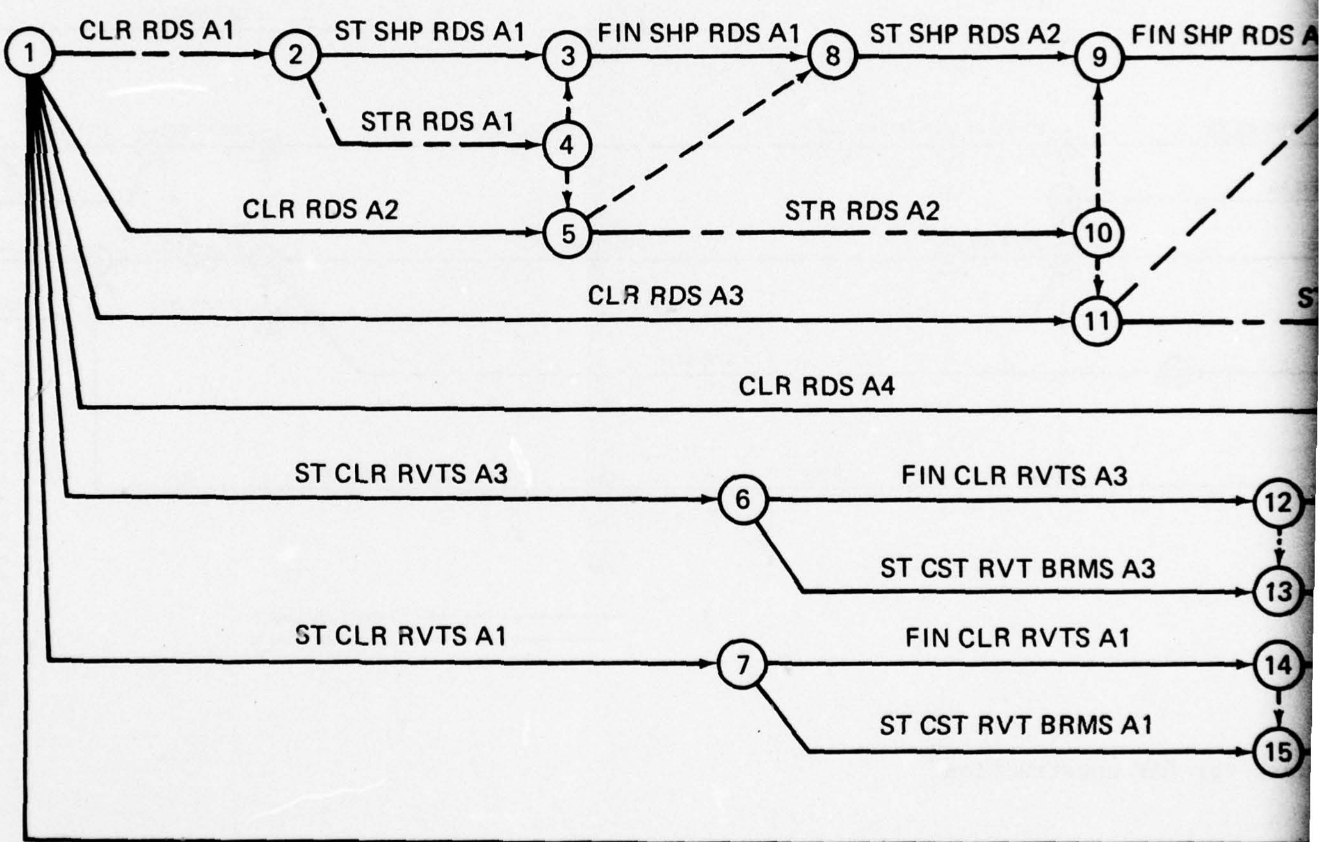
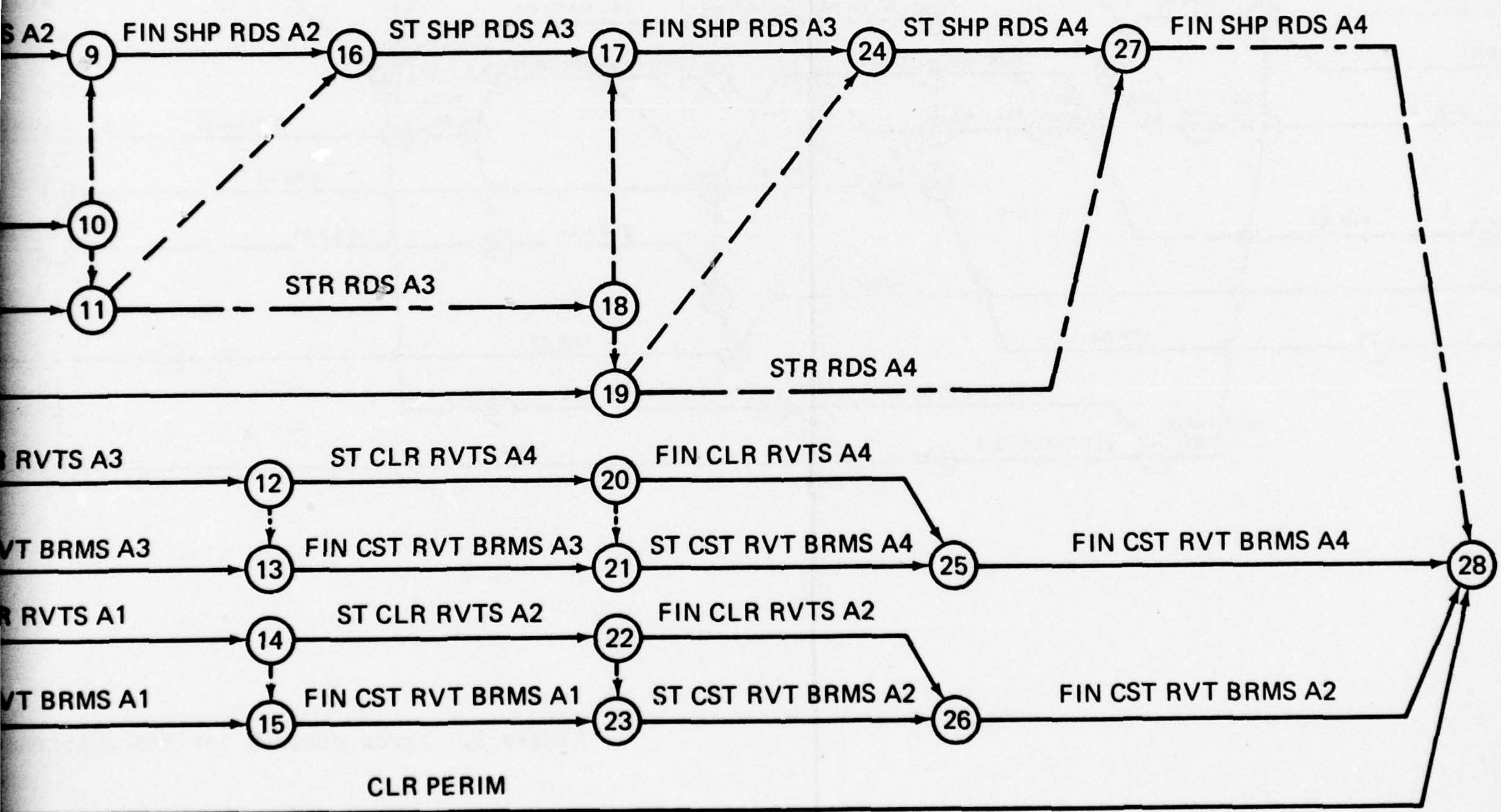


Figure 3. Arrow network for 5,

2



Arrow network for 5,000-ST ASP construction.

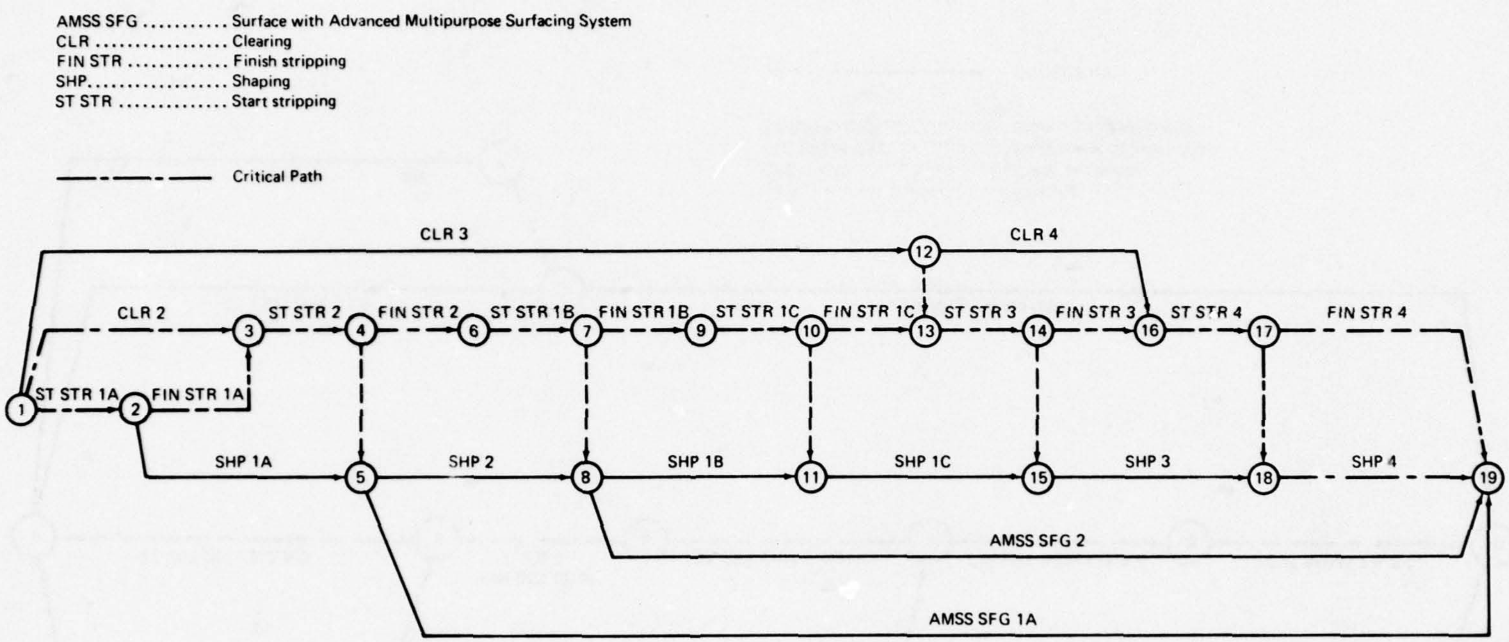


Figure 4. Arrow network for MSR construction.

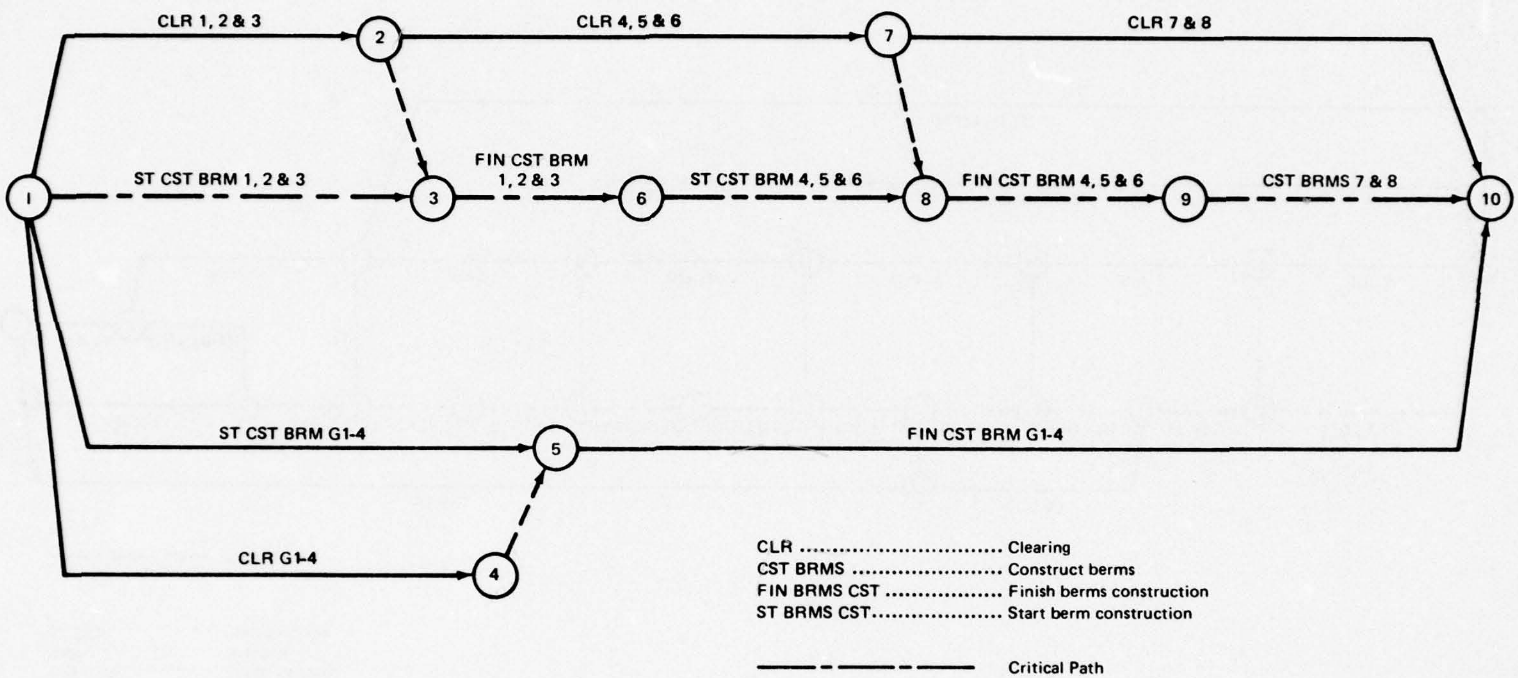


Figure 5. Arrow network for AAFS construction.

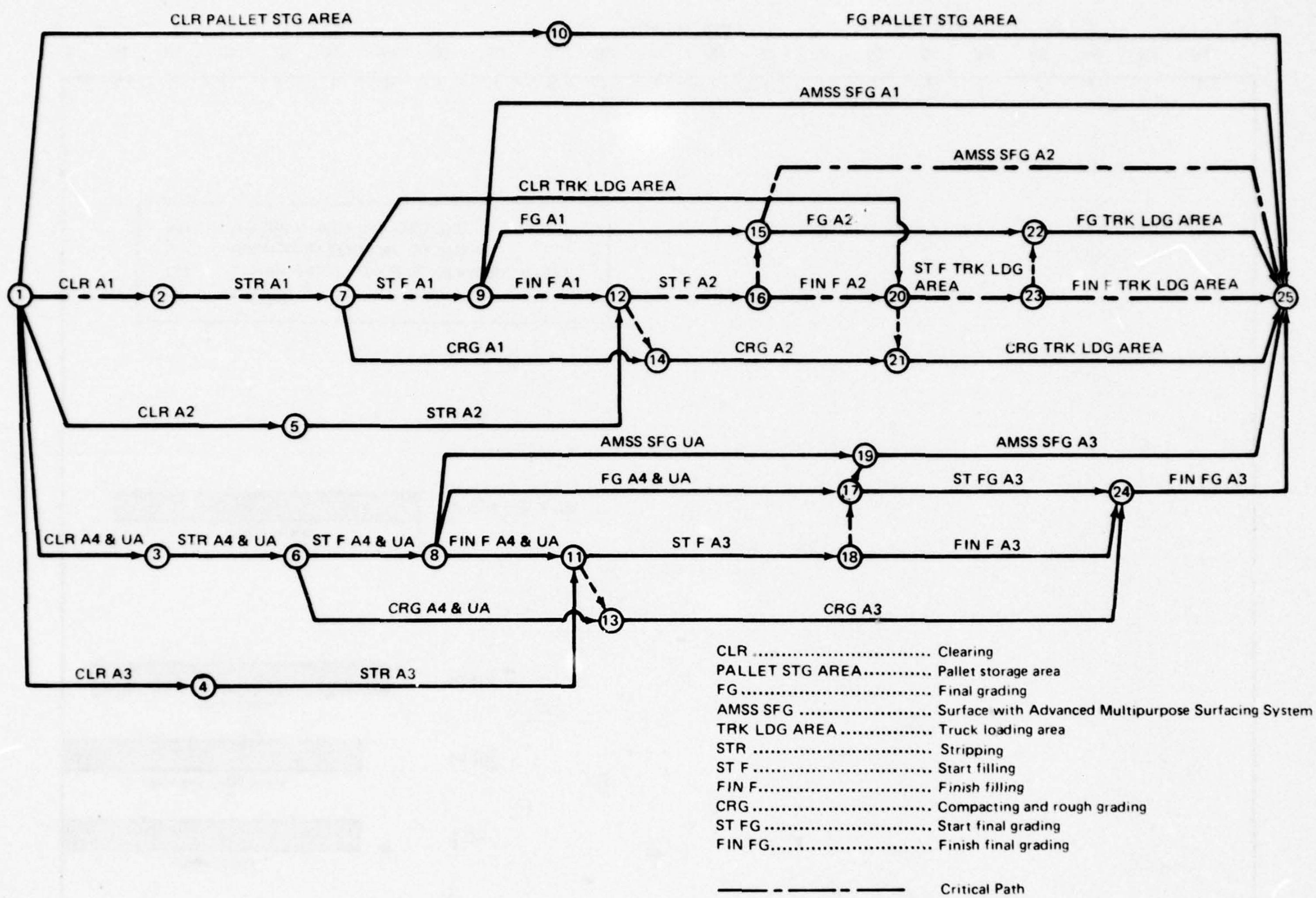


Figure 6. Arrow network for LSA construction.

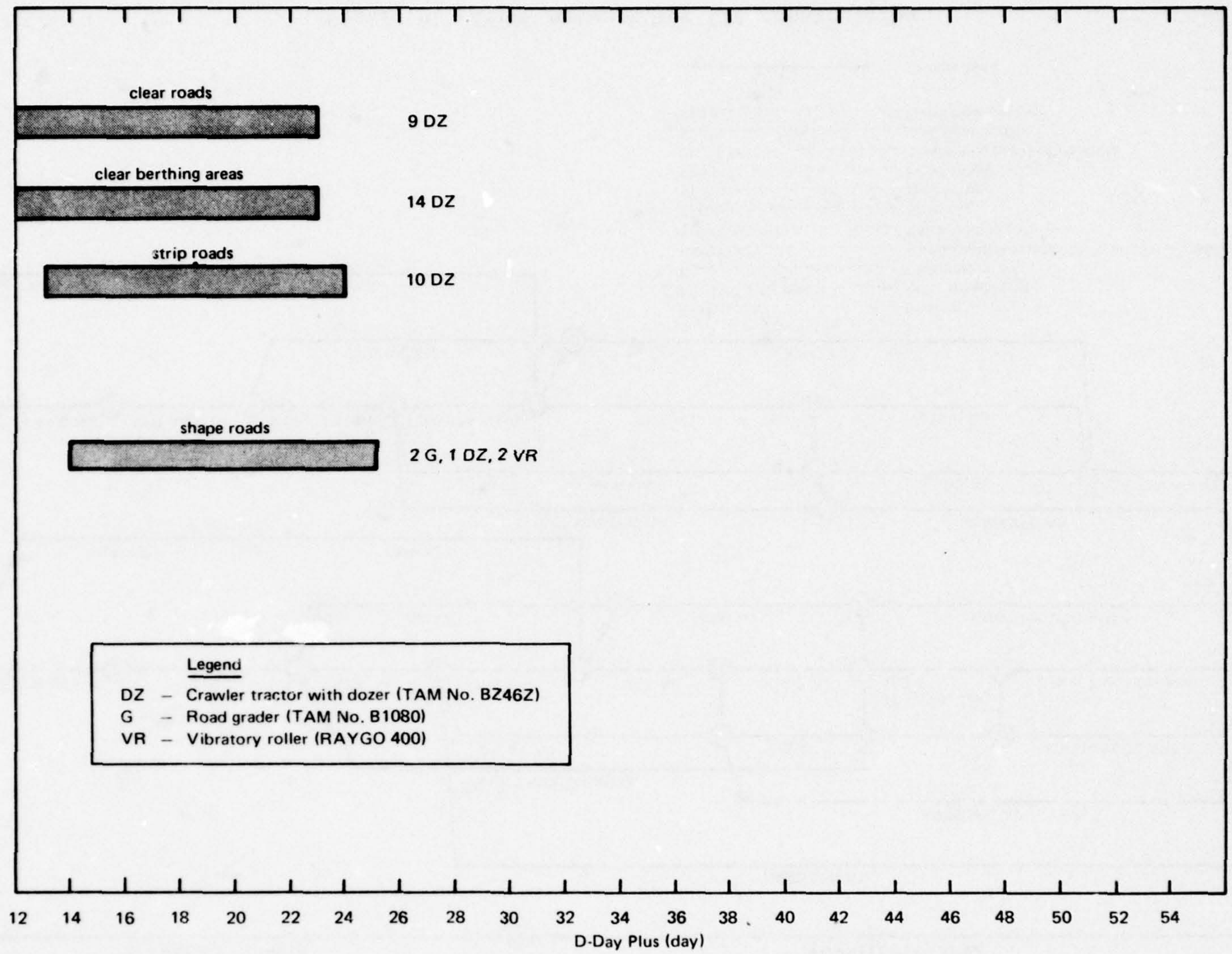


Figure 7. Activity schedule for cantonment construction.

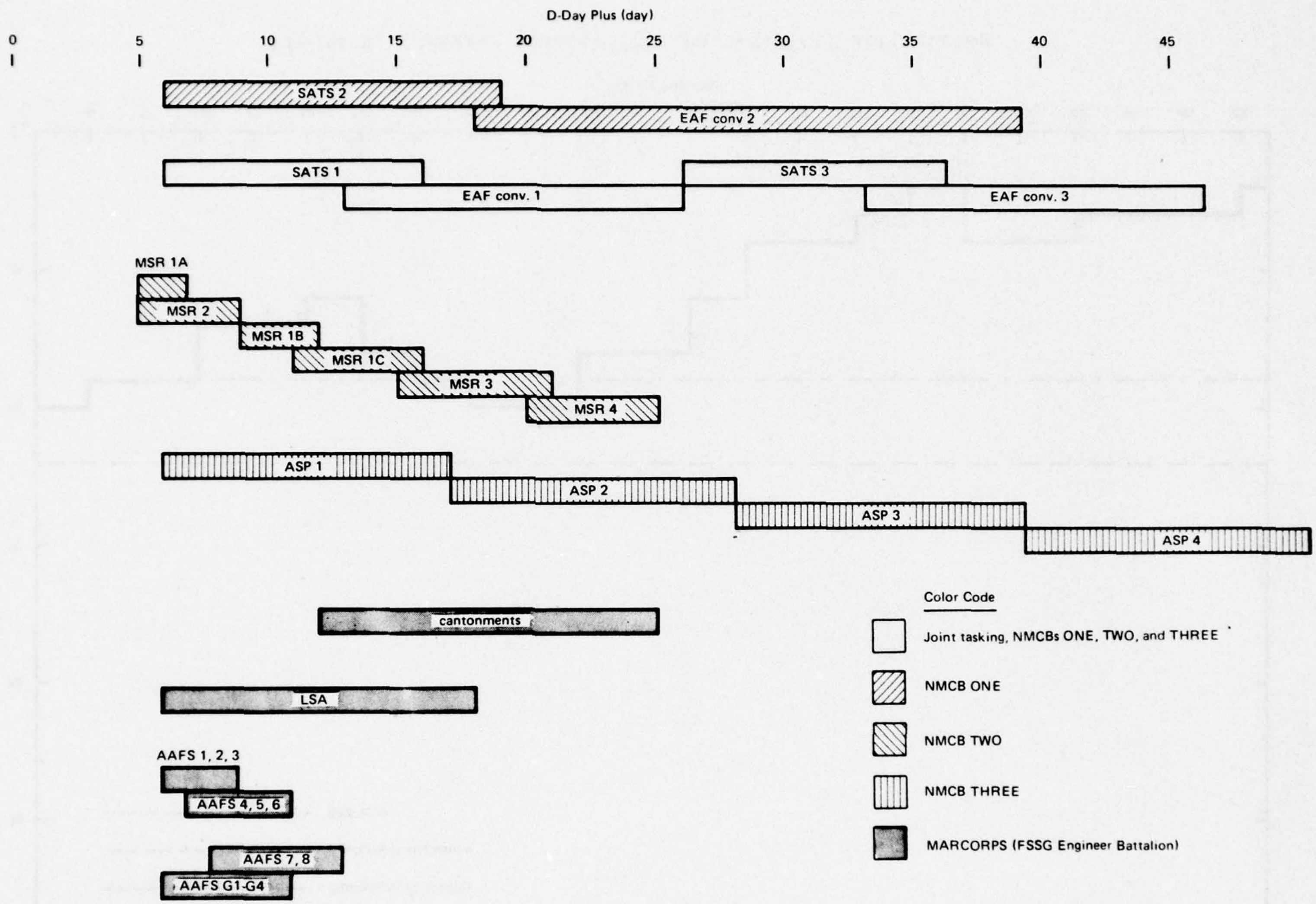


Figure 8. Time phasing of major horizontal construction projects.

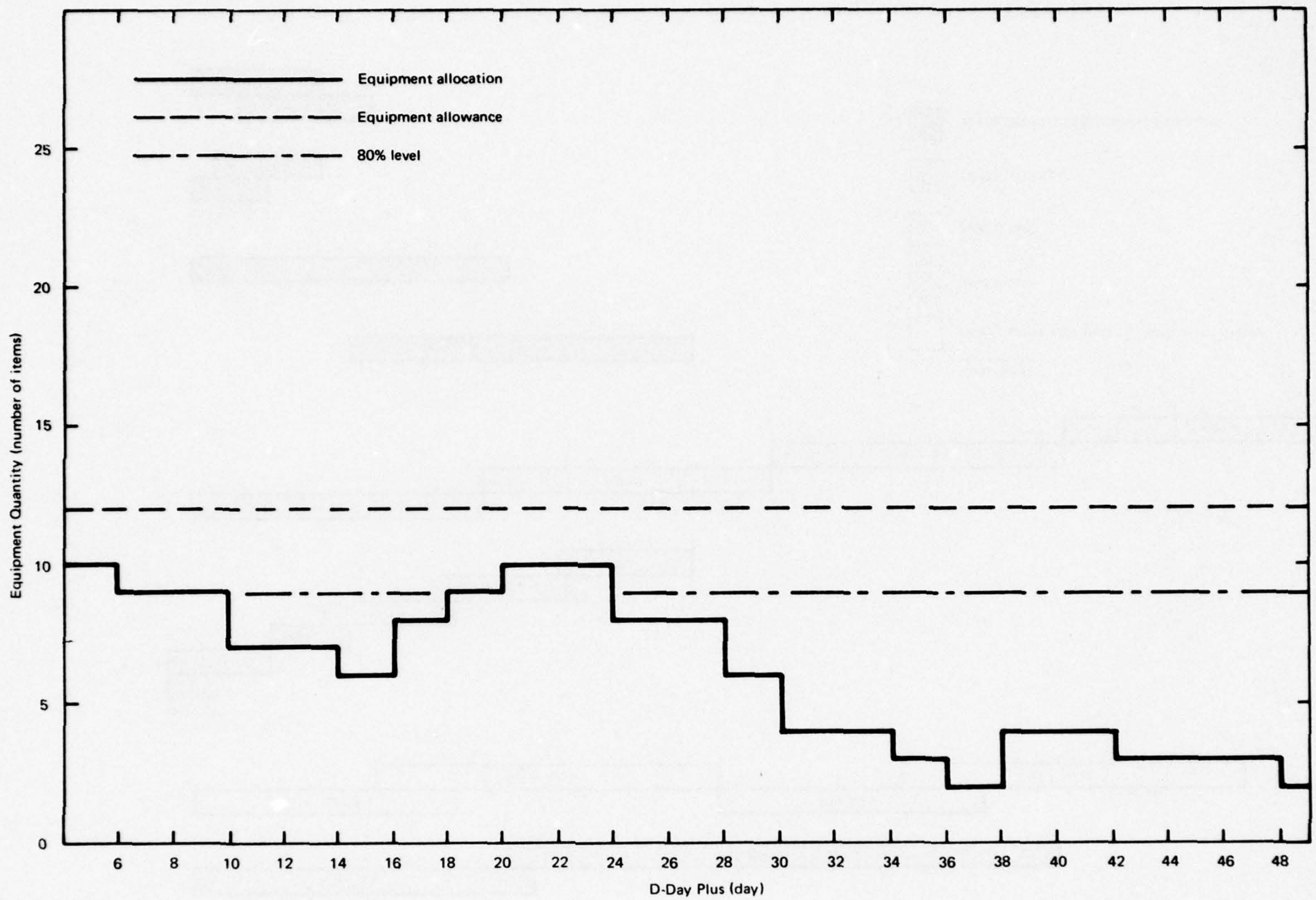


Figure 9. Crawler tractor (ECC No. 4850/11) utilization.

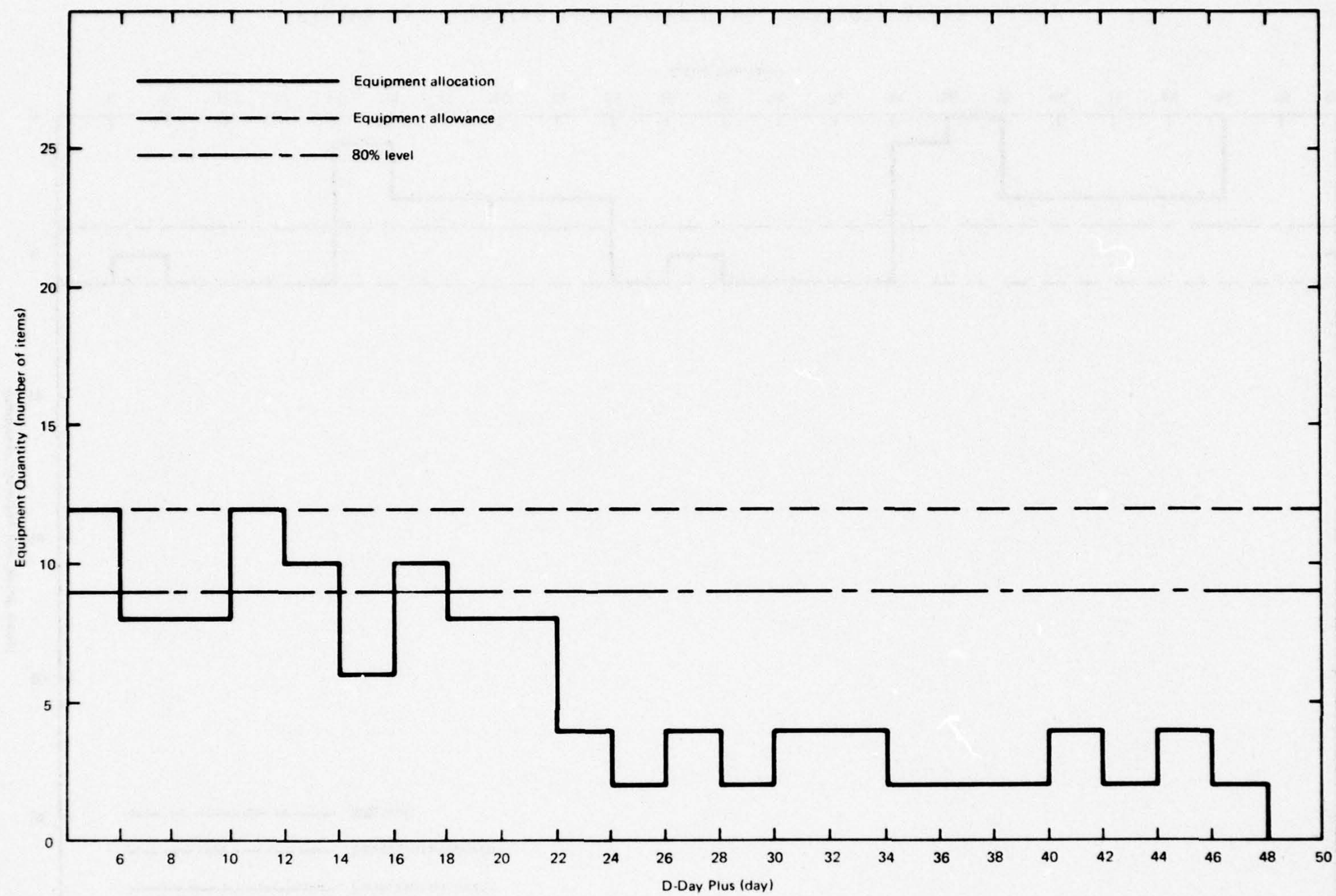


Figure 10. Crawler tractor (ECC No. 4850/21) utilization.

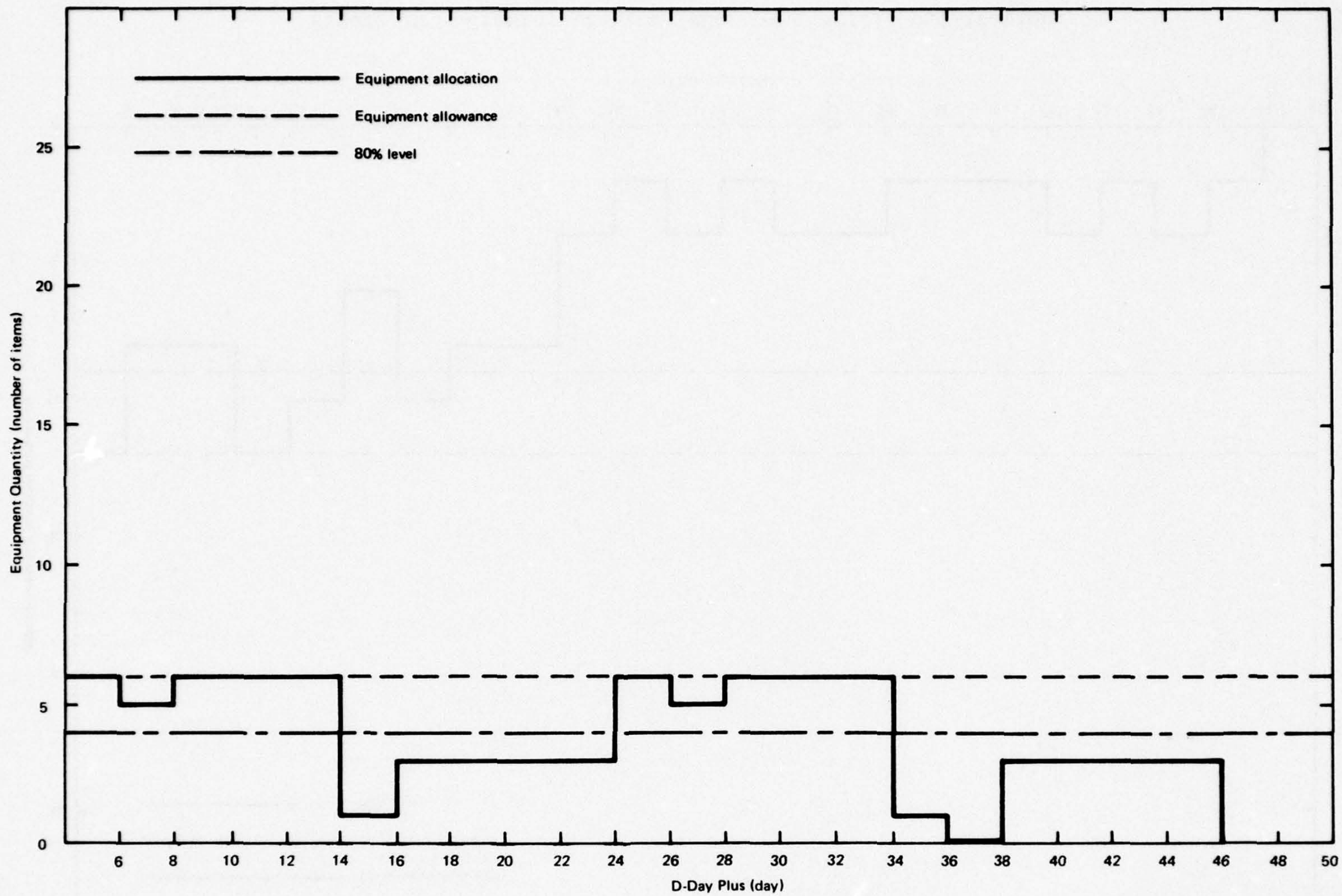


Figure 11. Crawler tractor (ECC No. 4851/01) utilization.

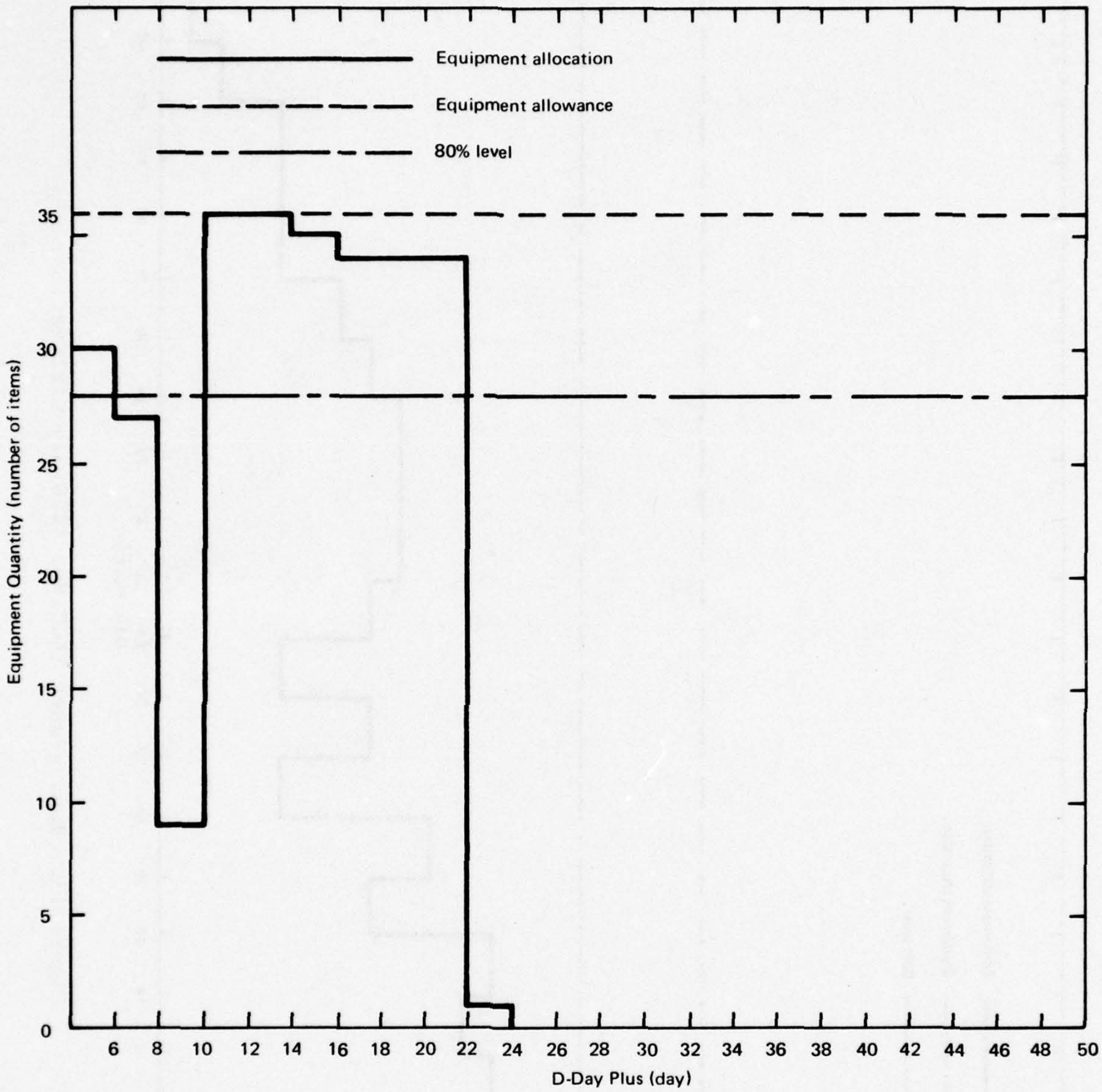


Figure 12. Crawler tractor (TAM No. B2462) utilization.

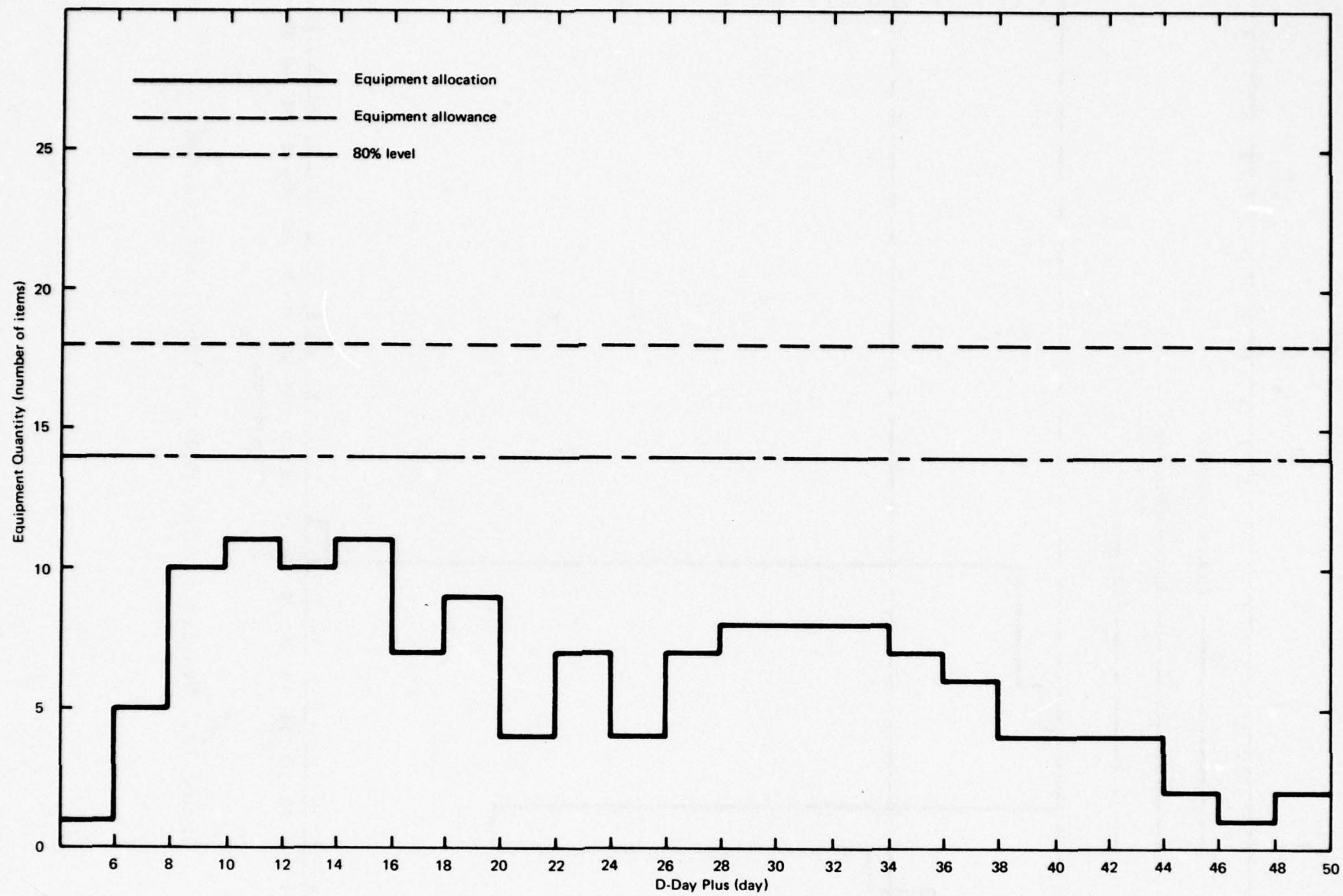


Figure 13. Road grader (ECC No. 4420/31) utilization.

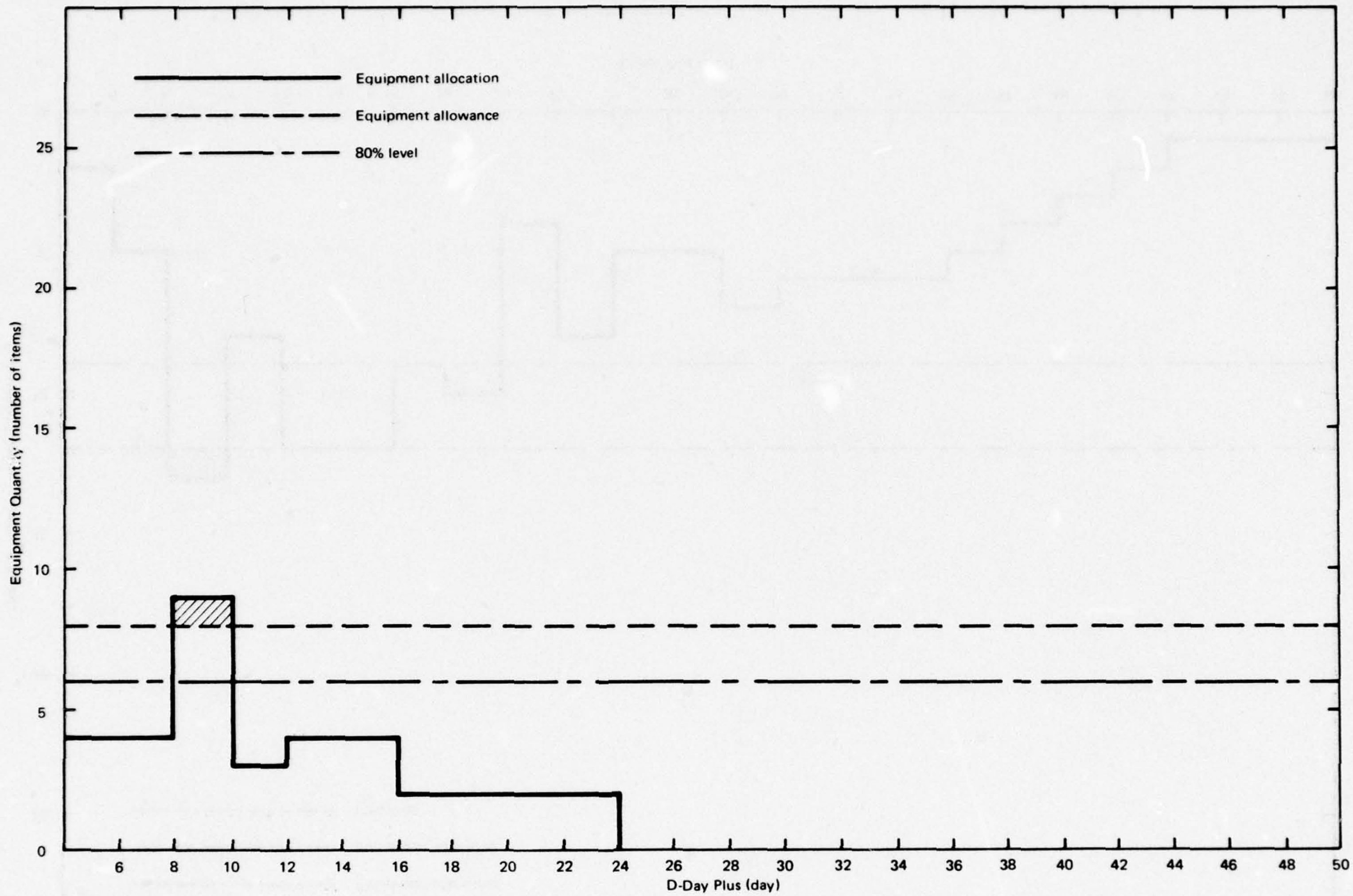


Figure 14. Road grader (TAM No. 1080) utilization.

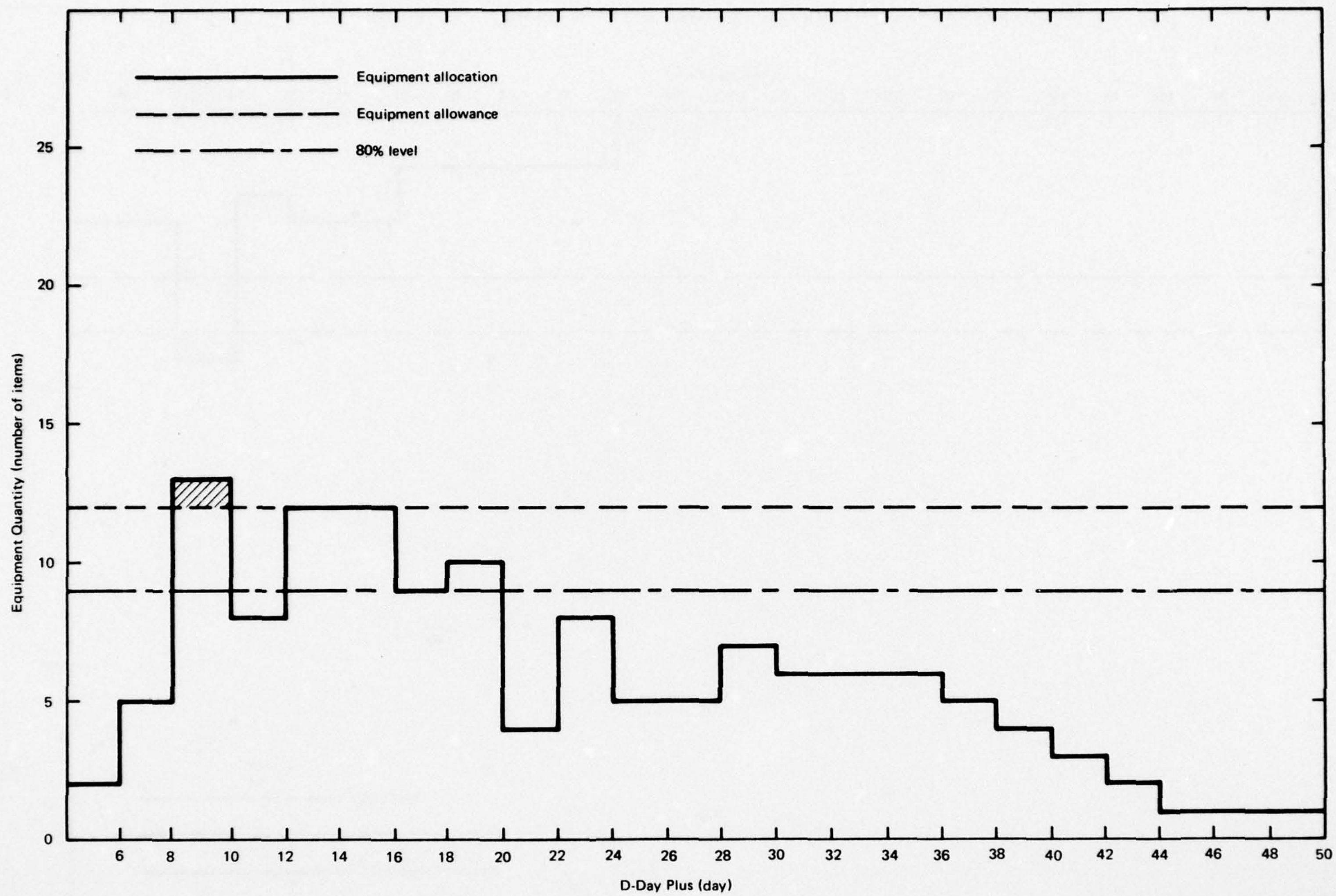


Figure 15. Self-propelled vibratory roller (ECC No. 4635/31) utilization.

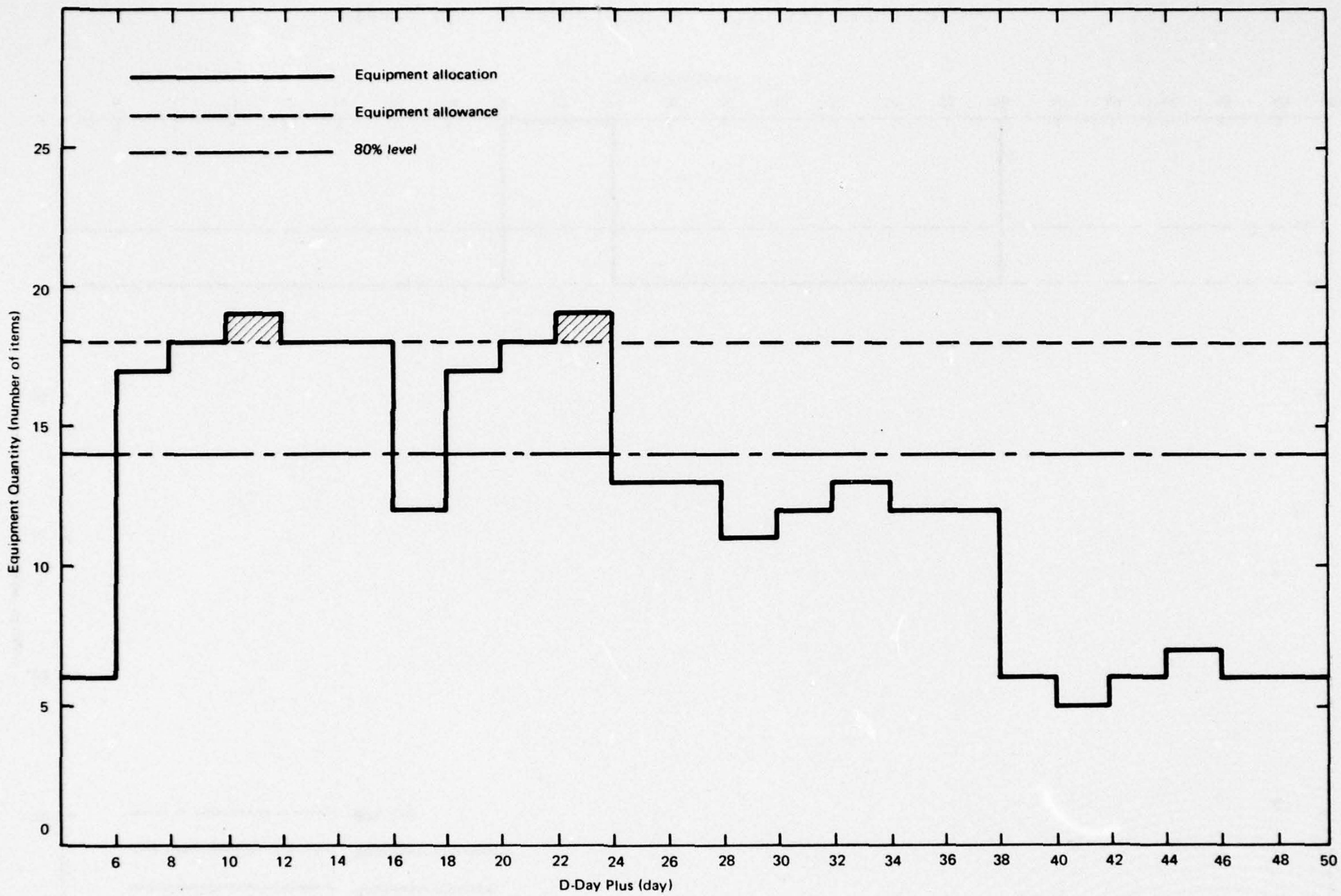


Figure 16. Scraper (ECC No. 4750/01) utilization.

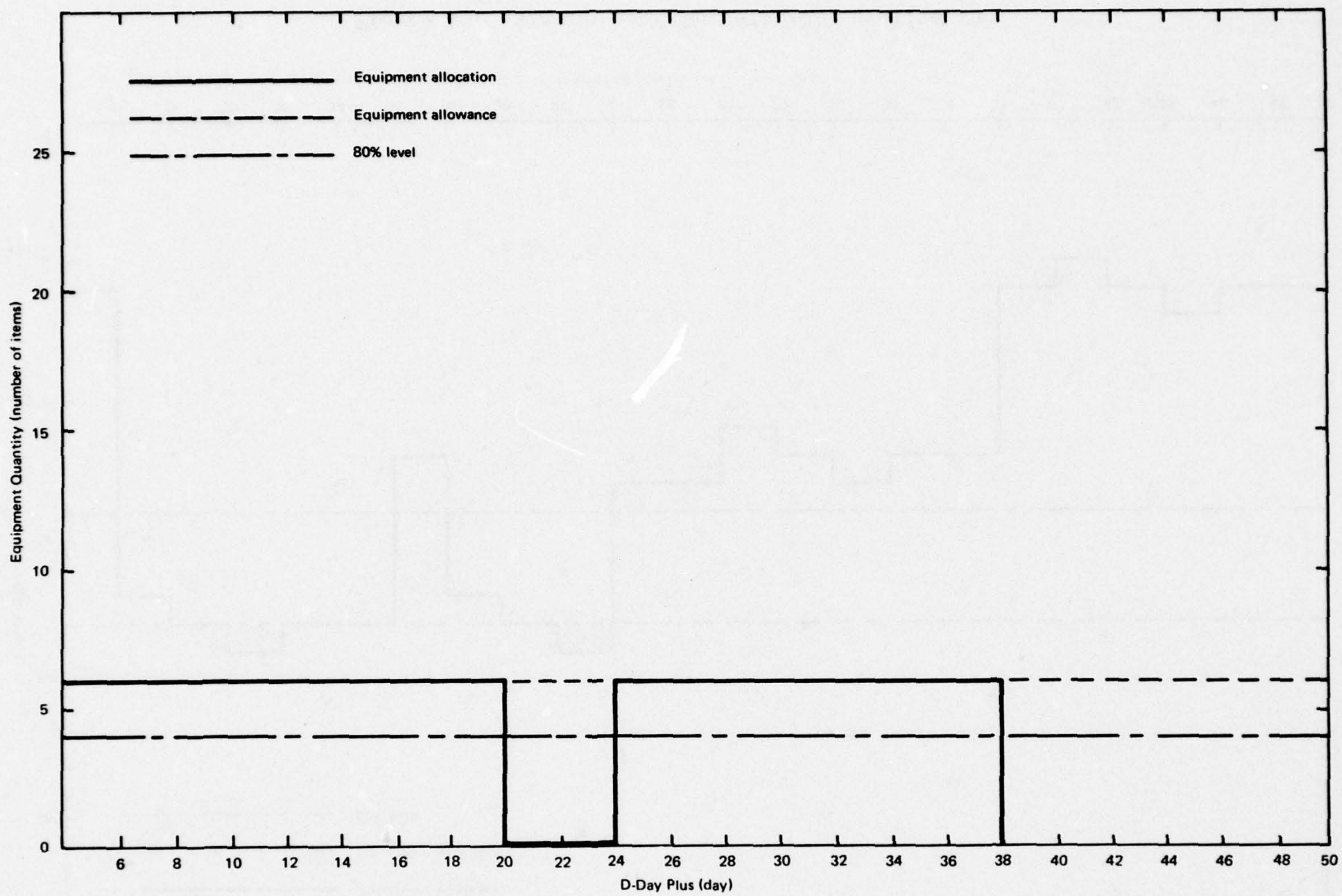


Figure 17. Scraper (ECC No. 4750/11) utilization.

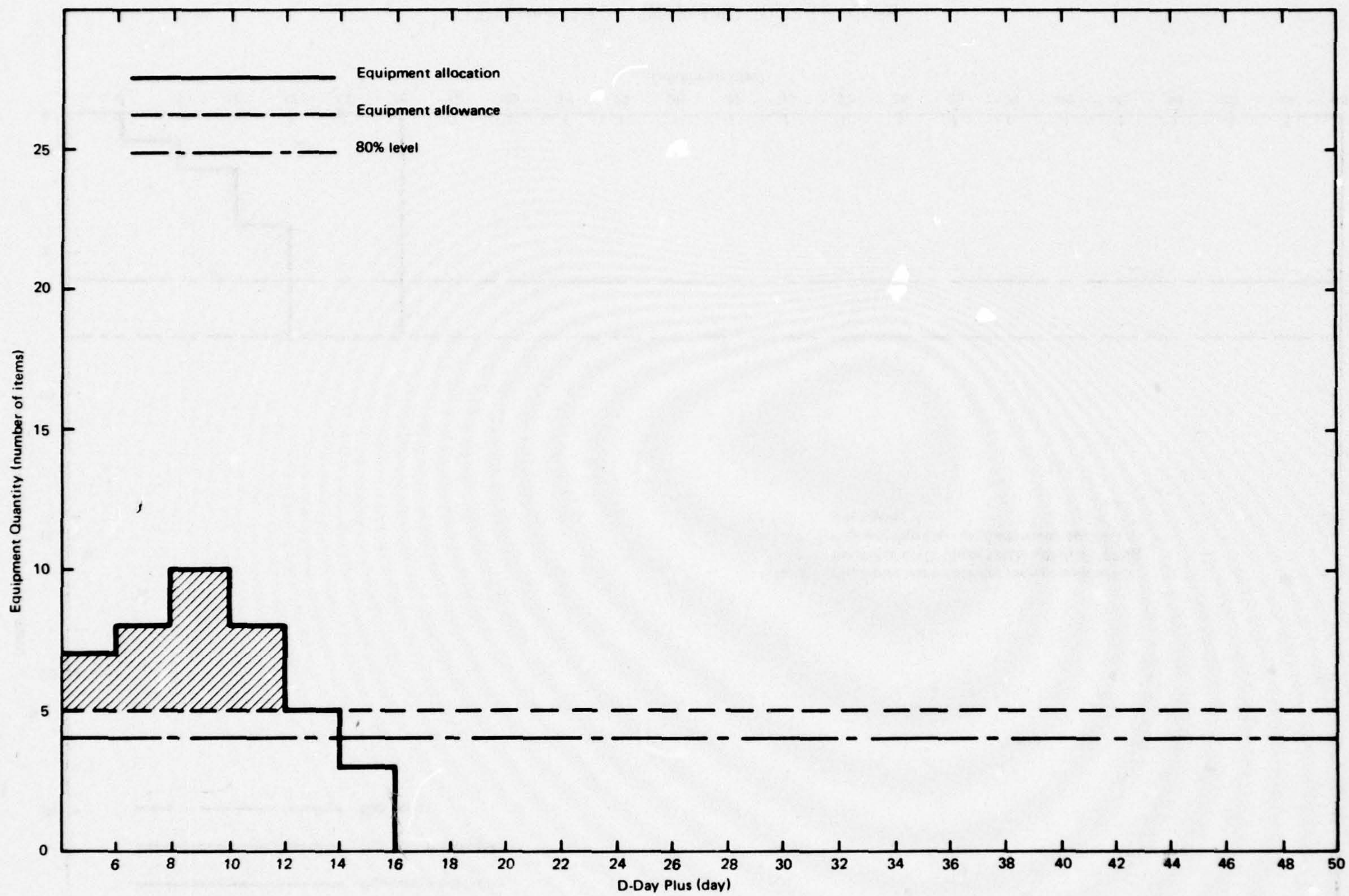


Figure 18. Scraper (TAM No. B1900) utilization.

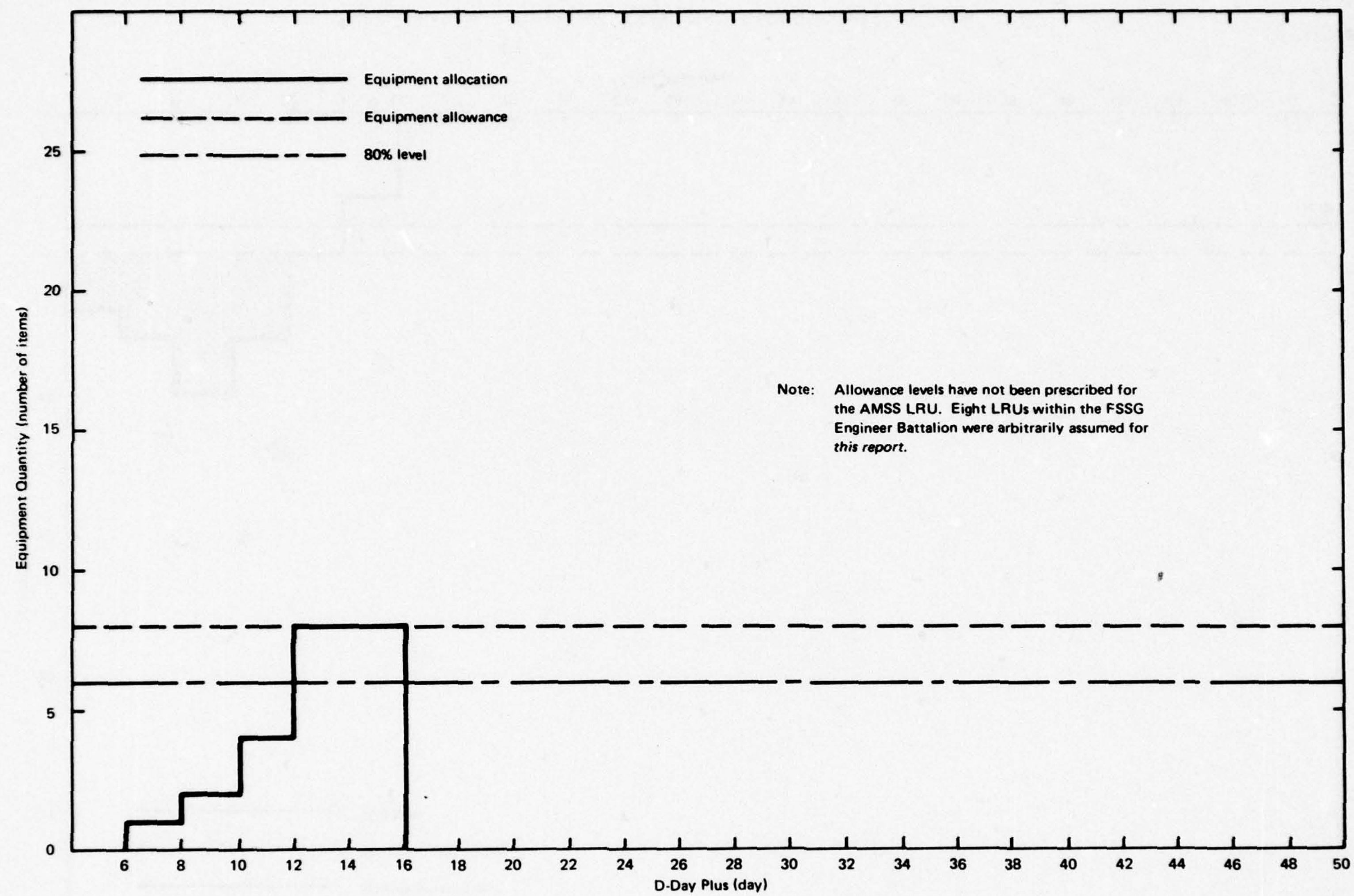
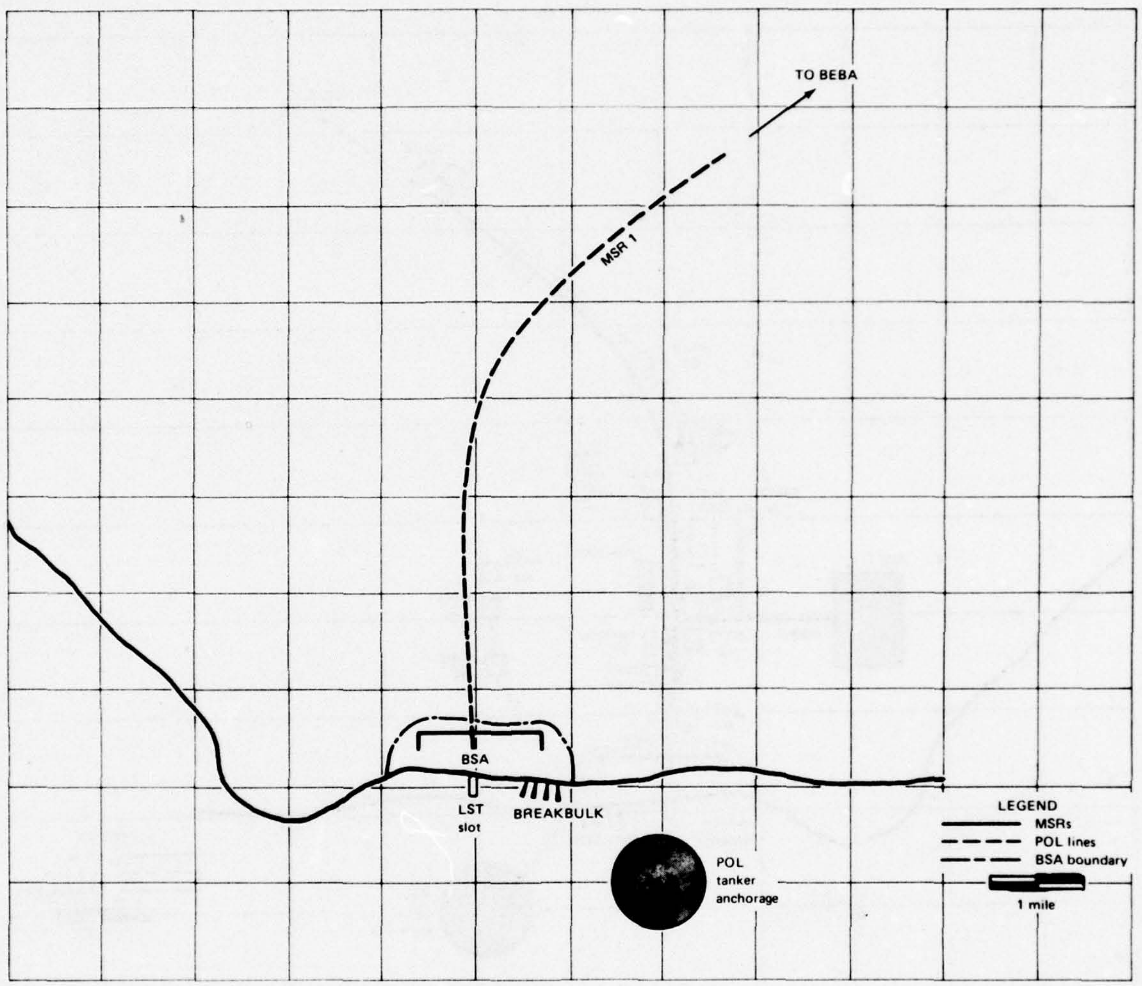
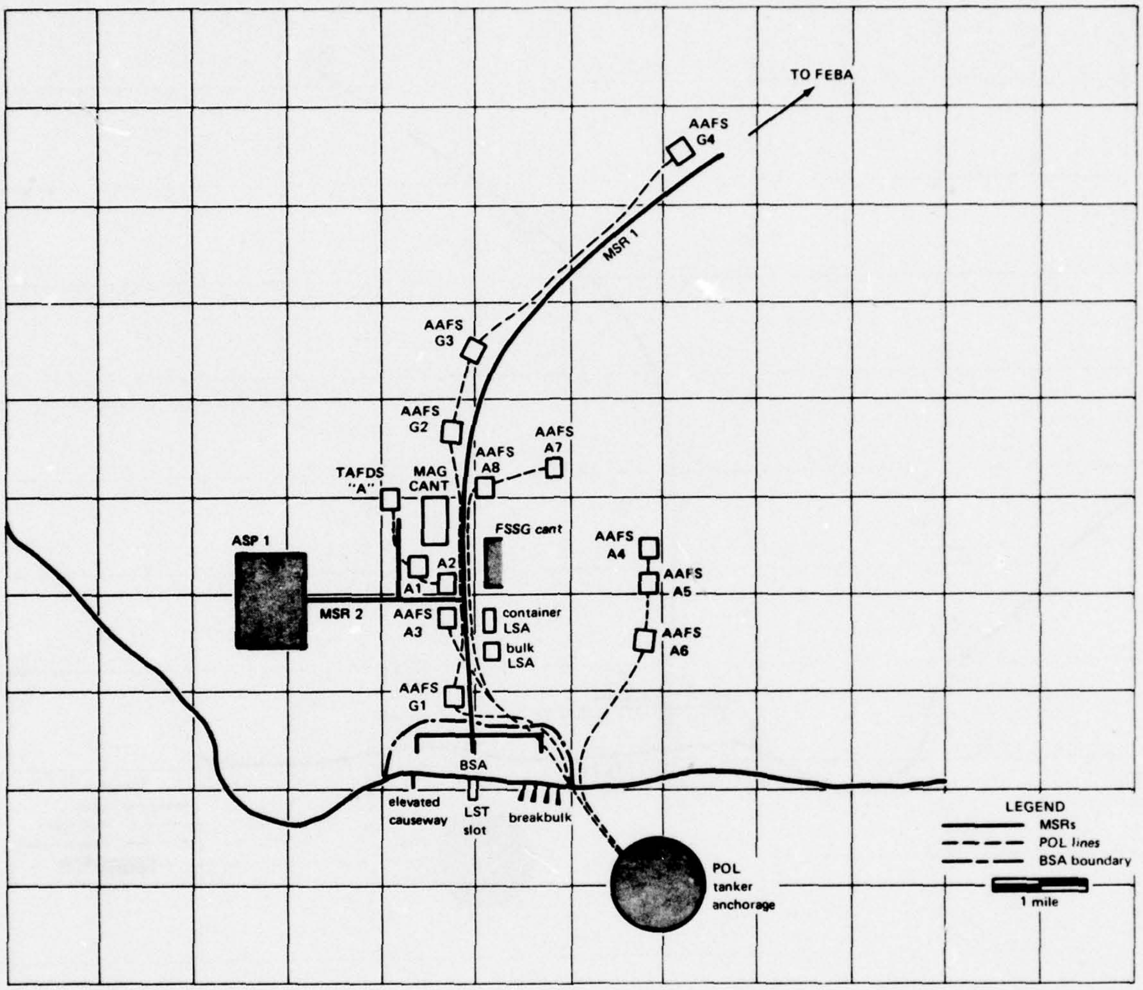


Figure 19. AMSS LRU utilization.



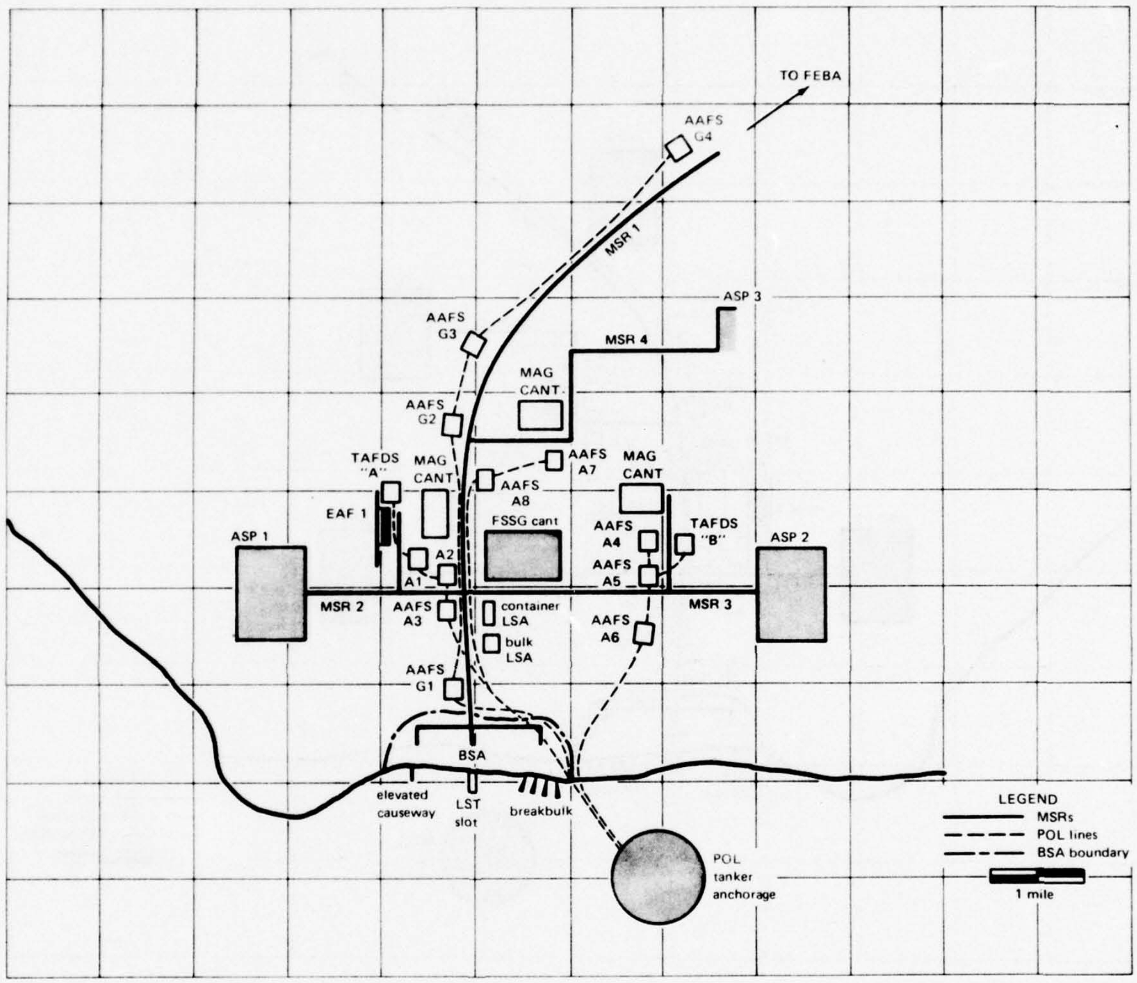
(a) D + 6

Figure 20. MAF rear support area.



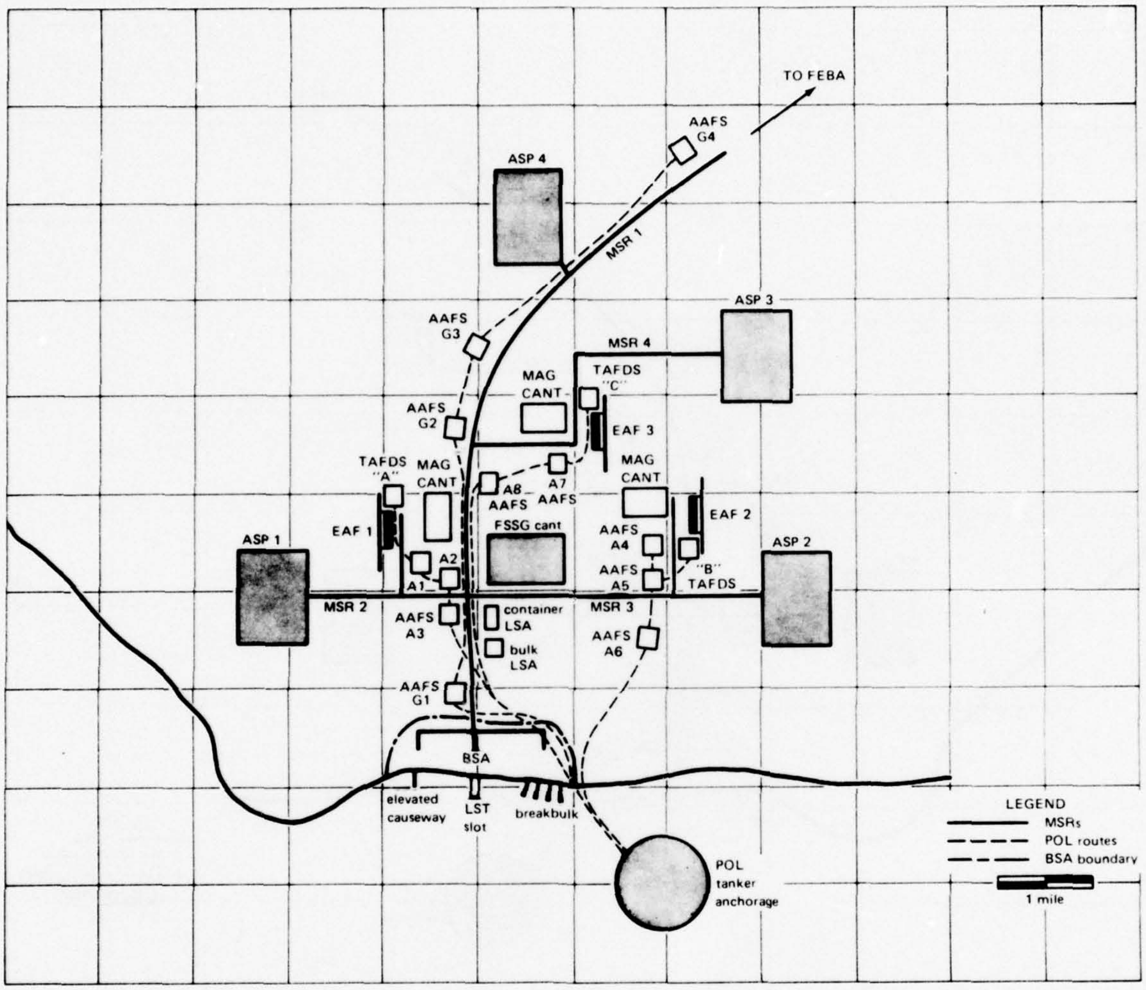
(b) D + 16

Figure 20. (continued)



(c) D + 30

Figure 20. (continued)



(d) D + 45

Figure 20. (continued)

Appendix A

PRIORITIES AND DEFINITIONS FOR HORIZONTAL CONSTRUCTION PROJECTS

Instead of assigning individual priority numbers to each construction project, it is preferable to group projects into priority classes. The projects within each priority class then carry approximately the same priority classification rating and are developed more or less concurrently as determined by mission requirements [2]. Table 1 lists the major types of horizontal construction projects with respect to their priority. Through Table 1 a priority level was assigned to each project defined below.

Vertical Takeoff and Landing (VTOL) Forward Landing Site: Priority 1.

A portable airfield of minimum size (72 ft sq) designed for operations that are dependent upon logistic or tactical support by helicopters (Figure A-1). The VTOL field does not have lighting, communications, launch, or recovery systems [13].

Vertical/Short Takeoff and Landing (V/STOL) Forward Operating Facility: Priority 1.

A portable airfield capable of providing support through V/STOL, fixed-wing aircraft and helicopters (Figure A-1). Field consists of a 600-ft-long by 79.5-ft-wide surfaced runway, turnoff, and parking and maintenance areas. A field lighting system and a Fresnel Lens Optical Landing System (FLOLS) enhance aircraft recovery capability [13].

Short Airfield for Tactical Support (SATS): Priority 1.

A portable airfield designed for use by one tactical jet squadron. Consists of a 2,210-ft-long by 96-ft-wide surfaced runway, turnoff areas at either end, a hot pad, and parking and maintenance areas (Figure A-1). Includes a CE 1-3 Catapult, two M-21 Primary Recovery Systems, two FLOLS, extensive field lighting, and audio-visual communication systems [13].

Expeditionary Airfield (EAF): Priority 1.

An extension of SATS (Figure A-1) that provides a 96-ft-wide by 4,000-ft-long surfaced runway and parking and maintenance areas for up to four tactical jet squadrons. Includes SATS catapult and recovery system as well as three FLOLS, two M-21 Emergency Recovery Systems, and expanded field lighting and communication systems [13].

Main Supply Routes (MSR): Priority 1.

A system of two-way, improved roads that link primary rear area facilities, e.g., airfields, ammunition supply points, logistic areas, bulk fuel farms, etc. The hypothetical MSR system contains 15.9 mi of roads (Figure A-2) with typical cross sections as shown in Figure A-3. The MSR system was assumed to be constructed to meet Army specifications for military roads [14].

Bulk Fuel Storage (AAFS): Priority 1.

Onshore bulk fuel storage facilities that are capable of storing 8.6 million gal of POL for air and ground elements of the MAF. POL bulk storage facilities consist of twelve AAFS. Each AAFS (Figure A-4) is comprised of five tank farms with a storage capacity of 720,000 gal (including capacity of tanks at pump stations). Each tank farm contains six 20,000-gal fabric tanks that are individually bermed (Figure A-5).

Tactical Air Fuel Dispensing Systems (TAFDS): Priority 1.

One TAFDS area is located adjacent to the parking apron at each of the three EAFs. A total of 2.4 million gal of aviation fuel is stored and issued from these TAFDS areas. The TAFDS areas are composed of tank farms equal in size to the TAFDS units, i.e., six 20,000-gal fabric tanks.

Ammunition Supply Points (ASP): Priority 2.

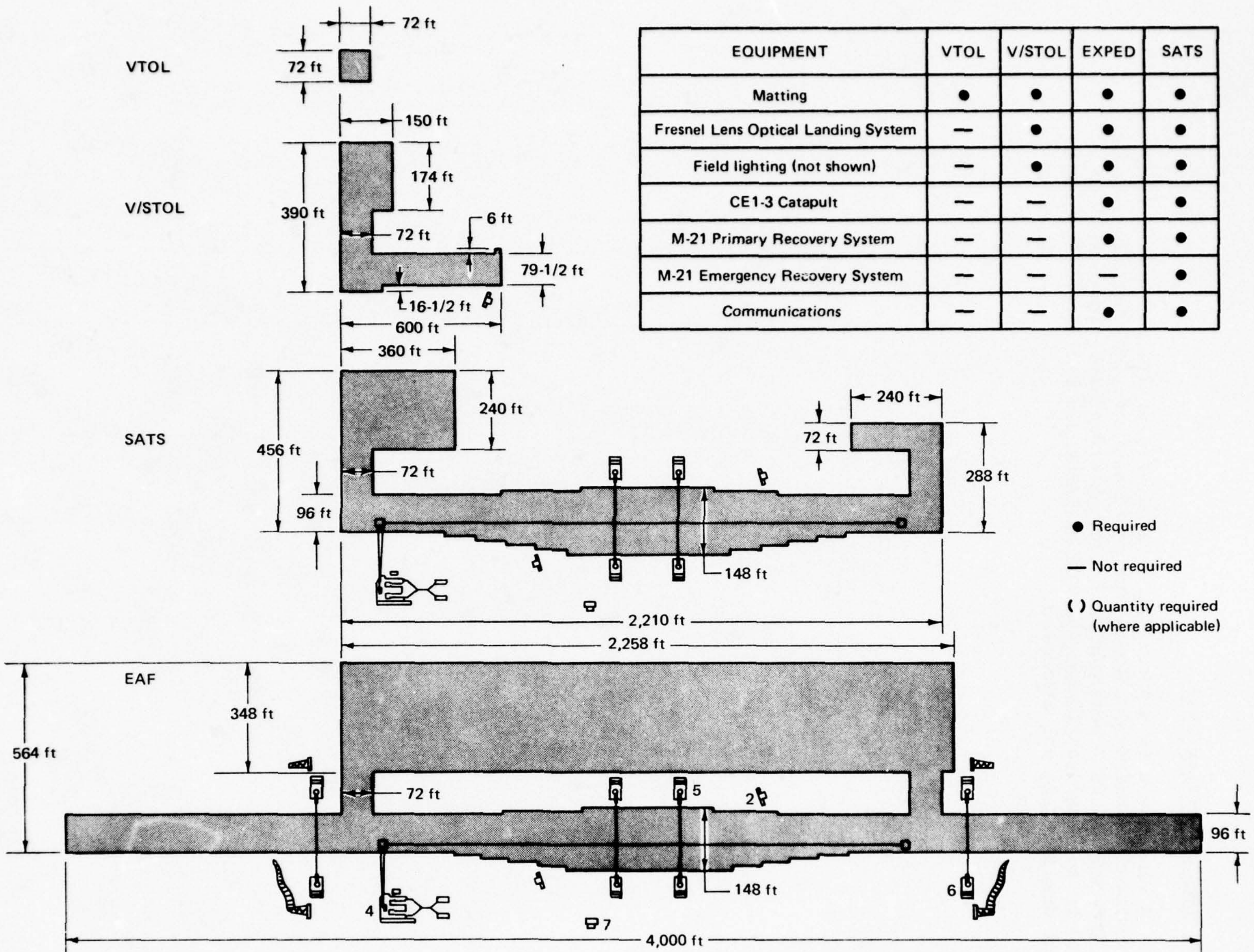
There are four ASPs that individually cover 407 acres and have perimeters of 3.2 mi. Each ASP contains approximately 7.9 mi of ditched roads and 20 aboveground, earth-bermed revetments (Figures A-6 and A-7). Each ASP is capable of storing 5,000 ST of high explosive ordnance in accordance with NAVSEA OP-5 design criteria [15].

Logistic Support Area (LSA): Priority 1.

An LSA covers 18.8 acres and has expedient surfacing for storing and handling 1,645 full and 1,645 empty 8 x 8 x 20-ft containers. These containers hold supplies other than classes III and V. The LSA contains surfaced aisles for straddlelift and cargo truck traffic, an administrative area, and areas for container unstuffing, pallet staging, and cargo truck loading (Figure A-8).

Cantonments: Priority 2.

A cantonment is a partially cleared area of 490 acres with 27 mi of unsurfaced secondary roadway. The cantonment provides berthing for 24,000 MAW and FSSG personnel. A cantonment module (Figure A-9) was used to estimate total cantonment area (Appendix B). Specific cantonment designs were not attempted.



EQUIPMENT	VTOL	V/STOL	EXPED	SATS
Matting	●	●	●	●
Fresnel Lens Optical Landing System	—	●	●	●
Field lighting (not shown)	—	●	●	●
CE1-3 Catapult	—	—	●	●
M-21 Primary Recovery System	—	—	●	●
M-21 Emergency Recovery System	—	—	—	●
Communications	—	—	●	●

Figure A-1. Expedient airfield layouts [13].

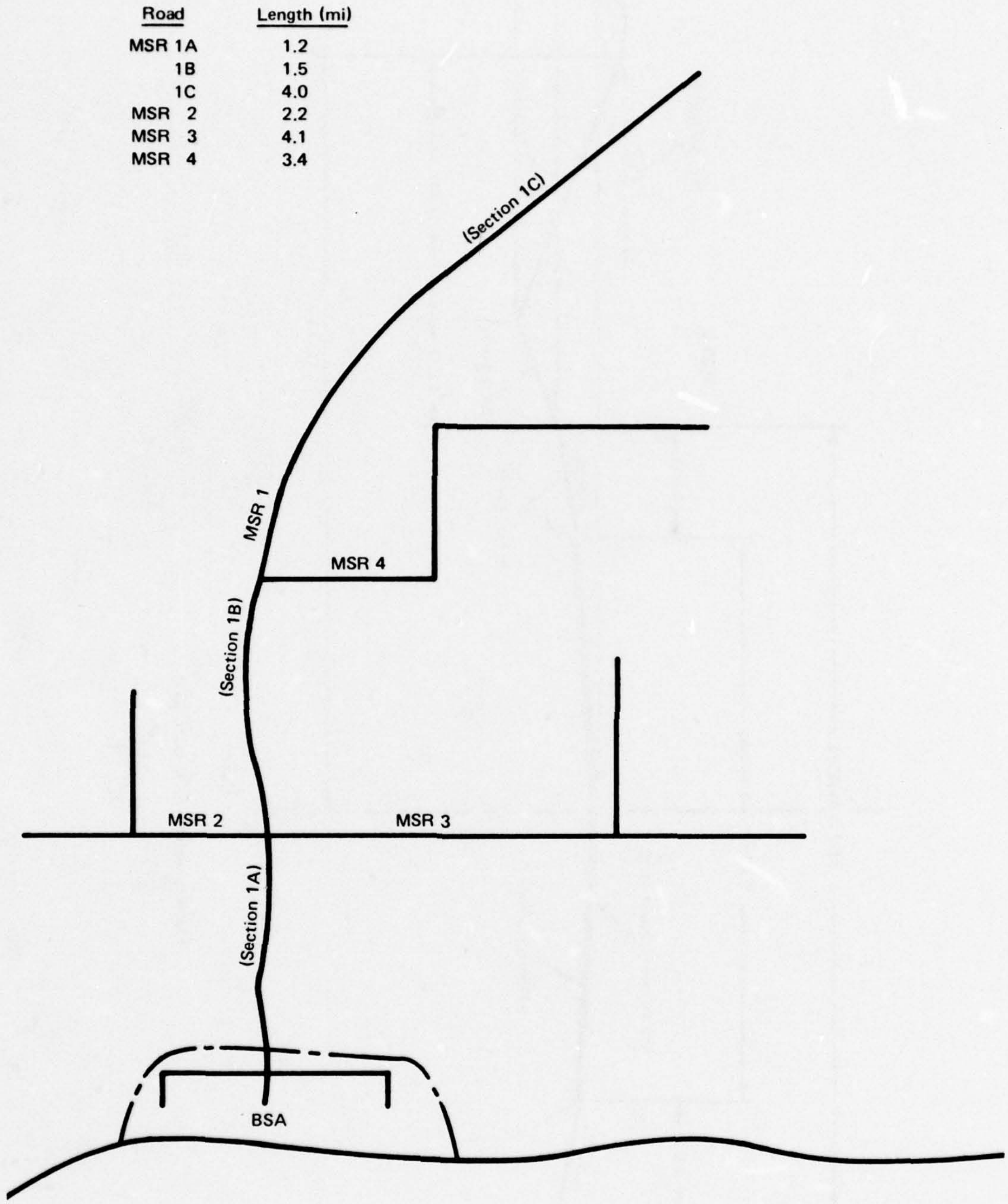


Figure A-2. Hypothetical MSR network.

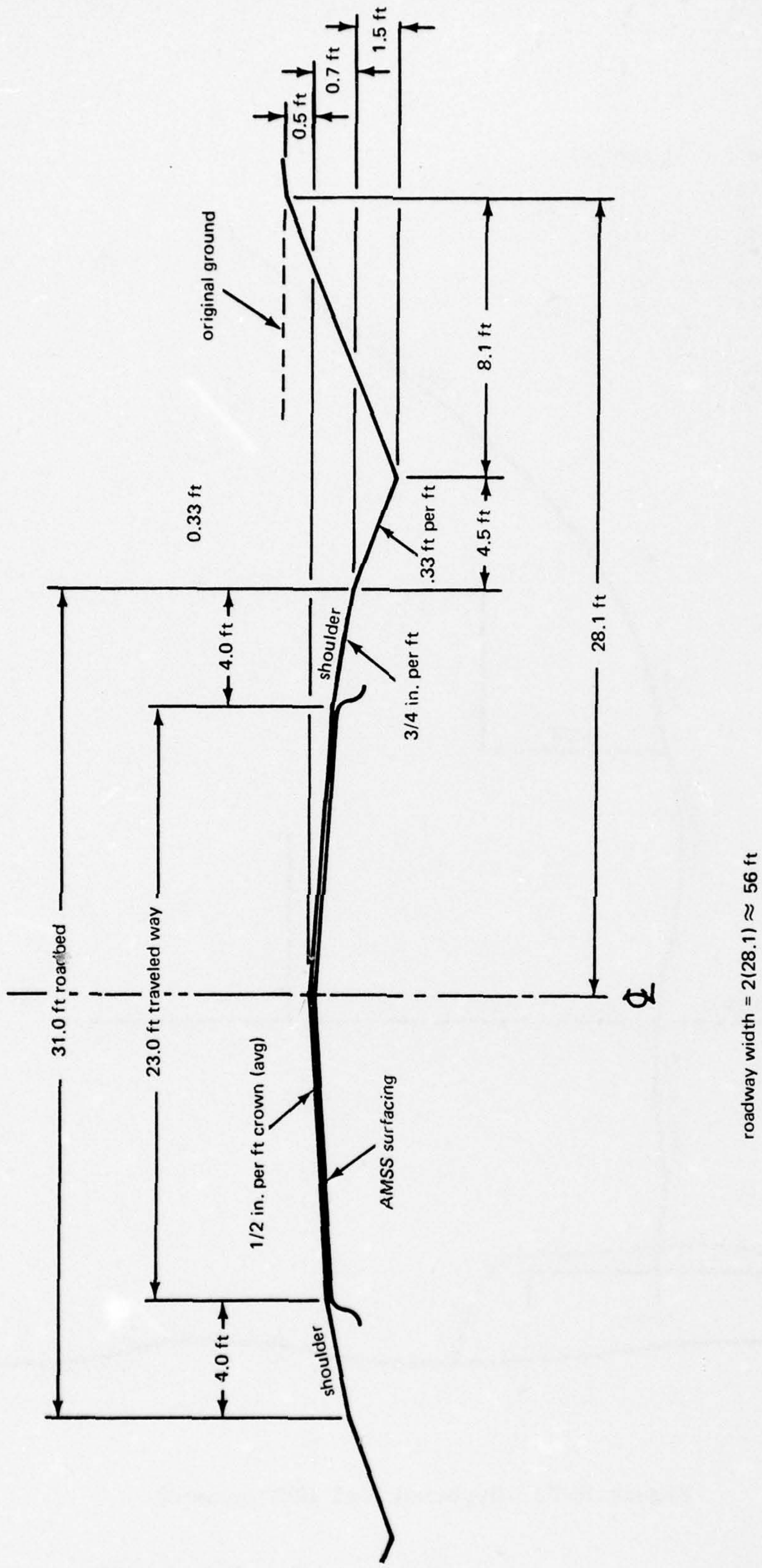


Figure A-3. Typical MSR cross section.

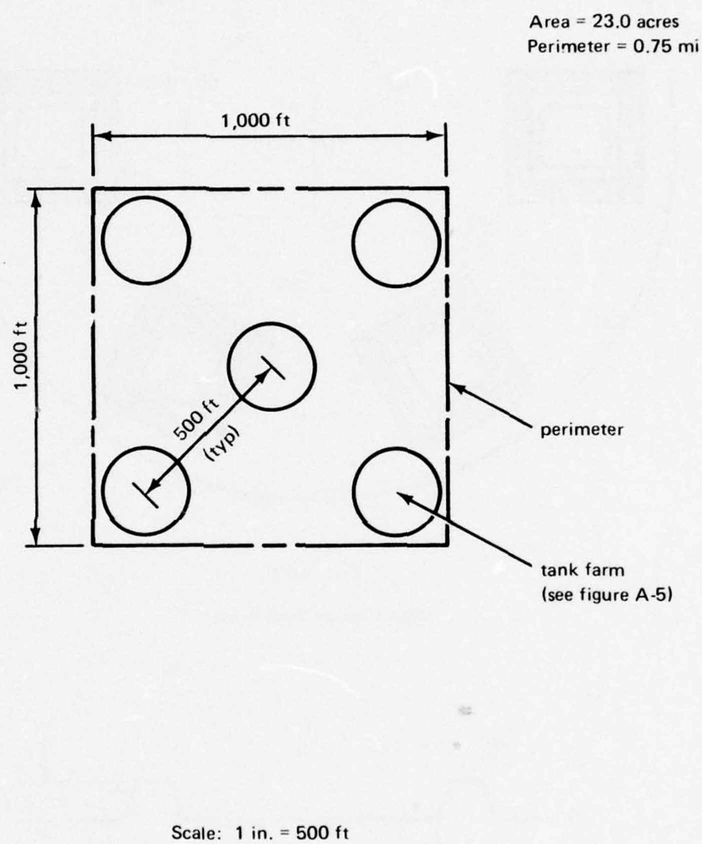
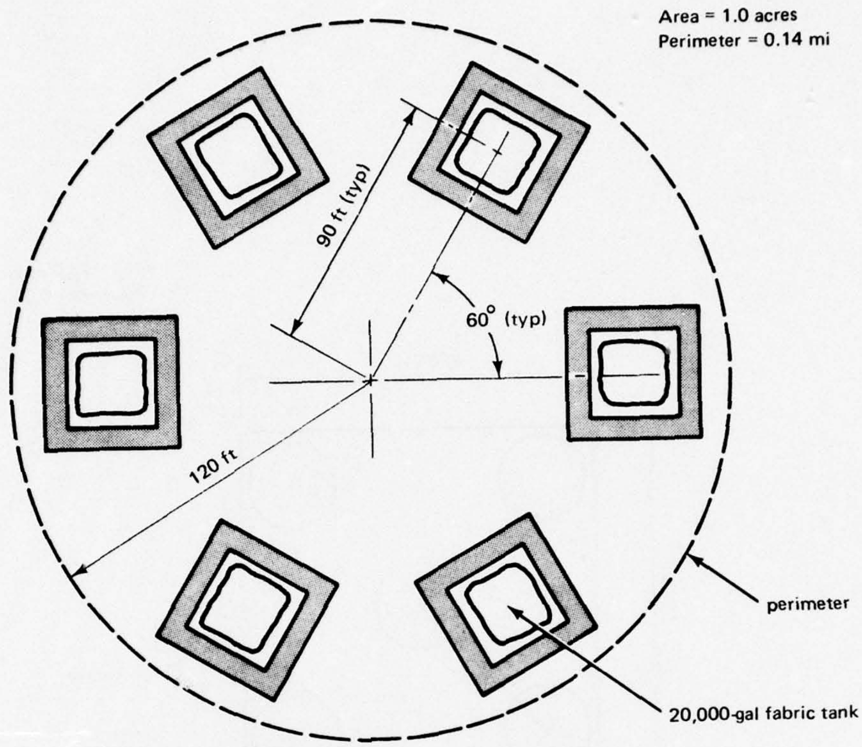
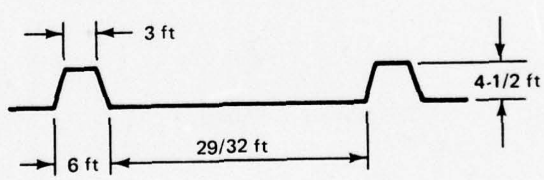


Figure A-4. Typical AAFS layout (600,000-gal capacity).



1 in = 60 ft

Plan View of Tank Farm



1 in = 20 ft

Typical Berm Profile (20,000-gal tank)

Figure A-5. Typical tank farm layout (120,000-gal capacity).

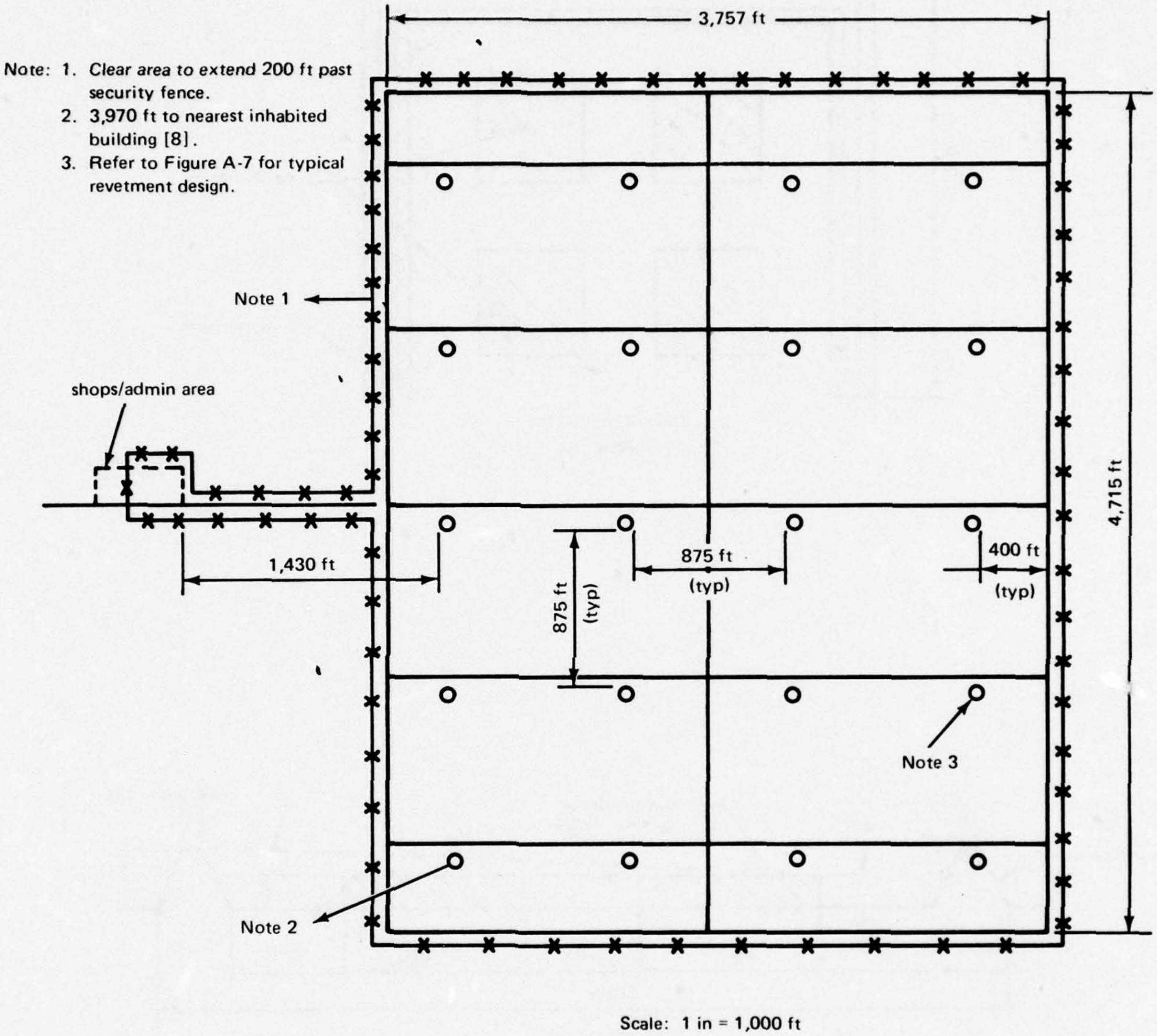
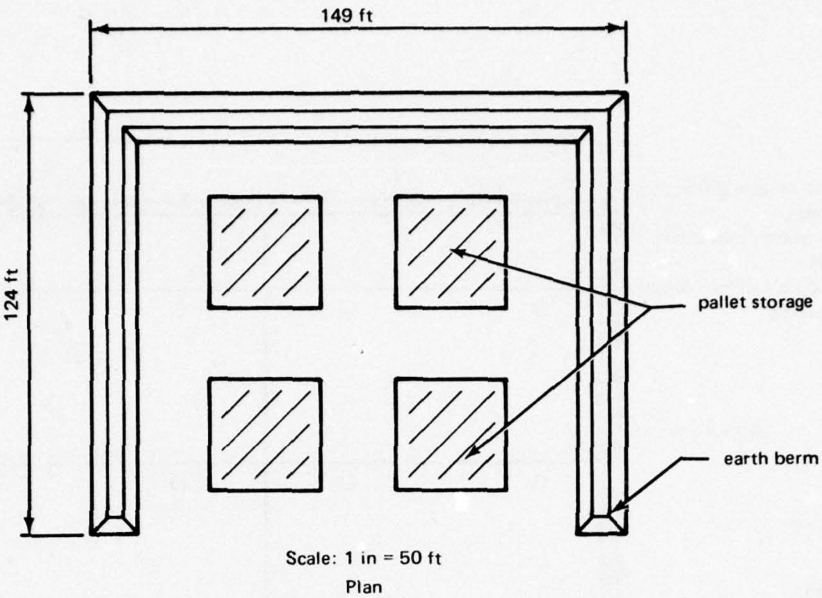


Figure A-6. 5,000-ST ASP layout.



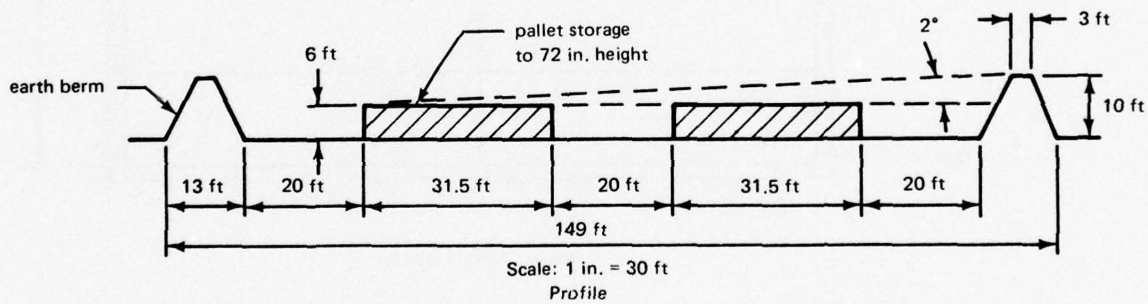


Figure A-7. Typical 250-ST, aboveground, noncovered, earth-bermed revetment.

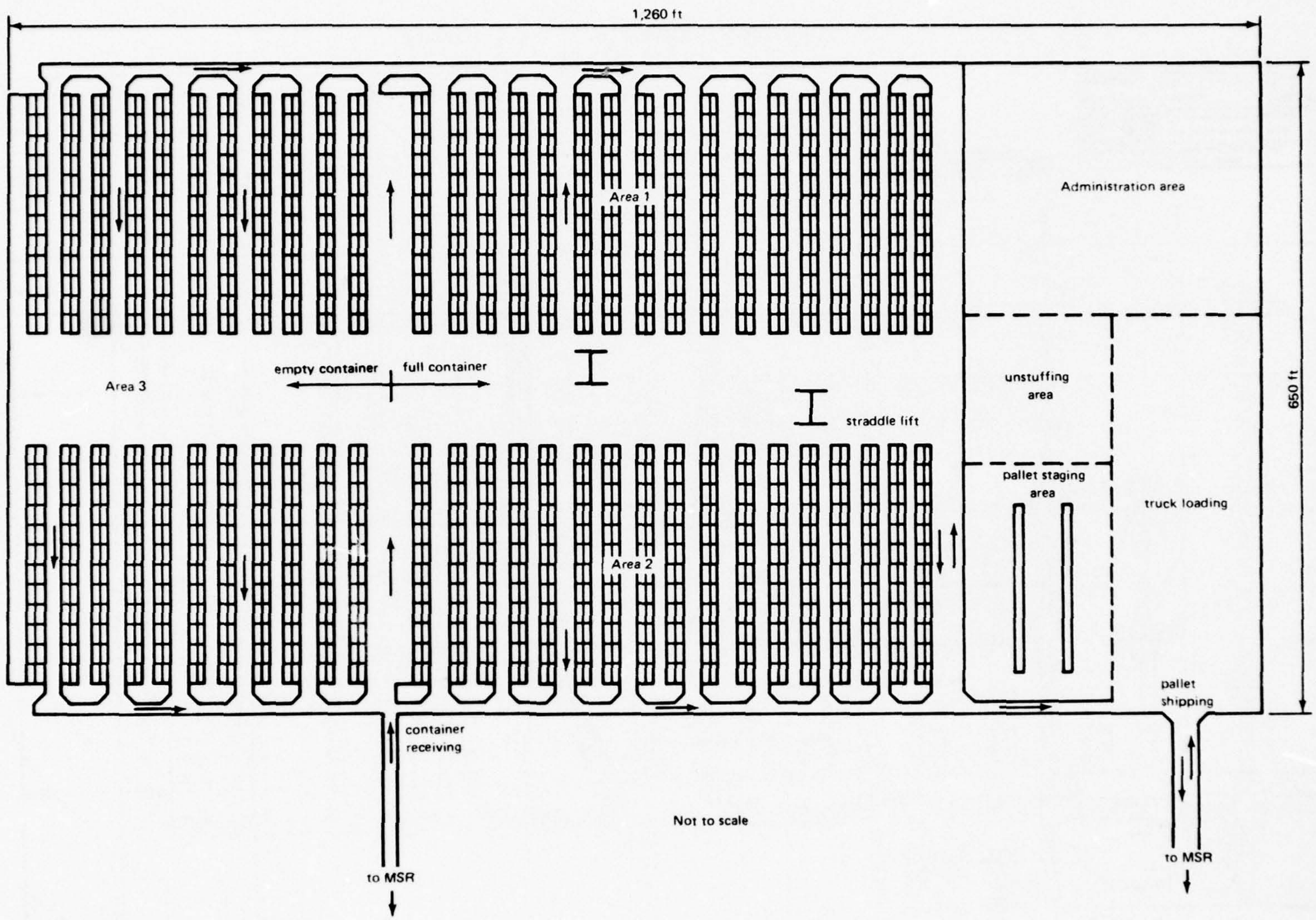


Figure A-8. Conceptual LSA layout.

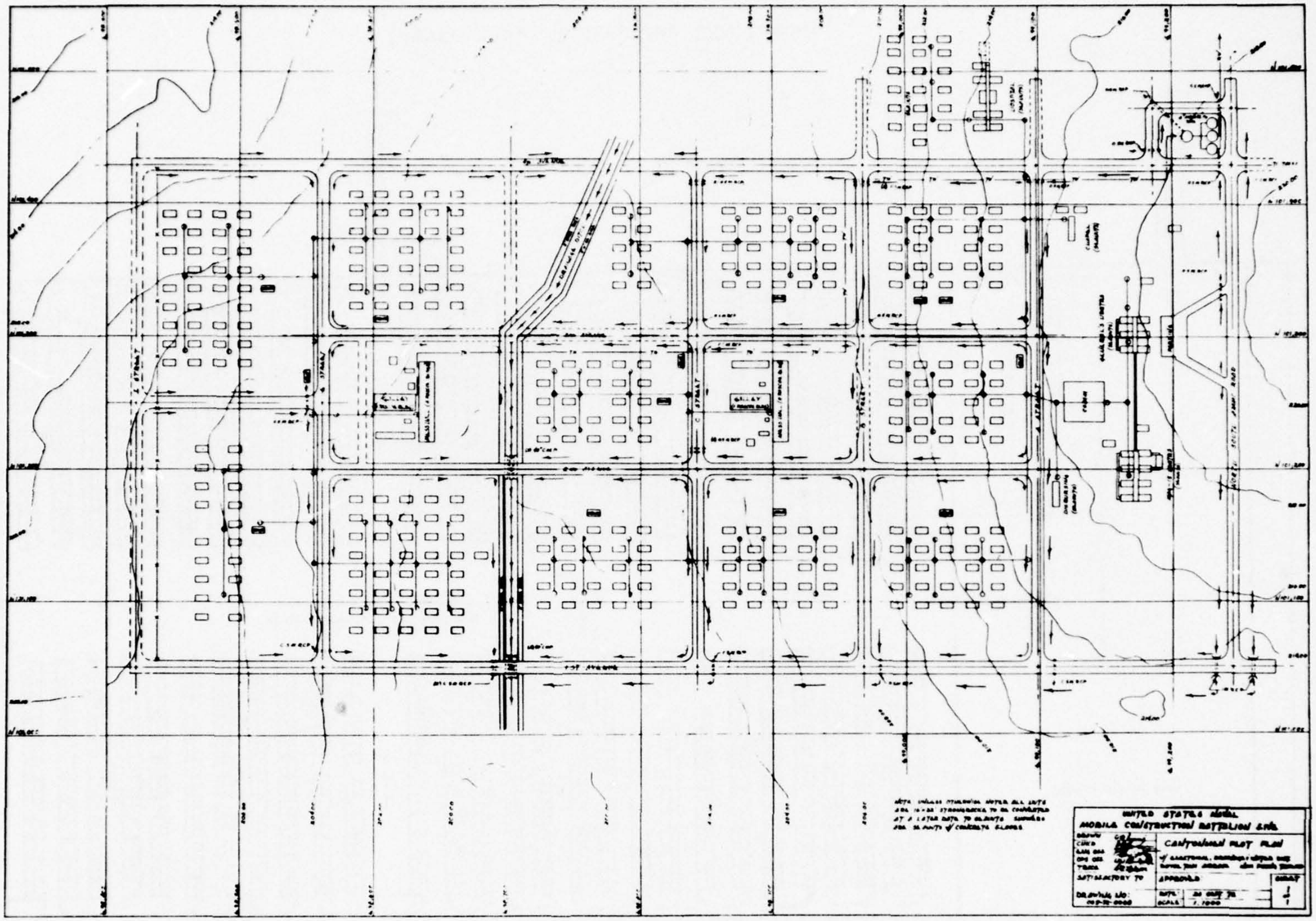


Figure A-9. Cantonment module [16].

Appendix B

PROJECT ACTIVITY ESTIMATION

EXPEDITIONARY AIRFIELD

The general limiting assumptions and several specific assumptions were applicable to estimation of EAF construction activities. The specific assumptions included:

1. Preliminary (pioneer) layout of the EAFs and construction of haul roads to borrow pits (approximately 1 mi from the EAF) were completed by MARCORPS Division engineers. The borrow pit area was stripped and cleared, but the EAF site was not cleared.
2. Site topography was assumed to be essentially level. Runway, taxiway,and parking apron were to be graded with a transverse slope of 0.5% and a longitudinal slope of 0%. Grading tolerance was such that the maximum permissible surface variation from a 12-ft straightedge was 1.0 in. The runways were to be constructed with 20-ft-wide shoulders and a 35-ft-wide clear area along all edges.

The slope, surface tolerance, and shoulder specifications of Assumption 2 closely conform to minimum airfield requirements specified by the U.S. Army for a tactical, rear area airfield [14]. Earthwork estimates were formulated using the cross section illustrated in Figure B-1. This cross section was designed along the specified transverse slope requirements.

Construction of an EAF was divided into two phases - the first consisted of constructing a SATS to achieve quick operating capability, and the second converted the SATS to an EAF. The SATS airfield was proportioned into four approximately equal areas (Figure B-2), and construction was scheduled to proceed consecutively from area to area. The same procedure of subdividing the construction effort into areas was followed for the conversion (Figure B-3). As the earthwork in any area was completed or sufficiently advanced to not present interference, matting placement was scheduled. The matting was placed in various sections as shown in Figures B-2 and B-3.

MAIN SUPPLY ROUTES

There is no reference that can define the extent or design of an MSR network capable of providing adequate logistic support to a MAF. Instead, the extent of the MSR network in the AOA must be determined by the siting of the primary facilities in the rear area, e.g., airfields, ammunition supply points, logistic areas, bulk fuel farms, etc. The siting of these facilities would be influenced by safety, operational, topographical, and tactical considerations.

The MSR system of this report was developed primarily from consideration of operational and safety requirements. However, an actual MSR network may have to be more extensive to overcome or circumvent natural obstacles or to comply with tactical factors. Construction estimates were based upon the MSR network shown in Figure A-2. The network consisted of four MSRs with the main MSR (MSR 1) subdivided into three sections. Activity estimates were formulated for construction of each MSR and the three sections of MSR 1.

Construction estimates were derived with consideration given to the general limiting assumptions. The design cross section, (Figure A-3) was selected to meet the U.S. Army military road specifications for a theatre of operations [14]. Estimates for provision of drainage control (other than a standard "V" ditch to either side of the road), bridging, or placement of culverts were neglected. MSRs were assumed to be constructed over gently rolling terrain without encountering difficult topographical features, such as marshes and rocks. MSR 1 was assumed to have been totally cleared by the Division engineers earlier in the assault. MSR construction procedure was assumed to be (1) clearing of the roadway, (2) stripping 12 inches of deleterious material from the roadway, (3) cutting "V" ditches to either side of the roadbed while casting the cut material onto the roadbed, and (4) grading and compacting the roadbed to shape the traveled way and shoulders.

AMMUNITION STORAGE POINTS

A MAF of 48,362 personnel would use ammunition at a rate of approximately 32,136 ST/mo [17]. To build a 30-day reserve, it would be logical to assume that this amount would be doubled during the first month of the operation - half the supply being consumed and half of it being stock-piled [14]. Approximately 57% of the ammunition belongs to Class VA with the remainder in Class VW [17].

To size the ASPs, it was necessary to determine the net charge weight of the ammunition. A factor of 0.60 was selected; therefore, the net weight of explosives to be stored was estimated to be 19,282 ST. If the ammunition is stored in four ASPs (one for each EAF and one for MARDIV), the ASP capacity would have to be approximately 5,000 ST.

Since an NMCB was to be tasked with the ASP construction, it seemed appropriate to use an ABFC, specifically System No. J36 (5,000-T Ammunition Depot). Drawings for this component were found to be defective (intermagazine separation distances exceeded those specified in NAVSEA OP-5), and the ASP was extremely large (650 acres). Therefore, a preliminary design for a 5,000-ton ASP (Figure A-6) was completed in accordance with NAVSEA OP-5 criteria. This ASP contained 20 250-ST-capacity aboveground revetments (Figure A-7).

All ASP construction activity estimates were referenced to the preliminary design of Figure A-6. Estimates were not included for drainage control (except minimum road ditching). The ASP areas were considered to be relatively level. Magazine berms were constructed by using scrapers to deposit material along the berm line. A scoop loader then piled the earth and shaped the berm with assistance from a road grader. Activity estimates considered construction of the ASP road systems by (1) clearing the roadway, (2) stripping 12 in. of deleterious material from the roadway, (3) cutting "V" ditches to either side of the roadbed while casting cut material onto the roadbed, and (4) grading and compacting the roadbed to shape the traveled way and shoulders.

An ASP was subdivided into four equal areas for construction scheduling, with roadway and magazine construction scheduled to proceed from area to area.

AAFS AND TAFDS

It is estimated that a MAF with 48,362 personnel will consume POL at a rate of 101,749 ST/mo. Approximately 70% of this is aircraft fuel (JP-5), with the remainder being MOGAS and diesel [17]. Using an average conversion factor of 283.6 gal/ton, the MAF consumption of POL equates to 28.9 million gal/mo.

Present concepts (not established doctrine) of MAF organization include two Bulk Fuel Companies within the Engineer Support Battalion of the FSSG [18]. Each of these two companies is assigned six AAFS. Each AAFS represents a storage capacity of 720,000 gal (36 20,000-gal tanks) [18,19]. Therefore, the POL storage ashore, will approximate 8.6 million gal (excluding TAFDS storage).

For purposes of this report, bulk fuel (AAFS) storage was assigned in increments of Tank Farms (six 20,000-gal tanks) and AAFS (five Tank Farms). In addition, each AAFS was considered to be supported by six booster tanks located along the supply lines. Typical Tank Farm and AAFS layouts are presented in Figures A-4 and A-5. The

AAFS system offers considerable layout flexibility; thus, the layout illustrated in this report is only representative of one possible configuration. Eight AAFS were positioned to provide support to the three EAFs, and four AAFS were sited to provide MOGAS and diesel fuel for ground elements (Figure 1). The locations of the 72 tanks at pumping stations were not delineated in Figure 1 because of the small scale of the figure. The AAFS assignments were as follows:

AAFS	Supported Element/Facility	Total Storage Capacity (million gal)
A1,A2,A3	EAF 1	2.16
A4,A5,A6	EAF 2	2.16
A7,A8	EAF 3	1.44
G1,G2,G3,G4	Ground	2.88
		8.64

MAF organization concepts also include 20 TAFDS units assigned to the TAFDS section of the WSG [18]. In the future, each TAFDS unit may consist of six 20,000-gal fabric tanks [20]; therefore, 20 TAFDS units would provide storage for 2.5 million gal of aviation fuel. The TAFDS units were assigned as follows:

TAFDS Area	No. of TAFDS Units	Location
A	6	EAF 1
B	6	EAF 2
C	8	EAF 3

AAFS and TAFDS construction activity estimates were based upon constructing the tank farms as shown in Figure A-5. Each tank was considered to be individually bermed, with a clear area extending 10 ft from the outer toe of its berm. The general limiting assumptions were applied to the activity estimation. Berms were constructed using equipment and procedures identical to those employed for ASP berms. Overburden stripping was not included in the activity estimates for the POL site work.

CANTONMENTS

There would be approximately 15,000 personnel assigned to the MAW and 9,000 combat service support personnel assigned to the FSSG [3]. These personnel would be primarily confined to the rear of the MAF and would require areas for layout of berthing shelters. Rather than endeavor to predict a reasonable design for the various cantonments, it was decided to use an available cantonment design as a module and to multiply the module by appropriate factors to estimate clearing and road requirements.

The selected design (Figure A-9) was that of a cantonment constructed by NMCB FIVE during 1972 in Nam Phong, Thailand, for MAG-15 of Task Force Delta (III MAF). The cantonment, which measured 1,230 ft by 2,231 ft (63.0 acres), contained 309 strongback tents/SEA HUTS and 3.5 mi of road [16]. If each hut averaged 10 personnel, the cantonment was capable of berthing 3,090 personnel. Although future MARCORPS amphibious operations could utilize container-type personnel shelters instead of SEAHUTS or strongback tents, it was estimated that the selected cantonment module would be sufficiently accurate for gross estimation since population density (troops/acre) would probably be independent of shelter type as a result of tactical and sanitation limitations. A single cantonment capable of berthing 24,000 personnel would require 7.8 modules, which is on the order of 27 mi of roadway and 490 acres of land.

Although Figure 1 depicts a cantonment at each airfield and one in the vicinity of the LSA for the FSSG, individual cantonment project estimates were not produced, but were lumped together as if one large cantonment were to be built. Estimates for total cantonment earthwork were formulated for the various activities involved. These estimates were based upon the general limiting assumptions. The cantonment area was considered to be essentially level with neither significant drainage problems nor natural obstructions. Clearing requirements were estimated to total 25% of the cantonment area. This is a smaller percentage of cleared area than was present in the design module (Figure B-4). Estimates for road construction activities were based on a single lane, 14-ft-wide traveled way with 4-ft-wide shoulders and 1.5-ft-deep "V" ditches to either side of the roadway. The Engineer Support Battalion of the FSSG was assigned cantonment construction.

LOGISTIC SUPPORT AREAS

Based on daily cargo requirements and containerability of the cargo, it was calculated that 106 8 x 8 x 20-ft cont/day would be required to support a full-sized MAF operation. A double rate was assumed to be necessary initially to achieve a reserve stock of 30 days while concurrently meeting daily demands. Thus, the throughput rate would have to be at least 212 cont/day. This double rate by material class is as follows [21]:

Class	Rate (cont/day)
III	10
V	108
Other	94
	212

Safety factors require Class III and V materials to be separated from the other classes. Containers with Class III and V cargos would probably be routed to bulk fuel farms and ammunition storage points, respectively. The LSA must, therefore, be capable of handling the remaining 94 containers per day of other classes of supply items.

Allowing for a contingency of 5 days, the double rate would continue for a period of 35 days building to a total of 3,290 containers in the LSA. Half of these would be unstuffed in the LSA each day, with pallet-sized loads going forward or being stored in a pallet area forward of the LSA for subsequent forward movement. A design for a container-handling LSA does not presently exist. However, such an LSA must be capable of

1. Storing 1,645 empty containers in a compact area for retrograde.
2. Storing 1,645 full containers in arrays to facilitate handling/unstuffing.
3. Unstuffing 47 cont/day by transferring them to an unstuffing dock and/or bringing the unstuffing capability to the container.

Accordingly, a rough LSA design was developed to satisfy these three criteria. The LSA design should not be considered a blue print for LSA construction. The design was intended solely to facilitate estimation of LSA earthwork requirements. The design was based on arrangements of clusters of containers (Figure B-5). The cluster aisle spacing was derived by assuming the use of straddlelifts for container handling (Figure B-6). Assuming loaded containers are stacked two high and empty containers three high, then 4.3 clusters would be required for the full containers and 2.9 clusters for the empty containers. A plan view of the LSA concept is presented in Figure A-8.

The LSA discussed thus far was designed for containerizable cargo in classes other than Class III and V. There would be some noncontainerizable cargo from Classes IV and VII that would necessitate an additional LSA area. No attempt was made to accurately determine this area size; also, construction of an area for storage of the bulk cargo was not included in this report.

Specific assumptions applied to LSA activity estimates included:

1. Construction of the LSA by functional areas (Figures 6 and A-8).

2. Stripping of 12 in. of deleterious material from areas of the LSA subject to container-capable MHE traffic. Hauling, placing, grading, and compacting of fill to provide a +0.5% slope from the longitudinal edges of the LSA to the longitudinal centerline.

3. Surfacing Areas 1, 2, and 3 and the Container Unstuffing Area with components of the AMSS.

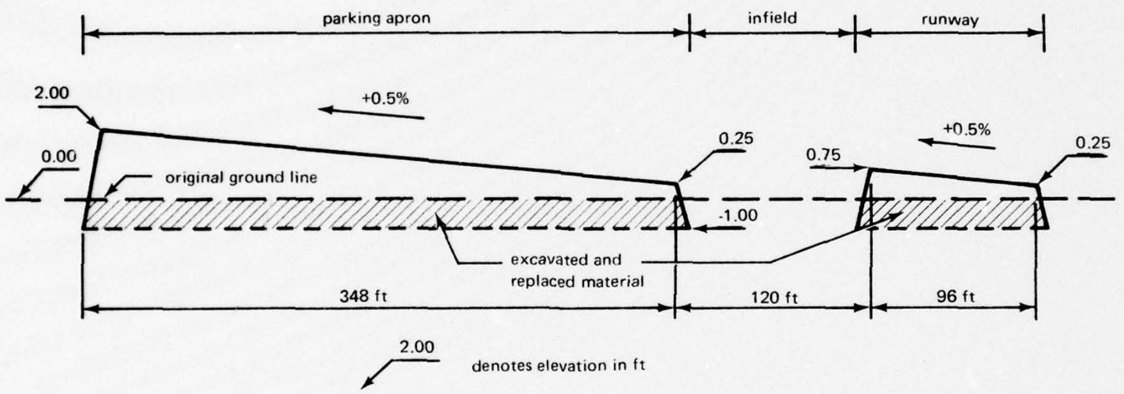
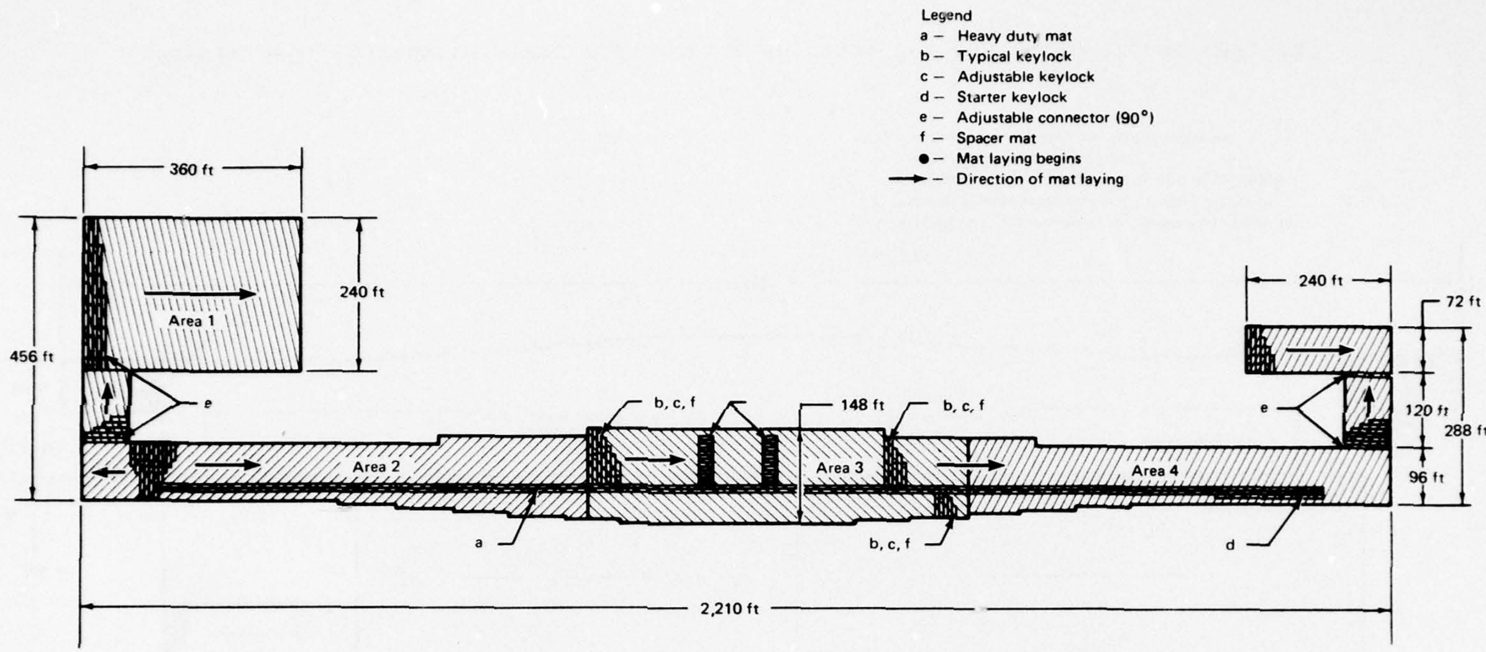


Figure B-1. EAF cross section.



Notes:
1. SATS area equals 373,000 sq ft
2. Row of typical keylocks installed every 100 ft in runway. Row of typical keylocks installed 276 ft from beginning.
3. Earthwork areas added to original reference.

Figure B-2. Earthwork areas and matting sections for a SATS [13].

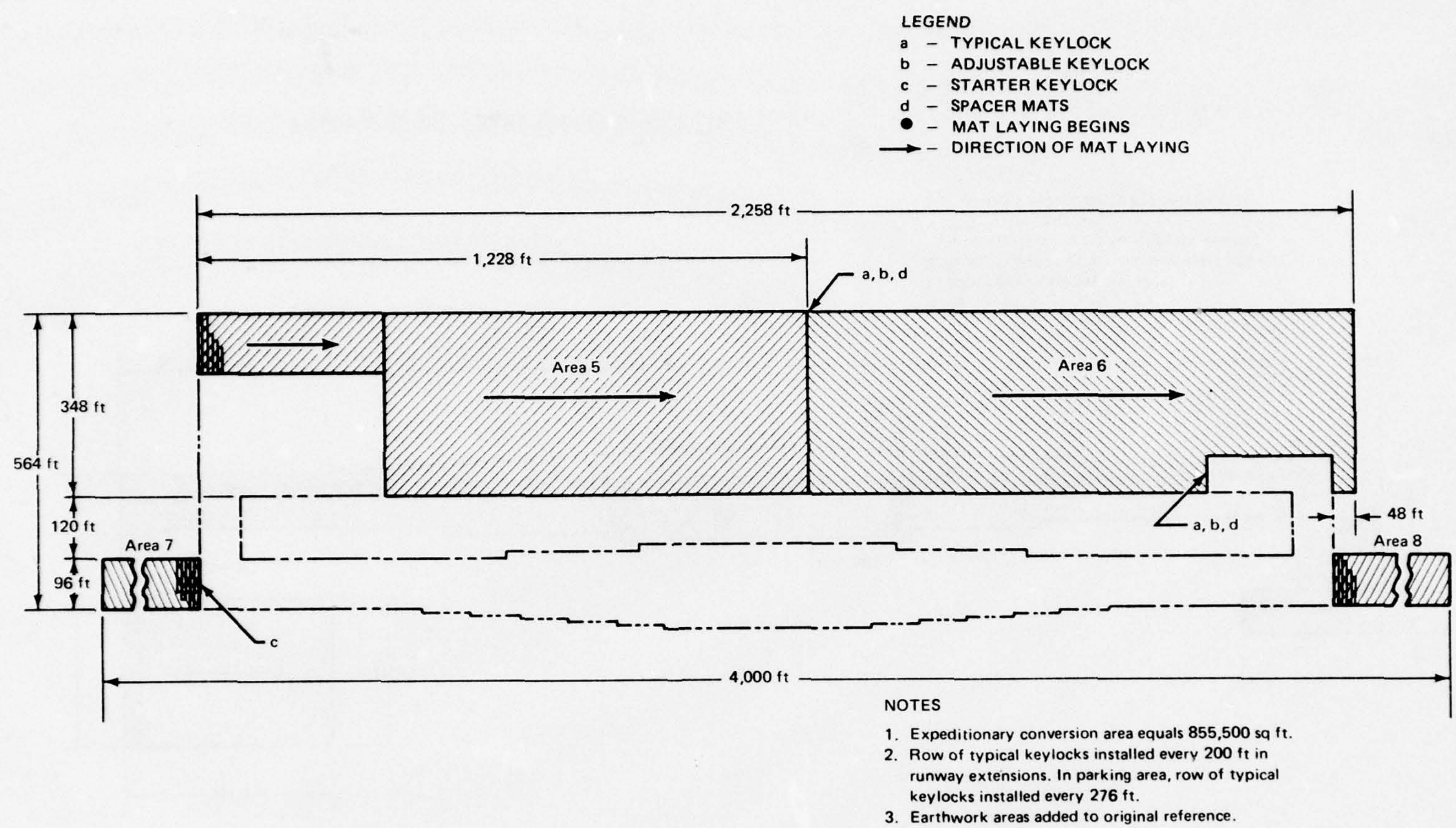


Figure B-3. Earthwork areas and matting sections for conversion to an EAF [13].

Figure B-4. Actual cantonment module. Note proportion of cleared land area.

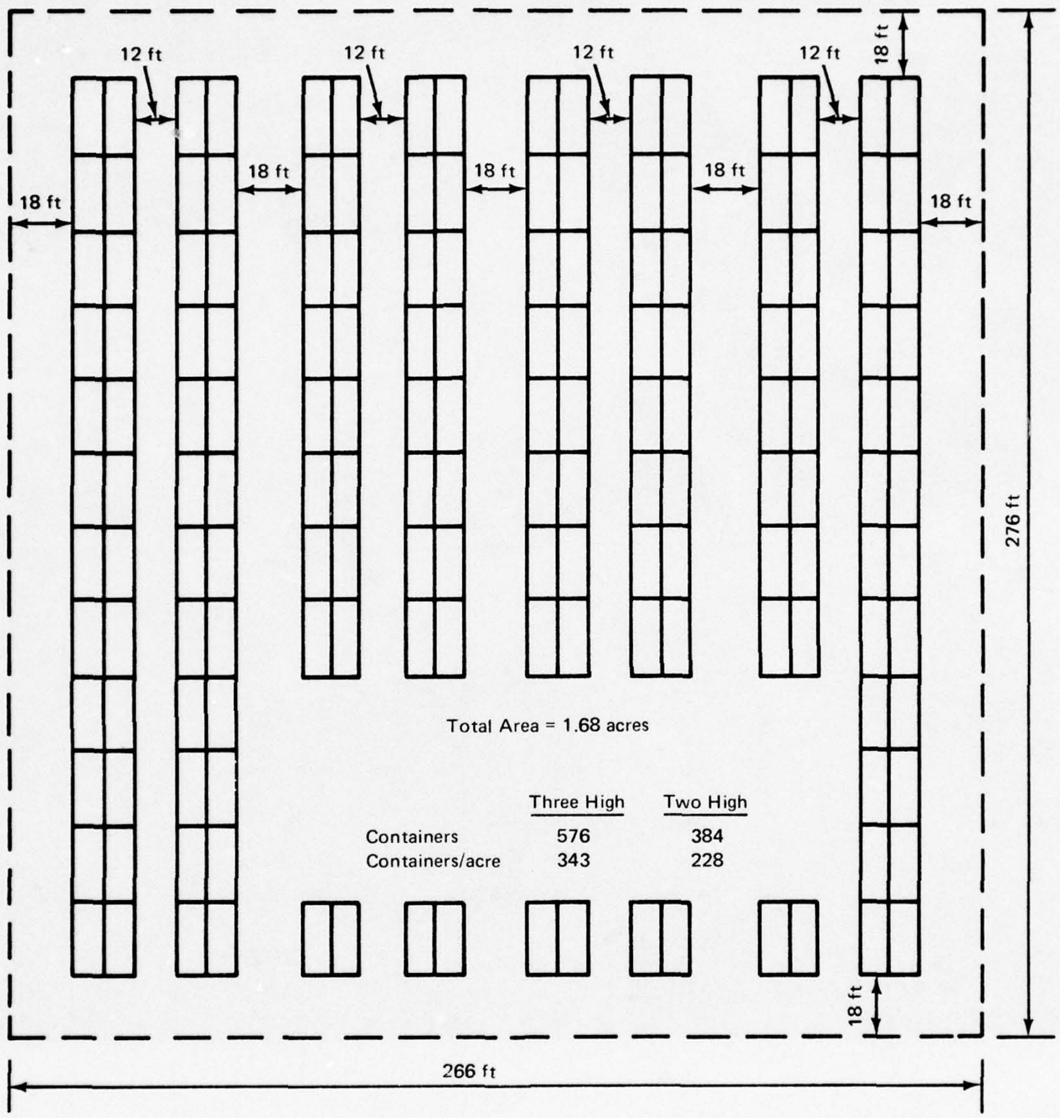


Figure B-5. Typical container cluster for straddlelift handling [21].

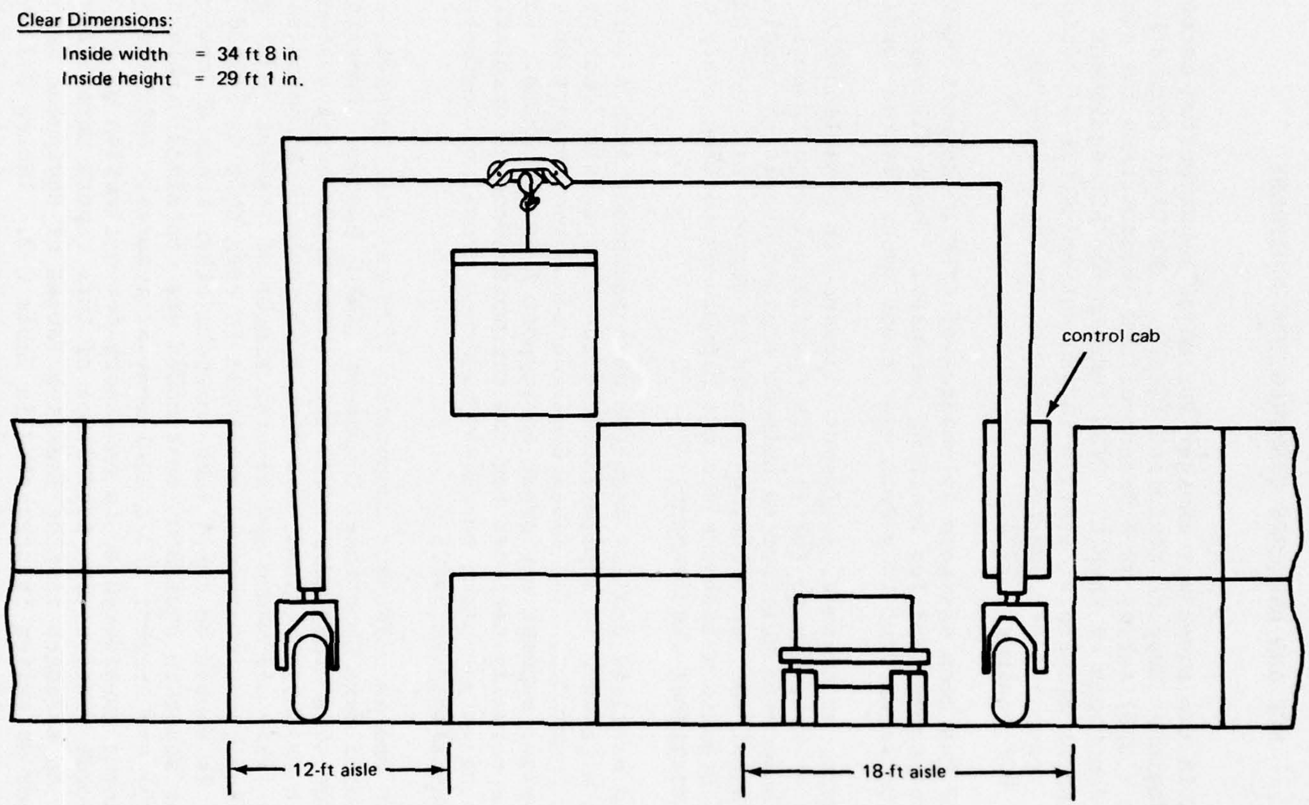


Figure B-6. Container-handling arrangement with straddlelift [21].

Appendix C

NCF AND MARCORPS CONSTRUCTION EQUIPMENT

NAVFAC is the inventory manager for major construction material and Civil Engineer Support Equipment (CESE). The Civil Engineer Support Office (CESO) serves as a decentralized headquarters for equipment management functions of NAVFAC. CESO budgets for NCF equipment and tactical support materials, assists in the determination of equipment allowances, and provides management guidance in the maintenance and overhaul of NCF equipment [22].

The NCF has been assigned allowances of CESE to support operations during a contingency and for training purposes. These allowances include tactical equipment to permit operations under adverse conditions.

The basic, or organic, equipment allowance is established to enable a unit or activity to fulfill its operational requirements. Allowance items have been selected to balance typical operating conditions and cost against the capability of providing support in a contingency situation. Organic allowances are not capable of meeting every conceivable operational requirement.

When an assigned project requires more equipment than a Unit has, the organic allowance is supplemented by the responsible Fleet or Operational commander. The Naval Construction Force Support Unit (NCFSU) provides augment equipment to support NCRs and NMCBs. This equipment is normally tailored for the accomplishment of specialized tasks, such as large-volume earth moving, rock crushing, concrete and asphalt production, etc. [22].

An NMCB and an NCFSU are components (P25 and P31, respectively) of the Advanced Base Functional Component (ABFC) System. Construction estimates for this study were based upon three NMCBs being assigned to the MAF. It was hypothesized that each NMCB would be accompanied by its organic (P25) allowance and several pieces of augment (P31) equipment. The equipment considered available to each NMCB is listed in Table C-1. It should be noted that numerous other items of equipment listed under separate equipment cost codes are contained within the organic (P25) and augment (P31) equipment allowances. Only the major equipment items considered to be necessary for estimation of the primary horizontal construction activities of this report were listed in Table C-1. An abridged listing from the Tables of Equipment for the FSSG Engineer Battalion is presented in Table C-2. Tables C-3 through C-13 contain specifications and performance characteristics for the equipment listed in Table C-1. Tables C-14 through C-17 contain specifications and performance characteristics for several MARCORPS (FSSG Engineer Battalion) equipment items.

Table C-1. NMCB Organic (P25) and Augment (P31) Equipment

ECC	Short Description	Quantity	Representative Manufacturer/Model
Organic Equipment[a]			
0587/01	TRK 5T Dump	12	—
0644/11	TRK 15T Dump	8	—
4420/31	Grader Motor	6	Galion, Model T-500L
4530/11	Tractor w/Load (W/W)	2	Caterpillar, Model 977L
4530/21	Tractor w/Load (W/BH)	2	Caterpillar, Model 977L
4531/31	Loader Front End (W/FK)	1	John Deere, Model JD644
4531/41	Loader Front End (Arctic)	3	John Deere, Model JD644
4635/21	Roller Vibrate	3	RAYGO Model 400
4635/31	Roller Vibrate (ASP)	1	RAYGO Model 400
4750/01	Tractor Scraper	6	MRS I110, S110, or Int. 433
4850/01	Tractor Crawler U	2	International TD-20B
4850/11	Tractor Crawler A	4	International TD-20B
4850/21	Tractor Crawler R	2	International TD-20B
Augment Equipment[b]			
4750/11	Tractor Scraper	2	Caterpillar, Model 637
4851/01	Tractor Crawler U	4	Caterpillar, Model D8H

[a]Extracted from Reference 23. Represents an abridged P25 organic equipment listing.

[b]Extracted from P31 equipment list of Reference 23.

Table C-2. FSSG Engineer Battalion Equipment Allowance[a]

TAM No.	Short Description	Quantity	Representative Manufacturer/Model
B-1080	Grader, Road, Motorized	8	—
B-1900	Scraper, Earth Paving, Towed, Cable-Operated, 16 cu yd	8	*b*
B-1920	Scraper, Earthmoving, Towed, Hydraulically Operated, 8 cu yd	5	MRS 100-M69
B-2460	Tractor, Industrial	8	MRS 200
B-2462	Tractor, Medium, Full-Tracked	36	TEREX 82-30FA-M2
B-2463	Tractor, Full-Tracked w/Multipurpose Bucket	6	CASE 1150
B-2465	Tractor, Rubber-Tired, Arctic, Steering	6	TEREX 72-31
B-2480	Tractor, Wheeled, Industrial	9	MRS 100-M69
1070	Truck, Dump, 5T, 6x6 M54A2C	84	—

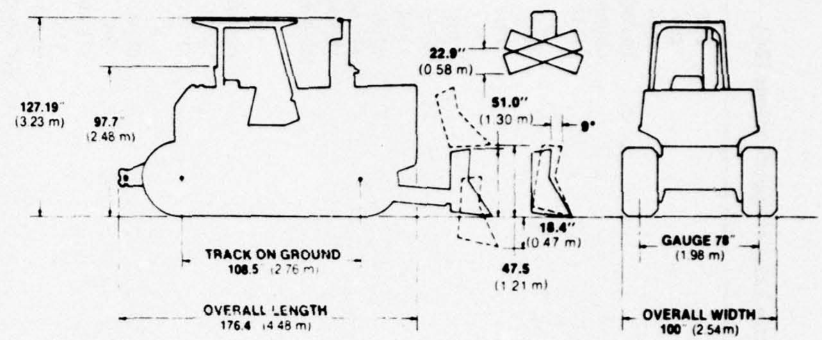
[a]Abridged listing from Tables of Equipment.
[b]To be replaced by five MRS I110 scrapers.

Table C-3. TD-20 (ECC 4850) Tractor Crawler Specifications [24,25]

Specification Sheet For IHC TD-20B

Gear	Forward Speed (MPH)	Reverse Speed (MPH)	Approximate Rated Pull (lb)
First low	2.2	2.5	22,119
First high	3.1	3.6	15,698
Second low	4.3	4.9	11,200
Second high	5.9	6.7	8,247

Approximate Blade Capacities	
Straight Blade	Angle Blade
5 cu yd	4.6 cu yd



Engine: Make and Model	International DVT-800	
Type	Diesel, 4 Cycle, turbocharged	
Flywheel Horsepower @ 2100 rpm (kW)	210 (157)	
Number of Cylinders	8	
Torque Converter Dia., in. (mm)	Single Stage 14 (356)	
Transmission	Countershaft, power shift	
	Forward	Reverse
Number of Speeds	3	3
Traveling Speed Range, mph (km/h)	0 to 6.38 (0 to 10.26)	0 to 7.48 (0 to 12.03)
Steering Unit	Multiple disc clutches with multiple disc brakes	
Number Track Rollers each side	6	
Ground Clearance from Base of Shoe, in. (mm)	18.1 (460)	
Weight, (Approx.) Shipping, lb (kg)	46,600 (21,110)	

OPTIONAL EQUIPMENT AND ATTACHMENTS

Bulldozers	Ripper	Air Conditioned Cabs
Bullgraders	Winches	Cable Plows
2-Speed Geared Steer – Power in Turns		

Table C-4. Caterpillar D8H (ECC 4851) Tractor Crawler Specifications [26]

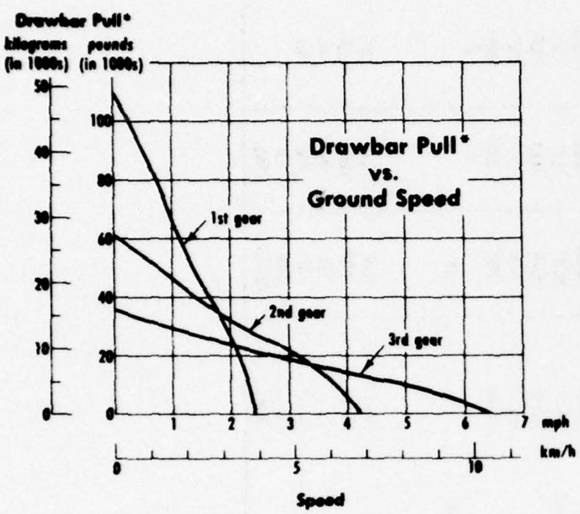
Flywheel Horsepower			270
Kilowatts[a]			201
Rated Engine RPM			1280
Full Horsepower		ft.	10,000
to attitude		(metres)	(3000)
Model:			D342
No. of Cylinders			6
Bore		in.	5.75"
		(mm)	(146)
Stroke		in.	8"
		(mm)	(203)
Displacement		cu. in.	1246
		(litres)	(20.4)
Basic[b]	PS	lb.	51,000
Machine		(kg)	(23 100)
Weight	DD	lb.	50,500
		(kg)	(22 900)
General Dimensions:			
Length (overall)		ft.	17'
		(mm)	(5200)
Width (std. shoes)		ft.	9'1"
		(mm)	(2770)
Height (excl. exhaust,		ft.	8'
precleaner)		(mm)	(2440)
Gauge		in.	84"
		(mm)	(2130)
Ground clearance		in.	15.2"
(from face of shoes)		(mm)	(386)
Choice of Shoe Width		in.	20" to 28"
		(mm)	(510-710)
Ground Contact Area		sq. in.	4942
(with std. shoe)		(m^2)	(3.19)
Length of Track		in.	124"
on ground		(mm)	(3150)
Capacities:			
Cooling system		U.S. Gal.	31
		(litres)	(117)
Fuel Tank		U.S. Gal.	134
		(litres)	(510)
Engine Crankcase		U.S. Gal.	8.75
		(litres)	(33)
Trans., Torque Div., Bevel Gear, Steer. Clutch Compts.		U.S. Gal.	31
		(litres)	(117)
Trans. Bevel Gear, Steer. Clutch Flywheel Clutch		U.S. Gal.	31[c]
		(litres)	(117)
Final Drivers (each)		U.S. Gal.	9
		(litres)	(34)
Blade Types Available			Straight Angle Universal Cusion Rip

[a]Kilowatts is the International System of Units equivalent of horsepower.

[b]Shipping weight including collant, hydraulic fluid, lubricant, 5% fuel in tank.

[c]Also includes flywheel clutch.

Table C-5. Caterpillar D8H (ECC 4851) Tractor Crawler Performance Characteristics [26].



POWER SHIFT TRANSMISSION

Planetary-type power shift with 21" (534 mm) diameter, high-torque capacity, oil clutches. Modulating valve permits unrestricted speed and direction changes under full load.

Gear	Forward MPH	Forward (km/h)	Reverse MPH	Reverse (km/h)
1	0-2.4	(3,9)	0-3.0	(4.8)
2	0-4.2	(6,8)	0-5.2	(8.4)
3	0-6.5	(10,5)	0-8.1	(13,0)

DIRECT DRIVE TRANSMISSION

Constant mesh with helical gears and fast forward-reverse shift. Filtered, cooled, full pressure lubrication. Unit construction.

SPEED AND DRAWBAR PULL

	Forward		Reverse		Drawbar Pull Forward* At Rated RPM		Maximum at Lug	
Gear	MPH	km/h	MPH	km/h	Pounds	kg	Pounds	kg
1	1.6	(2.6)	1.6	(2.6)	52,410	(23 790)	63,860	(28 990)
2	2.1	(3.4)	2.1	(3.4)	39,130	(17 760)	47,930	(21 760)
3	2.9	(4.7)	2.9	(4.7)	26,870	(12 200)	33,210	(15 080)
4	3.7	(6.0)	3.8	(6.1)	19,490	(8850)	24,360	(11 060)
5	4.9	(7.9)	4.9	(7.9)	13,840	(6280)	17,580	(7980)
6	6.7	(10.8)	6.8	(10.9)	8,660	(3930)	11,360	(5160)

*Usable pull will depend on traction and weight of equipped tractor.

Table C-6. Caterpillar D8 Bulldozer Specifications [26].

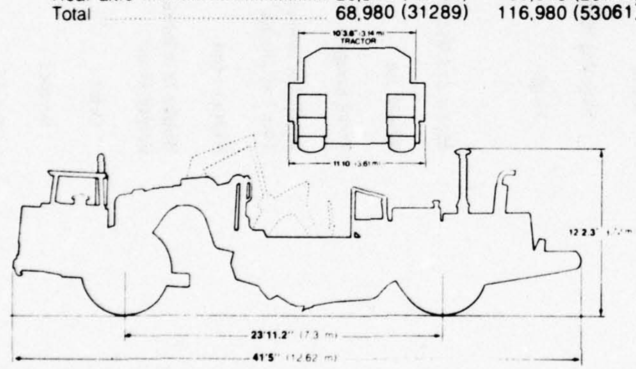
Model		8A	8S	8U
Type		Angling	Straight	Universal
Weight, Shipping (Installed)	–lb	11300	10900	12100
	–(kg)	(5125)	(4950)	(5500)
General Dimensions: (Tractor & Dozers)				
Length (Blades Straight)	–ft	21'10-1/3"	21'8"	22'11-2/3"
	–(mm)	(6650)	(6600)	(6930)
Length (Blade Angled)	–ft	24'11"		
	–(mm)	(7590)		
Width (Blade Straight)	–ft	15'5-1/3"	13'1/2"	14'2"
	–(mm)	(4720)	(3990)	(4320)
Width (Blade Angled)	–ft	14' 1/3"		
	–(mm)	(4270)		
Width (with C Frame only)	–ft	11'4-1/3"		
	–(mm)	(3450)		

Model		8A	8S	8U
Blade:				
Length (Including End Bits)	–ft.	15'5-2/3"	13'1/2"	14'2"
	–(mm)	(4720)	(4000)	(4320)
Height	–in	44"	60"	60"
	–(mm)	(1120)	(1520)	(1520)
Max. Drop Below Ground	–in	22.5"	23"	23"
	–(mm)	(570)	(580)	(580)
Max. Tilt	–in	11.6'	35"	38"
	–(mm)	(295)	(890)	(965)
Max. Pitch Adjustment			9°	9°
Blade Angle (either side)		25°		
Attachments:				
Tilt Cylinder				
Max. Hydraulic Tilt	–in	11.6"	35"	38"
	–(mm)	(295)	(890)	(965)
Push Cup – C Frame		Yes	No	No
– Blade		No	Yes	No
Weight, Shipping	–lb	5535	750	
(blade only)	–(kg)	(2510)	(340)	

Table C-7. International 433 Pay Scraper and MRS S110 (ECC 4750/01) Scraper Specifications [24,25].

SPECIFICATIONS

Scraper bowl capacity		
Heaped, SAE, yd.^{3} (m^3)	21 (16.06)	
Struck measure, SAE, yd.^{3} (m^3)	14 (10.70)	
Payload, lb. (kg)	48,000 (21773)	
Engine: tractor	International DVT-800	
Type	Diesel, 4 cycle, turbocharged	
Rated hp @ 2600 rpm (kw)	333 (248)	
Flywheel hp @ 2600 rpm (kw)	310 (231)	
Torque converter type	Single stage with automatic lock-up in 2nd through 5th	
Torque ratio @ stall	2.28 : 1	
Transmission type	power shift, countershaft	
Number of speeds	**Forward**	**Reverse**
Torque converter drive	5	1
Torque converter lock-up	4	1
Axles	Full floating, double reduction	
Engine: scraper	International DT-466	
Type	Diesel, 4 cycle, turbocharged	
Rated hp @ 2500 rpm (kw)	200 (149)	
Flywheel hp @ 2500 rpm (kw)	185 (138)	
Torque converter type	Single stage	
Torque ratio @ stall	3.06:1	
Transmission type	Power shift, countershaft	
Number of speeds	**Forward**	**Reverse**
Torque converter drive	5	1
Steering type	Positive hydraulic, Equa Torque with follow-up	
Tractor and scraper 180° non-stop turning width, ft. (m)	34' (10.36)	
Brakes type	Internal expanding, 2-shoe	
Actuation	Air over hydraulic, wedge	
Tires tractor and scraper	29.5 x 29 28 PR (E-3)	
Scraper actuation	Positive hydraulic, separate controls for bowl, apron and ejector	
Weights, approx., lb. (kg)	**Empty**	**Loaded**
Front axle	40,767 (18492)	57,964 (26292)
Rear axle	28,213 (12797)	59,016 (26769)
Total	68,980 (31289)	116,980 (53061)



MRS S110 Scraper

Capacity

Struck – 14 cu yd
Heaped – 17 cu yd
Weight of Scraper – 25,250 lb

MRS I110 Tractor

Weight – 38,500 lb

Gear	Speed	Rated (lb)
1st	4.88	37,800
2nd	6.7	27,531
3rd	9.2	20,050
4th	13.0	14,190
5th	18.4	10,025
6th	26.5	9,961

Table C-8. Caterpillar 637 (ECC 4750/11) Scraper Specifications [26]

Model 637		
Flywheel Horsepower		
Tractor		415
Scraper		225
Kilowatts		
Tractor		309
Scraper		168
Rated Engine RPM		
Tractor		1900
Scraper		2200
Full Horsepower To		
Altitude:	ft.	5000
	(M)	(1500)
Capacity: Payload		
	ibs.	72000
	(kg)	(32700)
Struck:	yd^3	2L
	(m^3)	(16)
Heaped:	yd^3	30
	(m^3)	(23)
Tires:		
Tire Size – PR		
Drive		33.25x35-32
Rear		33.25x35-32
General Dimensions		
Length	ft.	44'9 1/2"
	(mm)	(13650)
Width	ft	12'6"
	(mm)	(3800)
Shipping Width	ft.	11'4"
	(mm)	(3450)
Height	ft.	12'10 1/2"
	(mm)	(3900)
Model 637 With Cushion Hitch		
Wheelbase	-ft.	27'5"
	-(mm)	(8350)
Tread Scraper	-ft.	7'9"
	-(mm)	(2360)
Width For Non-stop Turn Left/Right[a]	-ft.	47'11"/38'4"
	-(m)	(14.6/11.7)
Width of Cut	-ft.	10'10"
	-(mm)	(3300)
Weight Distribtuion[b]		
Empty Front	-lbs	–
	-(kg)	–
Drive	-lbs	56,700
	-(kg)	(25700)
Scraper	-lbs	33,500
	-(kg)	(15200)
Total	-lbs	90,200
	-(kg)	(40900)

continued

Table C-8. Continued

Percent Loaded:	
Tractor Front	—
Drive	51
Scraper	49

[a]Turns to left restricted by ROPS mountings.

[b]Weight is include ROPS case and frame.

Table C-9. Caterpillar 637 (ECC 4750/11) Scraper Performance Characteristics [26]

637 PUSHPULL MODEL – SELF LOADING

637 (415 & 225 HP) ESTIMATED HOURLY PRODUCTION IN BANK CUBIC YARDS (B C Y) & BANK CUBIC METERS (Bm³)

Total Effective Grade*		2%			6%			10%		
Approx. Total Resistance*		40 lb/Ton–(20 kg/t) Good			120 lb/Ton–(60 kg/t) Average			200 lb/Ton–(100 kg/t) Poor		
Haul Distance (One Way)		Cycle Time	Hourly Production		Cycle Time	Hourly Production		Cycle Time	Hourly Production	
FEET	METERS	MINUTES	B.C.Y.	(Bm³)	MINUTES	B.C.Y.	(Bm³)	MINUTES	B.C.Y.	(Bm³)
500	150	2.25	640	489	2.32	622	475	2.43	592	453
1000	300	2.62	550	420	2.78	519	397	3.05	471	360
1500	450	2.98	482	368	3.19	451	345	3.66	394	301
2000	600	3.33	433	331	3.62	398	304	4.27	338	258
2500	750	3.67	392	300	4.03	357	273	4.86	296	226
3000	900	4.01	359	274	4.45	324	248	5.45	264	202
3500	1050	4.36	330	252	4.87	296	226	6.04	238	182
4000	1200	4.70	306	234	5.28	273	209	6.63	217	166
4500	1350	5.04	285	218	5.70	253	193	7.22	199	152
5000	1500	5.39	267	204	6.11	235	180	7.81	184	141
5500	1700	5.73	251	192	6.53	221	169	8.41	171	131
6000	1850	6.07	237	181	6.95	207	158	9.00	160	122
6500	2000	6.42	224	171	7.36	196	150	9.59	150	115
7000	2150	6.76	213	163	7.78	185	141	10.18	141	108
7500	2300	7.10	203	155	8.19	176	135	10.77	134	102
8000	2450	7.45	193	148	8.61	167	128	11.36	127	97
8500	2600	7.79	185	141	9.02	160	122	11.95	120	92
9000	2750	8.13	177	135	9.44	153	117	12.54	115	88
9500	2900	8.48	170	130	9.85	146	112	13.13	110	84
10000	3050	8.82	163	125	10.26	140	107	13.72	105	80

*1% adverse grade = 20 lb/Ton (10 Kg/t)
Considerations
Tractor. 8 Speed Power Shift Transmission
Scraper. 4 Speed Power Shift Transmission
100% Efficiency (60 Min. Hour)

Scraper Payload
72000 lb. (32700 Kg.)
24 BCY (18.4 Bm³)
Empty Weight–95,500 lb. (43300 Kg.)

Included in Cycle Times
0.9 min. Load Time. 0.7 min. Maneuver & Spread
Accelerates from 2.5 MPH (4.0 Km/h)
Decelerates to 2.5 MPH (4.0 Km/h)

637 (415 & 225 HP) ESTIMATED HOURLY PRODUCTION IN BANK CUBIC YARDS (B C Y) & BANK CUBIC METERS (Bm³)

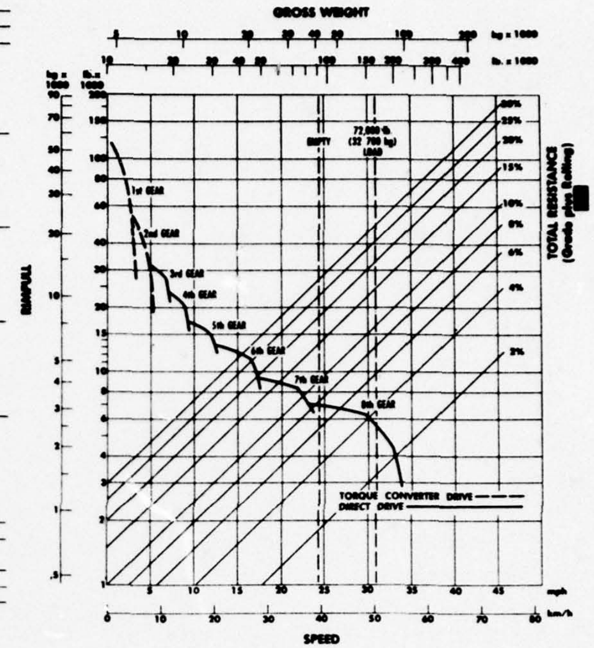
Total Effective Grade*		2%			6%			10%		
Approx. Total Resistance*		40 lb/Ton–(20 kg/t) Good			120 lb/Ton–(60 kg/t) Average			200 lb/Ton–(100 kg/t) Poor		
Haul Distance (One Way)		Cycle Time	Hourly Production		Cycle Time	Hourly Production		Cycle Time	Hourly Production	
FEET	METERS	MINUTES	B.C.Y.	(Bm³)	MINUTES	B.C.Y.	(Bm³)	MINUTES	B.C.Y.	(Bm³)
500	150	1.91	754	576	2.03	710	543	2.24	644	492
1000	300	2.31	622	475	2.59	555	424	3.11	463	354
1500	450	2.66	540	413	3.13	460	352	4.00	360	275
2000	600	3.00	480	367	3.66	394	301	4.87	295	225
2500	750	3.34	431	329	4.17	345	264	5.75	250	191
3000	900	3.67	393	300	4.68	308	235	6.63	217	166
3500	1050	3.99	361	276	5.19	277	212	7.50	192	147
4000	1200	4.32	333	255	5.70	252	193	8.38	172	131
4500	1350	4.65	310	237	6.22	232	177	9.26	156	119
5000	1500	4.98	289	221	6.73	214	164	10.13	142	109
5500	1700	5.30	271	207	7.24	199	152	11.01	131	100
6000	1850	5.63	256	196	7.75	186	142	11.88	121	92
6500	2000	5.96	242	185	8.26	174	133	12.76	113	86
7000	2150	6.29	229	175	8.77	164	125	13.64	106	81
7500	2300	6.62	218	167	9.28	155	118	14.51	99	76
8000	2450	6.95	207	158	9.80	147	112	15.39	94	72
8500	2600	7.27	198	151	10.31	140	107	16.27	89	68
9000	2750	7.60	189	144	10.82	133	102	17.14	84	64
9500	2900	7.93	182	139	11.33	127	97	18.02	80	61
10000	3050	8.26	174	133	11.84	122	93	18.89	76	58

*1% adverse grade = 20 lb/Ton (10 Kg/t)
Considerations: Pusher 1 D9G
Tractor. 8 Speed Power Shift Transmission
Scraper. 4 Speed Power Shift Transmission
100% Efficiency (60 Min. Hour)
Material: 3000 lb/Cu. Yd. (1780 Kg/m³)

Scraper Payload
72000 lb. (32700 Kg.)
24 BCY (18.4 Bm³)
Empty Weight–90,200 lb. (40900 Kg.)

Included in Cycle Times
0.6 min. Load Time. 0.6 min. Maneuver & Spread
Accelerates from 2.5 MPH (4.0 Km/h)
Decelerates to 2.5 MPH (4.0 Km/h)

637 RIMPULL CURVE



Typical Fixed Time

	Load Time (min)	Maneuver & Spread (min)
637 & One D9G	0.6	0.7

Table C-10. RAYGO 400 (ECC 4635) and RAYGO 600 Specifications [27]

		DYNAMIC 400	SUPER 600
PHYSICAL DIMENSIONS	Overall Length	16′ 11½″	17′ 0″
	Width	8′ 8″ (Shpg. 7′ 11″)	9′ 11¾″
	Height (including muffler)	7′ 2″	7′ 4″
	Shipping Weight (approx.)	17,900 lbs.	28,800 lbs.
	Drum Diameter	59″	60″
	Drum Length	84″	100″
	Turning Radius	16′ 10″	17′ 0″
	Wheelbase	9′ 0″	9′ 1½″
	Curb Clearance	15½″	16″
VIBRATION SYSTEM	Hydraulic Direct Drive (no belts, no chains)	Vibra-Drum	Vibra-Drum
	Dynamic Force	27,000 lbs.	45,000 lbs.
	Frequency	1100 to 1500 V.P.M.	1100 to 1500 V.P.M.
	Total Applied Force	44,900 lbs.	73,800 lbs.
PROPULSION SYSTEM	Traction Wheel Drive	"Dynapower" Hydrostatic Drive with "Torque Selector" Control	
	Controls	Single Lever for Forward-Reverse Travel Speed Control and Dynamic Braking	
	Steering System	Hydraulic Full-Power Steering – "Articulated" Type	
	Braking	1. Dynamic on Drive 2. Hydraulic Service in Wheels 3. Hand Parking	
	Speed	0-15 M.P.H	0-15 M.P.H.
	Tires (standard)	23.1 x 26 – 8 ply Flotation type	28.1 x 26 – 10 Ply Flotation type
POWER UNIT	Engine (Standard)	GM 3-53 Detroit Diesel 80 H.P. @ 2300 R.P.M.	GM 4-53/4 Valve Detroit Diesel 120 H.P. @ 2400 R.P.M.
	Electrical System	12-Volt	12-Volt
	Muffler	Donaldson Heavy Duty	Donaldson Heavy Duty
	Air Cleaner	Donaldson Heavy Duty Dry Type	Donaldson Heavy Duty Dry Type
	Fuel Tank	50 Gal.	50 Gal.
	Engine Disconnect Clutch	Yes	Yes
	Hour Meter	Yes	Yes
OPTIONS AND ACCESSORIES (available on special order at extra cost)	Tires – 20.5 x 25 – 12 Ply S.H. Rock Lug	No	Yes
	Driving Lights – Front and Rear	Yes	Yes
	Umbrella	Yes	Yes
	Cab with wiper	Yes	Yes
	Heater	Yes	Yes
	Air Conditioner	Yes	Yes

Table C-11. Galion Model T-500L (ECC 4420) Motor Grader Specifications [28].

BRIEF SPECIFICATIONS

Base weight (approx.)	27,800 lbs.
Engine: Detroit Diesel	155 h.p. (4-71-N)
IHC Diesel	160 h.p. (DT-466)
Speeds, 4 forward, 4 reverse	1.3 to 22.8 mph
Moldboard, hydraulic power shift	12" x 27" x 7/8"
Controls	Full hydraulic variable speed
Tires, front and rear	14.00 x 24, 10 ply, on 10" rims
Breaks	4-wheel hydraulic, self-adjusting, power-booster, mechanical parking
Steering	Hydraulic power booster
Torque converter and transmission	Hydraulic power-shift

Table C-12. John Deere Model JD644-A (ECC 4531) Loader Specifications [29].

OPERATING INFORMATION	BUCKET			
	General purpose	Loose materials	Light materials	Multi-purpose
Capacity, heaped, SAE	2-1/2 cu. yd. ($1.91 m^3$)	3 cu. yd. ($2.29 m^3$)	4-1/2 cu. yd. ($3.44 m^3$)	2-1/4 cu. yd. ($1.72 m^3$)
Capacity, struck, SAE	2.05 cu. yd. ($1.57 m^3$)	2.50 cu. yd. ($1.80 m^3$)	3.73 cu. yd. ($2.45 m^3$)	1.77 cu. yd. ($1.35 m^3$)
Bucket width	104.61 in. (2.65 m)	104.61 in. (2.65 m)	110.64 in. (2.80 m)	106 in. (2.69 m)
Bucket weight	1,867 lb. (847 kg)	2,025 lb. (918 kg)	2,480 lb. (1124 kg)	2,490 lb. (1129 kg)
* **Breakout force,** J732B SAE Standard	41,515 lb. (18831 kg)	34,975 lb. (15864 kg)	25,600 lb. (11612 kg)	36,500 lb. (16556 kg)
Pivot point to cutting edge	25.14 in. (639 mm)	29.69 in. (754 mm)	39.81 in. (1.01 m)	25.6 in. (650 mm)
Breakout force, J732C SAE Standard using bucket hinge pin as pivot point 4 in. (102 mm) behind cutting edge	23,945 lb. (10861 kg)	20,960 lb. (9507 kg)	16,125 lb. (7314 kg)	22,865 lb. (10371 kg)
Tipping load, straight	18,605 lb. (8439 kg)	18,425 lb. (8357 kg)	17,865 lb. (8103 kg)	17,700 lb. (8029 kg)
Tipping load, 35-deg. turn	16,710 lb. (7580 kg)	16,550 lb. (7507 kg)	16,040 lb. (7275 kg)	15,895 lb. (7210 kg)
Tipping load, 40-deg. full turn, SAE	16,155 lb. (7328 kg)	16,000 lb. (7257 kg)	15,510 lb. (7036 kg)	15,370 lb. (6972 kg)
Loader operating weight	25,220 lb. (11440 kg)	25,380 lb. (11512 kg)	25,835 lb. (11719 kg)	25,845 lb. (11723 kg)

* SAE Standard J732B has been superseded by J732C and is included for reference only.

Adjustments to operating weights and tipping loads (approx.):				
Add (+) or deduct (−) lb. (kg) as indicated for loader equipped with:	**Loader Operating Weight**	**Tipping Load, Straight**	**Tipping Load, 35-deg. turn**	**Tipping Load, 40-deg. full turn,** SAE
Roll-over protective structure w/canopy	+700 lb. (318 kg)	+630 lb. (286 kg)	+595 lb. (270 kg)	+580 lb. (263 kg)
Cab (includes roll-over protective structure)	+1,200 lb. (544 kg)	+1,080 lb. (490 kg)	+1,015 lb. (460 kg)	+1,000 lb. (454 kg)
One additional set of side counter-weights (total of two sets)	+750 lb. (340 kg)	+1,530 lb. (694 kg)	+1,330 lb. (603 kg)	+1,280 lb. (581 kg)
16-24, 12-ply-rating, rock grader tread tires w/1,304 lb. (592 kg) fluid in rear	−700 lb. (318 kg)	−630 lb. (286 kg)	−565 lb. (256 kg)	−545 lb. (247 kg)
17.5-25, 12-ply-rating, loader tread tires w/1,160 lb. (526 kg) fluid in rear	−1,015 lb. (460 kg)	−945 lb. (429 kg)	−850 lb. (386 kg)	−820 lb. (372 kg)

Table C-12. Continued

Horsepower (at 2,400 engine rpm):

	SAE	PS
Gross	141	143
Net	131	133

Net engine flywheel horsepower is for an engine equipped with fan, air cleaner, water pump, lubricating oil pump, fuel pump, alternator, and muffler. The gross engine horsepower is without fan. Gross and net flywheel horsepower ratings are under SAE standard conditions of 500-ft altitude and 85°F. temperature and DIN 70 020 (non-corrected). Engine maintains rated horsepower up to 10,000 feet (3,000 m) altitude.

Engine: John Deere Diesel, vertical 6-cylinder, valve-in-head, 4-stroke cycle—turbo-built with turbocharger

Bore and stroke .... 4.25 x 4.75 in. (108 x 121 mm)
Piston displacement .... 404 cu. in. (6620 cm)
Compression ratio .... 16.5 to 1
Governed speed range .... 800-2,600 rpm
Maximum torque @ 1,600 rpm .... 345 lb-ft (47,7 kg-m)
N.A.C.C. or A.M.A. (U.S. Tax) horsepower 43.3
Lubrication .... Pressure system with full-flow filter
Cooling .... Pressurized with thermostat and fixed bypass
Fan .... Blower-type
Air cleaner .... Dry type, dual element with restriction indicator
Electrical and starting system .... 12-volt with alternator

Transmission:

Twin-turbine torque converter with Power-Shift transmission (4 speeds forward—2 reverse).

Torque Multiplication Ratio .... 4.8 to 1

Differentials:

Front .... "No-Spin" type
Rear .... Standard

Drive Axles:

4-wheel drive with inboard-mounted planetary gears to each wheel. Front axle fixed. Rear axle oscillates 22-degree total. 15.3 in. (389 mm) vertical travel at center of tire.

Travel Speeds:

		mph	km/h
Forward:			
Low range:	1st and 2nd turbine	0 - 3.3	0 - 5,3
	2nd turbine	3.3 - 7	5,3 - 11,3
High range:	1st and 2nd turbine	0 - 12.6	0 - 20,2
	2nd turbine	12.6 - 23	20,2 - 37
Reverse:	1st and 2nd turbine	0 - 4.5	0 - 7,2
	2nd turbine	4.5 - 9.5	7,2 - 15,3

Shifting of turbines, within ranges, is automatic.

Brakes:

Service ... Power actuated, 4-wheel, inboard-mounted wet disk. Foot-operated by either right or left pedal.
Parking ... 10 x 1.5-in. (254 x 38 mm) expanding shoe type on transmission output shaft. Adjustable, hand operated with warning light on dash.

Steering:

Full power steering. Frame articulated 80 degrees by two hydraulic cylinders. Turning radius of 15 ft. 5 in. (4,70 m). Vehicle clearance circle is 35 ft. 8 in. (10,87 m).

Hydraulic Systems:

Loader functions system ... Live, transmission-driven, vane-type pump delivers 60 gpm (227 lpm) at 2,400 engine rpm and 2,250 psi (158,2 kg/cm2) relief-valve pressure setting.
Control .... Single-lever, double hydraulic system
Optional triple hydraulic system for fork or multi-purpose bucket.
Steering and brake systems ... Engine-driven, eight-piston, variable-displacement-type pump delivers 27 gpm (102 lpm) at 2,400 engine rpm and 2,000 psi (140,6 kg/cm2).

Tires:

16-24, 12-ply-rating, rock grader tread
17.5-25, 12-ply-rating, loader tread
20.5-25, 12-ply-rating, loader tread
20.5-25, 12-ply-rating, loader rock tread

Wheel Treads:

Front and rear (center-to-center) .... 80 in. (2,03 m)

Capacities:

	U.S.	Liters
Cooling system	9 gal.	34,1
Fuel tank	50 gal.	189,3
Crankcase and filter	17 qt.	16,1
Transmission case and filters	9.75 gal.	36,9
Front differential	6 gal.	22,7
Rear differential	6.5 gal.	24,6
Loader hydraulic sump	17.5 gal.	66,2

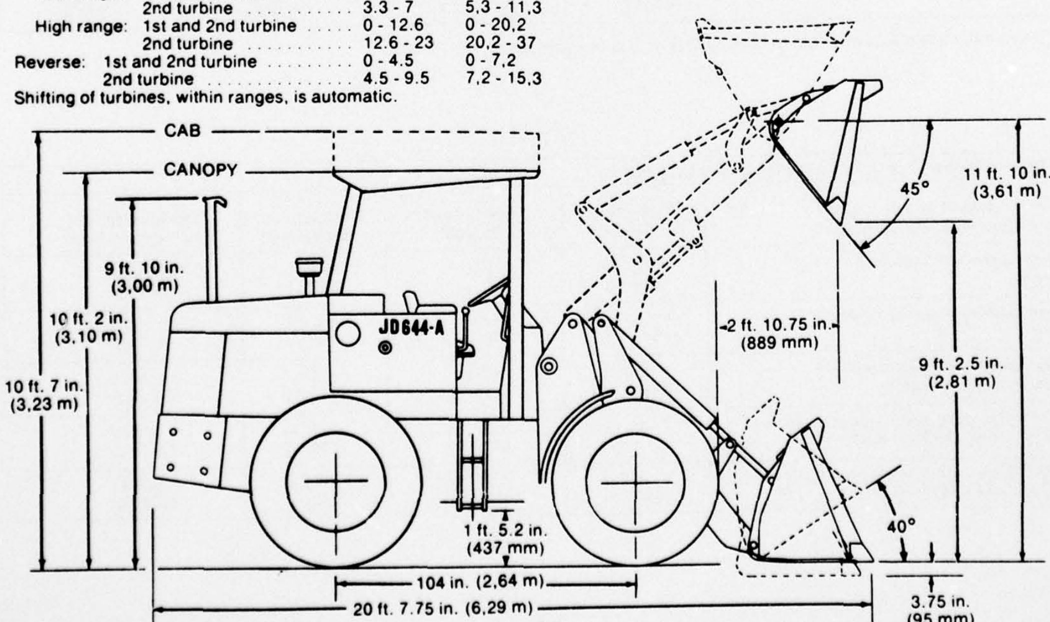


Table C-13. Caterpillar Model 977L (ECC 4530) Specifications [30].

Buckets (rated capacity)		2.5 to 3.25 cu. yd. (1.91 to 2.49 m³)		
Flywheel Horsepower		190 @ 1950 RPM		
Operating Weight (min)*		47,000 lb. (21 320 kg)		
Transmission		Single lever power shift, planetary		
Travel Speeds	forward mph (km/h)	2.15 (6.0)	3.75 (6.0)	5.8 (9.7)
	reverse mph (km/h)	2.60 (4.18)	4.54 (7.3)	7.0 (11.3)
Breakout Force		34,160 lb. (15 490 kg)		
Basic Static Tipping Load**		31,250 lb. (14 170 kg)		
Increase in static tipping load with:	counterweight	1670-3380 or 5140 lb. (650-1530 or 2320 kg)		
	ripper	8,050 lb. (3650 kg)		
Ground contact area		4,000 sq. in. (2.58 m²)		
Track frame		*7-roller non-oscillating*		
Width of standard shoe		18" (457 mm)		
Gauge		76" (1930 mm)		
Steering method		Pedal		
DIMENSIONS:				
A – Length of machine		13'3" (4040 mm)		
B – Overall length		19'4" (5890 mm)		
C – Height to top of ROPS		11'2" (3400 mm)		
D – Reach, max. lift @ 45°		4' (1220 mm)		
E – Dump height @ 45°		10'7" (3230 mm)		
F – Max. hinge pin height		13'2" (4010 mm)		
Bucket width (smallest)		98" (2490 mm)		
Specifications With Log Fork* **				
Operating weight with top clamp		42,792 lb. (19 410 kg)		
Overall length		21'1" (6350 mm)		
Tine spacing, to centers		7'6" (2290 mm)		
Maximum top clamp opening		9' (2750 mm)		
Minimum top clamp closure		39" (990 mm)		
Length of tines		54" (1370 mm)		

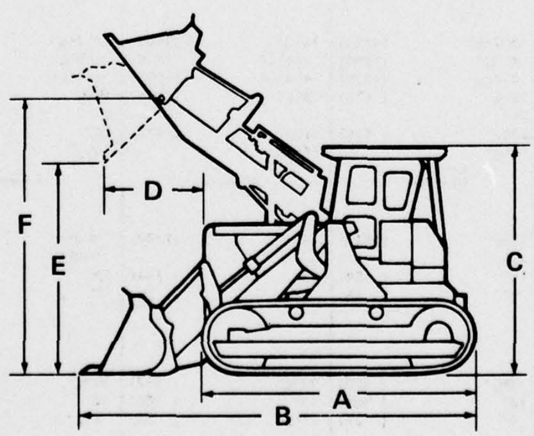
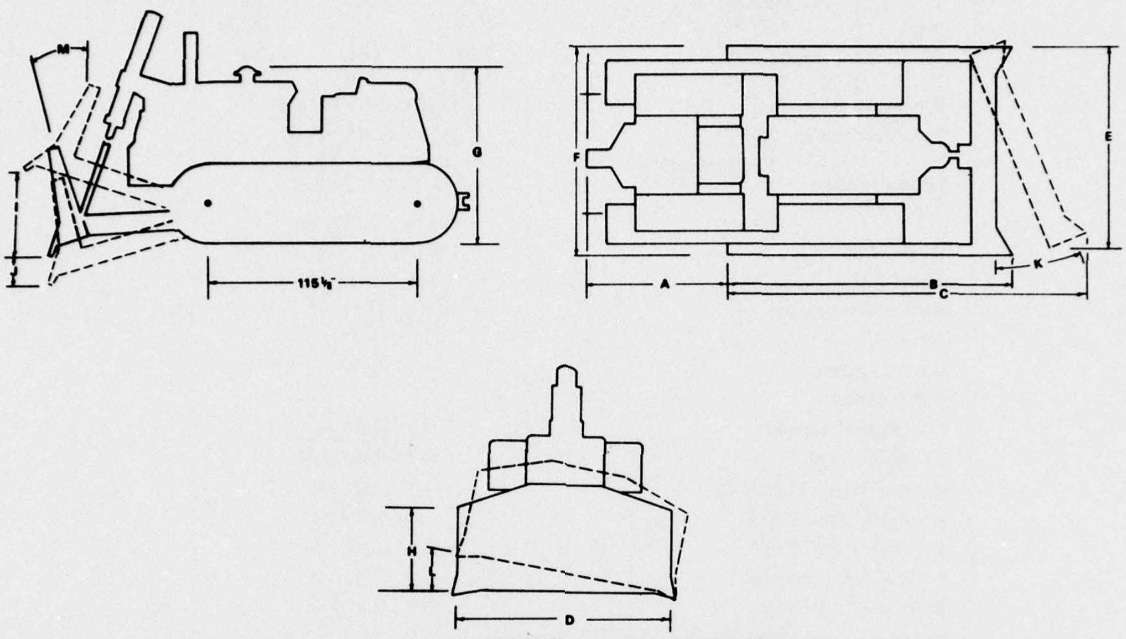


Table C-14. TEREX 82-30FA (TAM No. B-2462) Crawler Tractor Specifications [31].



BULLDOZERS FOR THE 82-30

	ANGLE	*(mm)	STRAIGHT	*(mm)	"U"	*(mm)	COAL "U"	*(mm)
Tractor Dimensions with Blade								
Trunnion to rear of tractor ....(A)	6'-3⅝"	(1921)	6'-3⅝"	(1921)	6'-3⅝"	(1921)	6'-3⅝"	(1921)
Trunnion to front of blade (Straight) ....(B)	14'-7"	(4285)	14'-6⅜"	(4283)	15'-7½"	(4591)	16'-4⅝"	(4994)
Trunnion to front of blade (Angled) ....(C)	17'-7¾"	(5201)	—	—	—	—	—	—
Width (Blade straight) ....(D)	15'-7⅜"	(4591)	12'-3"	(3665)	13'-2¾"	(3969)	17'-1"	(5207)
Width (Blade angled) ....(E)	14'-1¾"	(4272)	—	—	—	—	—	—
Width of C-Frame Only ....(F)	11'-9"	(3376)	—	—	—	—	—	—
Height (Same as bare tractor) ....(G)	7'-11¾"	(2432)	7'-11¾"	(2432)	7'-11¾"	(2432)	7'-11¾"	(2432)
Moldboard Dimensions								
Material—High Strength Carbon Alloy Abrasion Resistant Steel								
Length (Corner bit to corner bit) ....(D)	15'-7⅜"	(4591)	12'-3"	(3665)	13'-2¾"	(3969)	17'-1"	(5207)
Height ....(H)	4'-⅝"	(1235)	4'-6¼"	(1378)	4'-6¼"	(1378)	5'-1⅜"	(1559)
Max. Lift Above Ground (Hydraulic) ....(I)	4'-4¼"	(1230)	4'-4½"	(1334)	4'-4½"	(1334)	4'-7¾"	(1416)
Max. Drop Below Ground (Hydraulic) ....(J)	22¾"	(578)	19⅝"	(499)	19⅝"	(499)	22½"	(572)
Max. Angle (Either direction) ....(K)	25°	—	—	—	—	—	—	—
Max. Tilt ....(L)	22¾"	(578)	18½"	(470)	20"	(508)	25½"	(648)
Max. Pitch ....(M)	14½°	—	14½°	—	14½°	—	14½°	—
Cutting Edge	(4-Piece)		(3-Piece)		(4-Piece)		(3-Piece)	
Material—High Strength Boron Alloy Abrasion Resistant Steel								
Length—Center Section	12'6"	(3810)	9'-1"	(2746)	5'-0"	(1524)	10'-¾"	(3067)
Length—Wing Section	—	—	—	—	1'-6¼"	(464)	4'-5⅜"	(1356)
Width	10"	(254)	10"	(254)	10"	(254)	10"	(254)
Thickness	1"	(25)	1"	(25)	1"	(25)	1"	(25)
Corner Bits								
Material—High Strength Boron Alloy Abrasion Resistant Steel								
Length	18⅝"	(473)	21¾"	(552)	21¾"	(552)	—	—
Width	12"	(305)	12"	(305)	12"	(305)	—	—
Thickness	1"	(25)	1¼"	(32)	1¼"	(32)	—	—
Max. Allowable Track Shoe Width	28"	(711)	28" **	(711)	28" **	(711)	28" **	(711)
Approximate Weight	9585 lbs.	(4348 kg.)	8295 lbs.	(3763 kg.)	9835 lbs.	(4461 kg.)	11,610 lbs.	(5266 kg.)

*Millimeters except where otherwise indicated.

**Limited to use with push beams having mechanical tilt struts.

Table C-14. Continued

ENGINE

General Motors 6-71N, 2 Cycle Diesel

Gross Vehicle HP @ 2100 RPM 239
Flywheel HP @ 2100 RPM 225

NOTE: Above ratings at sea level and 60° F. Gross Vehicle Horsepower rating includes standard engine equipment such as waterpump, fuel pump and lubricating oil pump. Flywheel Horsepower is the net horsepower after deductions from Gross Vehicle Horsepower for fan and alternator requirements.

Number of Cylinders 6
Bore and Stroke ....4¼" x 5" (108mm x 127mm)
Piston Displacement ....426 cu. in. (7,0 liters)
Fuel—Commercial Grades ....Diesel Fuel
Oil—MIL-L-2104B ....SAE 30
RPM Governed at Full Load 2100
Piston Speed ....1750 ft. per minute (53,340cm/min.)
Lubrication ....Full Pressure
Air Cleaners ....Dry Type
Fuel System ....General Motors
Speed Control ....Hand Throttle & Foot Decelerator

SPEEDS & TRANSMISSION RATIOS

	Max. Speeds Forward mph	Forward km/h	Reverse mph	Reverse km/h	Trans. Gear Ratios For-ward	Re-verse
Low	1.9	3.06	2.2	3.54	3.04:1	2.52:1
Intermed.	3.8	6.15	4.3	6.91	1.51:1	1.25:1
High	7.3	11.78	8.3	13.34	0.76:1	0.63.1

DIMENSIONS

Overall Length (187½ inches) ....15'- 7½" (4763mm)
Overall Width (102½ inches) ....8'- 6½" (2604mm)
Height (exclusive of exhaust stack) (95¾ inches) ....7'-11¾" (2432mm)
Minimum Ground Clearance ....17½" (445mm)
Height—Drawbar above Ground ....21⅝" (549mm)
Shipping Weight ....44,500 lbs. (20,185 kgs.)

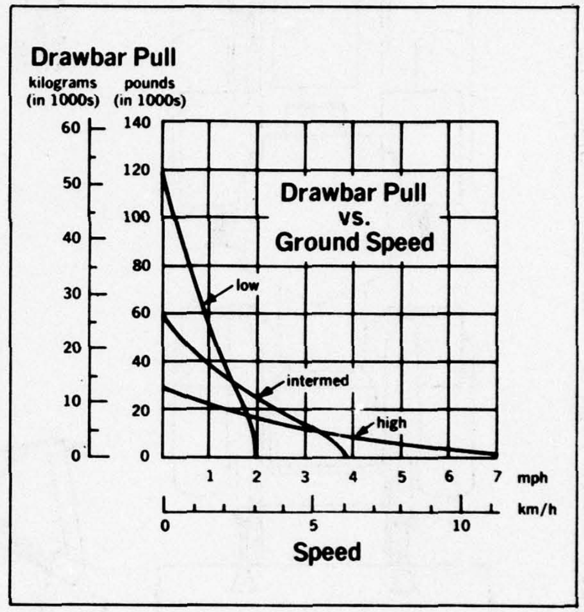
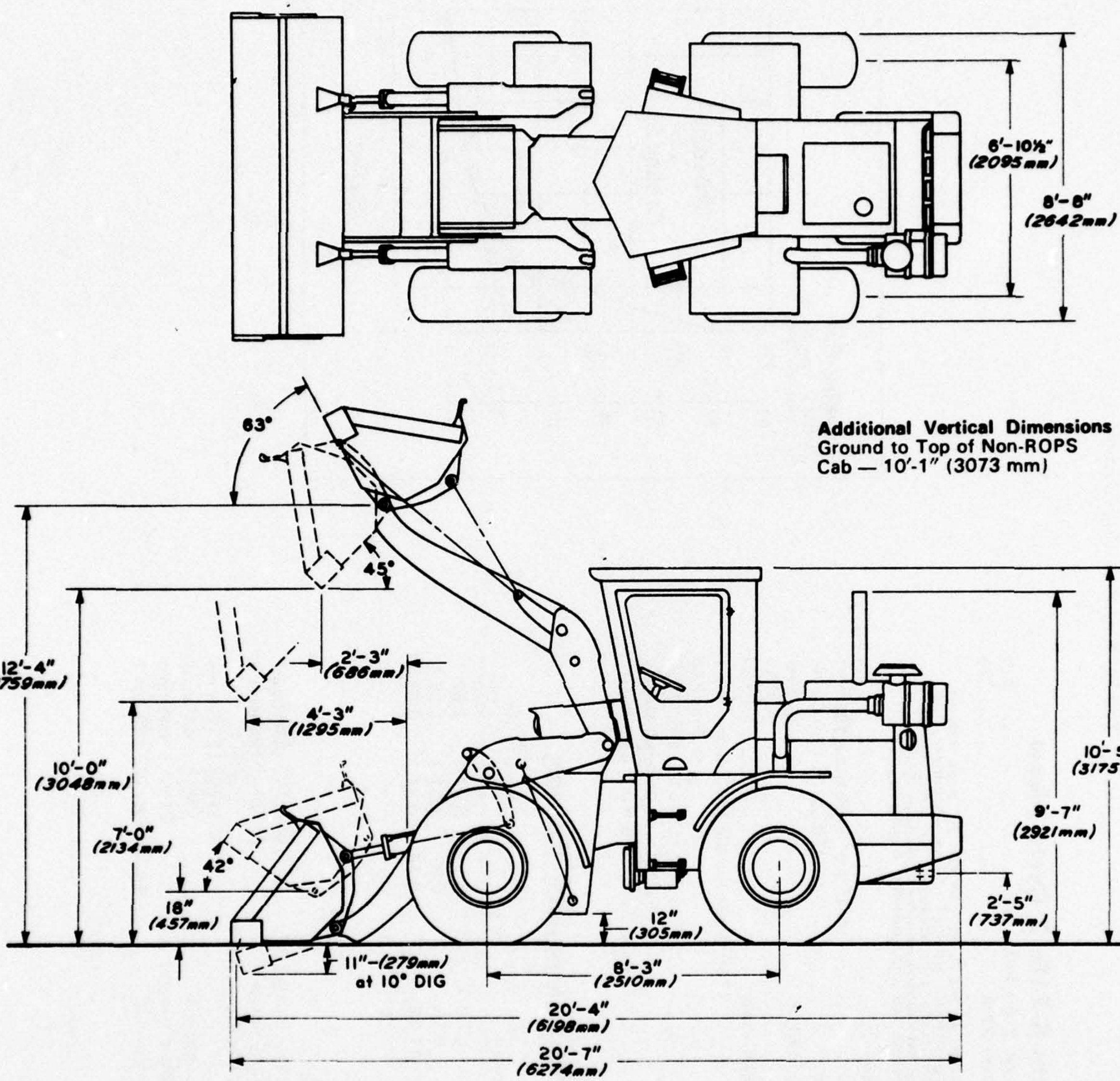


Table C-15. TEREX 72-31 (TAM No. B-2465) Loader Specifications [32].



NOTE: Unit shown with 2½ yd. G.P. bucket, 20.5 x 25 (12) L-2 tires, and TEREX ROPS cab.

Table C-15. Continued

Heaped Capacity (S.A.E.)	•2½ yd³ (1,91 m³) G.P.	•2¾ yd³ (2,10 m³) G.P.
Struck Capacity	2.12 yd³ (1,62 m³)	2.38 yd³ (1,82 m³)
Bucket Width	108" (2743 mm)	108" (2743 mm)
Bucket Weight	1640 lbs. (744 kg)	1720 lbs. (780 kg)
At Maximum Lift		
Dump Clearance @ 45°	10'-0" (3048 mm)	9'- 9" (2972 mm)
Reach to Tires @ 45°	2'-3" (686 mm)	2'- 6" (762 mm)
Spillboard Clearance	16'-0" (4877 mm)	16'- 0" (4877 mm)
Overall Length Carry	20'-7" (6274 mm)	20'-10" (6350 mm)
Overall Length on Ground	20'-4" (6198 mm)	20'- 8" (6299 mm)
Turning Radius Outside Bucket Corner	21'-3½" (6490 mm)	21'- 4" (6502 mm)
Breakout Force @ 4" From Cutting Edge	26,900 lbs. (12202 kg)	23,500 lbs. (10660 kg)
Static Tipping Load		
Straight Ahead	19,800 lbs. (8980 kg)	19,720 lbs. (8945 kg)
Full Turn	18,000 lbs. (8165 kg)	17,920 lbs. (8129 kg)
Operating Weight		
Front	11,292 lbs. (5122 kg)	11,422 lbs. (5181 kg)
Rear	16,808 lbs. (7624 kg)	16,758 lbs. (7601 kg)
Total	28,100 lbs. (12746 kg)	28,180 lbs. (12782 kg)

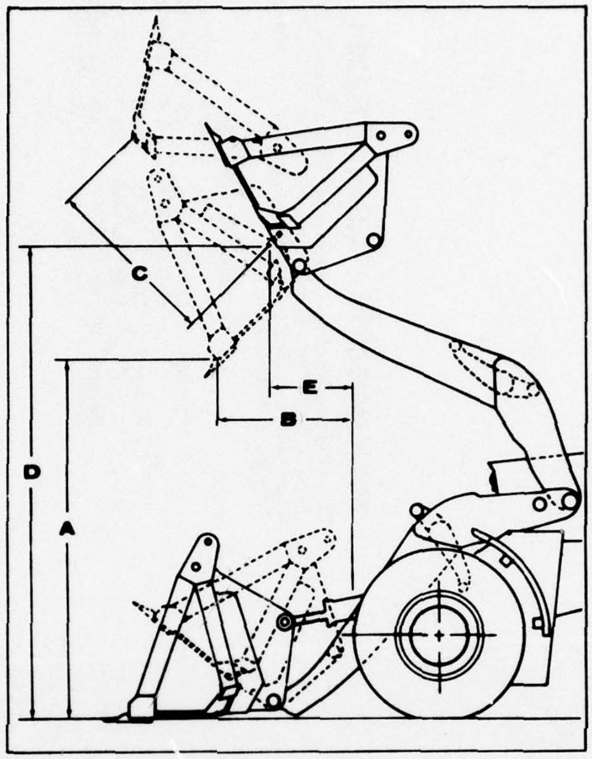
NOTE: For a bucket equipped with teeth reduce dump clearance by 5" (127 mm)
Other Special Buckets Available.

TRANSMISSION—Allison TT-2221

2 speeds forward and 1 reverse. Single lever full powershift control. Shift from first turbine to second turbine is automatic upon demand. Soft-shift feature for full powershift between forward and reverse.

VEHICLE SPEEDS

		MPH	(km/h)
Forward 1:	Low Turbine	2.7	(4,34)
	High Turbine	5.4	(8,69)
Forward 2:	Low Turbine	10.8	(17,38)
	High Turbine	20.6	(33,15)
Reverse 1:	Low Turbine	3.7	(5,95)
	High Turbine	7.4	(11,91)



			*(mm)
Bucket			
	S.A.E. Rated Capacity (cu. yds.)	2½	
	Overall Width	106"	(2695)
	Max. Tiltback at Ground	41°	
	At Max. Lift:		
A.	Dump Clearance @ 45° Dump	9'-7"	(2921)
B.	Reach @ 45° Dump	3'-0"	(914)
	Max. Dump Angle	60°	
	Max. Tiltback	64°	
	Overall Operating Height	16'-6"	(5029)
Clam-Dozer			
C.	Max. Clam Opening	4'-5"	(1345)
	At Max. Lift with Clam Open and Cutting Edge @ 45°:		
D.	Dump Clearance	12'-2"	(3708)
E.	Reach	2'0"	(610)
	Height of Moldboard	4'-2"	(1270)

*Millimeters except where otherwise indicated.

Table C-16. MRS Model 100 (TAM No. B-2480) Wheeled Tractor Specifications.

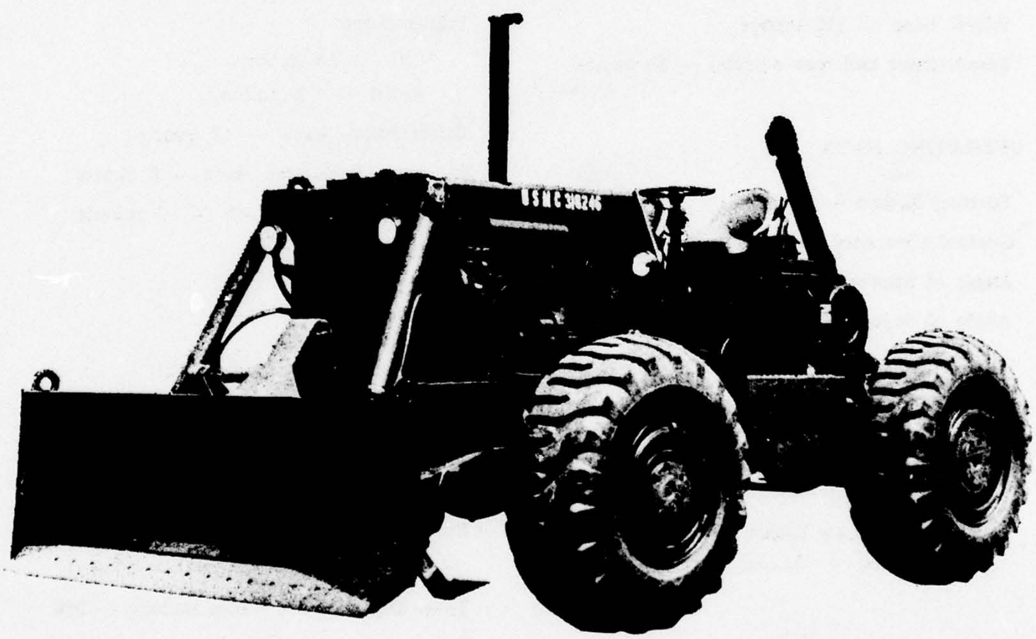
July 15, 1964
United States Marine Corps.

TRACTOR, WHEELED, INDUSTRIAL
MODEL 100 (4x4) MC
Pneumatic Tired, Diesel Engine Driven

FEDERAL STOCK NUMBER 2420-973-0019

	USA	USN	USAF	USMC
STATUS OR TYPE CLASSIFICATION				STD

Manufacturer: M-R-S Manufacturing Company (90407)



FUNCTIONAL DESCRIPTION:

1. The Model 100 (4x4) MC Tractor is designed for general purpose use as a prime mover, for light dozing, winching, towing, and in combination with a four-wheeled hydraulically operated scraper of approximately eight cubic yard capacity. It can be used in fording operations up to a depth of 5 feet (60 inches).

2. The tractor can be sectionalized to facilitate air transport by helicopter or relatively small airplane, then reassembled at point of use.

Table C-16. Continued

RELATION TO SIMILAR EQUIPMENT:

M-R-S Wheeled Tractor — Model 200 — Non-Sectionalized

TECHNICAL DESCRIPTION:

1. DIMENSIONS:

Length — 224 inches
Width (at dozer blade) — 108 inches
Height — 123 inches
Height, reduceable to — 88.5 inches
Weight — 24000 lbs.
Wheel Base — 112 inches
Tread (front and rear wheels) — 88 inches

2. OPERATING DATA

Turning Radius — 18 feet
Ground Clearance — 16.5 inches
Angle of approach — 24 degrees
Angle of departure — 53 degrees

Tractor Speeds:
1st Range — 3.2 M. P. H.
2nd Range — 10.0 M. P. H.
3rd Range — 29.0 M. P. H.

Available Tractive Effort:
(maximum) — 24,000 lbs.

3. TIE DOWN AND LIFTING DEVICES:

Front — Eyes welded to front of radiator guard

Rear — Eyes welded to main frame inboard of each rear tire.

4. APPROXIMATE CAPACITIES:

Fuel Tank -- 64 gallons
Cooling System — 12 gallons
Hydraulic Reservoir — 30 gallons
Engine Crankcase — 17 quarts
Engine Air Cleaner — 7 quarts
Transmission:
Fill — 7.5 gallons
Refill — 5.5 gallons
Differentials, each — 12 quarts
Planetary Reduction, each — 8 quarts
Steering Knuckles, each — 10 pounds
Winch — 3.5 gallons

5. ENGINE:

Make — Detroit Diesel (GMC)
Model — 4914 (Series 4-71)
Type — Diesel, 2-stroke cycle
Number of cylinders — 4
Bore and stroke — 4.25 x 5 inches
Compression Ratio (nominal) — 17 to 1
Total displacement (cubic inches) — 284
Firing order — 1-3-4-2
Number of main bearings — 5
Horsepower — 143
Maximum speed, no load, RPM — 2440
Maximum Torque (1600 RPM) ft. lbs. — 366

AD-A050 797 CIVIL ENGINEERING LAB (NAVY) PORT HUENEME CALIF F/G 13/2
EARTHWORK CONSTRUCTION IN SUPPORT OF A MARINE AMPHIBIOUS FORCE --ETC(U)
JAN 78 P S SPRINGSTON

UNCLASSIFIED CEL-TN-1514 NL

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Table C-17. MRS Model 100 (TAM No. B-1929) Towed Scraper Specifications.

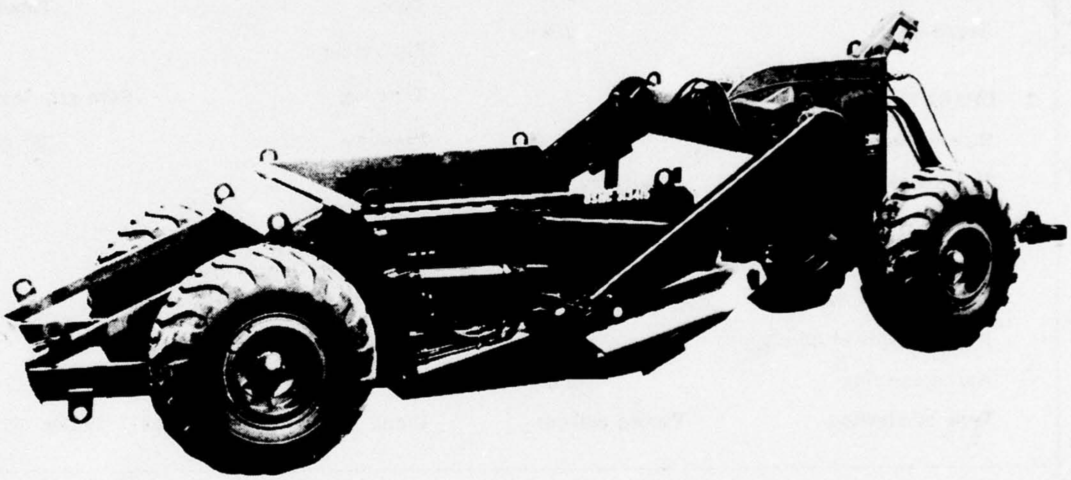
March 15, 1965
United States Marine Corps.

SCRAPER, EARTHMOVING, TOWED
MODEL MS100 (M-64)
4-Wheeled, Hydraulically Operated,
8 Cubic Yard Capacity

Federal Stock Number 3805-051-3139

	USA	USN	USAF	USMC
STATUS OR TYPE CLASSIFICATION				STD

Manufacturer: M-R-S Manufacturing Company (90407)



16,500 Pounds

FUNCTIONAL DESCRIPTION:

1. The Model MS100 (M-64) earthmoving scraper is a hydraulically operated, four wheel, towed unit capable of loading, hauling, dumping and spreading up to 10½ cubic yards of earth. It consists essentially of a body (with apron and ejector), a frame (yoke arm), a rear truck assembly, and a front axle and tongue assembly. It is equipped with a traction mast so it may be used to advantage with the weight transfer device incorporated on M-R-S Manufacturing Company tractors.
2. The scraper is equipped with rear wheel air operated brakes.
3. The scraper can be sectionalized to facilitate air transport by helicopter or relatively small airplane, then reassembled at point of use.

Table C-17. Continued

RELATION TO SIMILAR EQUIPMENT:

Scraper, Earthmoving, Towed, Model H-82 (M-62)

TECHNICAL DESCRIPTION:

1. **DIMENSIONS:**

Length overall	31' 6"
Width overall	9' 2"
Height overall	8' 9"
Cube	2527 cu. ft.
Weight	16,500 lbs.
Wheelbase	18' 4"
Tread (front)	5' 9"
Tread (rear)	7' 0"

2. **OPERATING DATA:**

Struck load capacity	8 cu. yd.
Heaped load capacity	10½ cu. yd.
Cutting width	8' 9"
Ground clearance	13"
Depth of cut (max.)	10"
Depth of spread (max.)	13"
Apron opening	5' 0"
Type of ejection	Forced roll-out

3. **BRAKES:**

Type — Air actuated (controlled from towing vehicle)

Brake shoe size — 17¼ x 4 inches

4. **TIRES:**

Size	20.5 x 25
Type	Tubeless
Ply rating	12
Type lug	Sure grip loader
Pressure	30 p.s.i.

5. **HYDRAULICS:**

Bowl lift cylinders (two) — 4 x 24⅞" double acting

Apron lift cylinders (two) — 4 x 17$\frac{5}{16}$" double acting

Dump cylinder (one) — 4 x 47" double acting

REFERENCE DATA AND LITERATURE:

TM-01023D-15, Technical Manual, Model MS100 (M-64) Scraper

SL-4-01023D, Repair Parts List, Model MS100 (M-64) Scraper

TM-01023C-15, Technical Manual, Model H-82 (M-62) Scraper

TM-04078A-15, Technical Manual, Model M-R-S 100-MC Tractor

TM-04075A-15, Technical Manual, Model TD-15-420-2/151/M-62 Tractor

TM-11275.1, Technical Manual, Maintenance of Engineer Equipment

TM-5-331, Technical Manual, Management and Utilization of Construction Equipment

Appendix D

TABLES OF NETWORK FILES, DESCRIPTIONS, AND SOLUTIONS

This Appendix contains input data and solutions for the arrow networks of the main text. The legends and definitions of abbreviations used in this Appendix are as follows:

NETWORK FILE LEGEND

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
20	1,	2,	4,	2,	2,	3,	2,	Typical Activity

(9)	(10)	(11)	(12)	(13)	
470	2,	4,	4,	Dozers (TD20U)	Typical Resource

(1) Computer line number.
(2) Beginning activity node number.
(3) Ending activity node number.
(4) Activity duration in 1/2 days.
(5) Resource identification number.
(6) Assigned quantity of resource number 2.
(7) Resource identification number.
(8) Assigned quantity of resource number 3.
(9) Computer line number.
(10) Resource identification number.
(11) Desired resource allocation level.
(12) Critical resource allocation level.
(13) Resource description.

DESCRIPTION FILE LEGEND

(1)	(2)	(3)	(4)
10	1	2	CLR A1 RDS

(1) Computer line number.
(2) Beginning activity node number.
(3) Ending activity node number.
(4) Activity description.

ABBREVIATIONS

AMSS SFG	Surface with Advanced Multipurpose Surfacing System
BRK DLVR MAT	Breakout and deliver matting
CLR	Clear
CLR PERIM	Clear perimeter
CLR RDS	Clear roads
CON FG	Continue final grading
CRG	Compacting and rough grading
CST BRMS	Construct berms
CST TAFDS BRMS	Construct TAFDS berms
DMY	Dummy
FG	Final grading
FIL	Fill
FILL TKS	Fill tanks
FIN CLR RVTS	Finish clearing revetments
FIN CST BRMS	Finish constructing berms
FIN CST RVT BRMS	Finish constructing revetment berms
FIN F	Finish filling
FIN FG	Finish final grading
FIN SF	Finish stripping and filling
FIN SHP RDS	Finish shaping roads
FIN STR	Finish stripping
INST TAFDS TKS	Install TAFDS fuel bladders
LAY MAT	Install matting
PALLET STG AREA	Pallet storage area
SHP	Shaping
ST CLR RVTS	Start clearing revetments
ST CST BRMS	Start constructing berms
ST CST RVT BRMS	Start constructing revetment berms
ST F	Start filling
ST FG	Start final grading

STR	Stripping
STR RDS	Strip roads
ST SF	Start stripping and filling
ST SHP RDS	Start shaping roads
ST STR	Start stripping
TRK LDG AREA	Truck loading area
TRP STG MAT	Transport and stage matting

Table D-1. EAF Network Description File

```
DESCB

10 1 2 CLR A1
20 1 59 TRP STG MAT
30 1 5 CLR A2
40 1 6 CLR A3
50 1 32 CLR A5
60 1 7 CLR A4
70 2 3 STR A1
80 3 59 BRK DLVR MAT
90 3 39 LAY MAT 3,6,12A
100 3 4 STF A1
110 3 8 CRG A1
120 4 10 ST FG A1
130 4 8 FN F A1
140 5 9 STR A2
150 6 15 STR A3
160 7 23 STR A4
170 8 10 DUMMY
180 8 13 CRG A2
190 8 9 DMY
200 9 11 ST F A2
210 9 12 CLR TAFDS U1
220 10 14 FIN FG A1
230 11 16 DMY
240 11 13 F FILL A2
250 12 27 CST TAFDS BRMS
260 12 24 CLR TAFDS U2,3
270 13 18 DMY
280 13 15 DMY
290 14 19 LAY MAT 1
300 14 16 DUMMY
310 15 21 CRG A3
320 15 17 ST F A3
330 16 18 ST FG A2
340 17 20 DMY
350 17 22 FIN F A3
360 18 20 FIN FG A2
370 19 39 LAY MAT 2
380 20 39 LAY MAT 4
390 20 26 ST FG A3
410 21 30 CRG A4
420 21 22 DMY
430 22 26 DMY
440 22 23 DMY
450 23 25 ST F A4
460 24 27 DMY
470 24 44 CLR A6
480 25 29 DMY
490 25 30 FIN F A4
500 26 28 FIN FG A3
510 27 36 INST TAFDS TKS
520 28 39 LAY MAT 7,5
530 28 29 DMY
540 29 33 ST FG A4
550 30 33 DMY
560 30 42 CRG A5
570 30 31 DMY
580 31 35 ST SF A5
590 32 31 DMY
600 32 40 CLR A7
610 33 34 FIN FG A4
620 34 39 LAY MAT 8,9,10
630 34 37 DMY
640 35 37 DMY
650 35 42 FIN SF A5
660 36 39 FILL TKS
670 37 38 ST FG A5
680 38 39 DMY
690 38 41 CON FG A5
700 39 59 LAY MAT 12B
710 40 50 STR A7
720 41 45 FIN FG A5
730 42 41 DMY
740 42 43 DMY
750 43 46 ST SF A6
760 43 51 CRG A6
770 44 43 DMY
780 44 45 CLR A8
790 45 47 ST FG A6
800 46 45 DMY
810 46 50 FIN SF A6
820 47 59 LAY MAT 13
830 47 49 CON FG A6
840 48 54 STR A8
850 49 53 FN FG A6
860 50 49 DMY
870 50 52 ST F A7
```

continued

Table D-1. Continued

```
880 51 50 DMY
890 51 54 CRG A7
900 52 53 DMY
910 52 54 FIN F A7
920 53 55 ST FG A7
930 53 59 LAY MAT 14
940 54 55 DMY
950 54 56 FILL A8
960 54 57 CRG A8
970 55 56 FIN FG A7
980 56 58 FG A8
990 56 59 LAY MAT 11
1000 57 56 DMY
1010 58 59 DMY
```

Table D-2. EAF (CASE 1) Network File

```
EAFNETA

10 1,2,3,2,2,3,2
20 1,59,58,7,1
30 1,5,2,2,2
40 1,6,2,2,2
50 1,32,11,3,2
60 1,7,2,2,2
70 2,3,2,1,6,3,1
80 3,59,34,7,2
90 3,39,10
100 3,4,2,1,6,3,1
110 3,8,6,4,1,5,1
120 4,10,6,4,1,5,1
130 4,8,6,1,6,3,1
140 5,9,2,2,2
150 6,15,3,2,2
160 7,23,3,2,2
170 8,10,0
180 8,13,3,4,1,5,1
190 3,9,0
200 9,11,1,1,6,3,1
210 9,12,2,2,2
220 10,14,1,4,1,5,1
230 11,16,0
240 11,13,2,1,6,3,1
250 12,27,7,1,1,4,1,6,1
260 12,24,5,2,2
270 13,18,0
280 13,15,0
290 14,19,1
300 14,16,0
310 15,21,2,4,1,5,1
320 15,17,1,1,6,3,1
330 16,18,2,4,1,5,1
340 17,20,0
350 17,22,2,1,6,3,1
360 18,20,1,4,1,5,1
370 19,39,5
380 20,39,4
390 20,26,2,4,1,5,1
410 21,30,3,4,1,5,1
420 21,22,0
430 22,26,0
440 22,23,0
450 23,25,1,1,6,3,1
460 24,27,0
470 24,44,11,2,2
480 25,29,0
490 25,30,3,1,6,3,1
500 26,28,1,4,1,5,1
510 27,36,2
520 28,39,6
530 28,29,0
540 29,33,3,4,1,5,1
550 30,33,0
560 30,42,9,4,1,5,1
470 30,31,0
580 31,35,2,1,6,3,1
590 32,31,0
600 32,40,3,2,2
610 33,34,1,4,1,5,1
620 34,39,2
630 34,37,0
640 35,37,0
650 35,42,10,1,6,3,2
660 36,39,2
670 37,38,2,4,1,5,1
680 38,39,0
690 38,41,4,4,1,5,1
700 39,59,14
710 40,50,3,2,2
720 41,45,2,4,1,5,1
730 42,41,0
740 42,43,0
750 43,46,2,1,6,3,2
760 43,51,12,4,1,5,1
770 44,43,0
780 44,48,3,3,2
790 45,47,2,4,1,5,1
800 46,45,0
810 46,50,12,1,6,3,2
820 47,59,16
830 47,49,6,4,1,5,1
840 48,54,3,3,2
850 49,53,2,4,1,5,1
860 50,49,0
870 50,52,1,1,6,3,1
```

continued

Table D-2. Continued

```
880 51,50,0
890 51,54,3,4,1,5,1
900 52,53,0
910 52,54,3,1,6,3,1
920 53,55,3,4,1,5,1
930 53,59,9
940 54,55,0
950 54,56,4,1,6,3,1
960 54,57,3,4,1,5,1
970 55,56,1,4,1,5,1
980 56,58,4,4,1,5,1
990 56,59,9
1000 57,56,0
1010 58,59,0
1030 1,6,6 SCRAPERS(MRSI110)
1040 2,4,4 DOZERS(TD20U)
1050 3,4,4 DOZERS(TD20A)
1060 4,4,8 GRADERS (GAL 500T)
1070 5,4,8 VIB ROLLERS(RAYGO 400)
1080 6,1,2 END LOADERS
1090 7,3,4 RT FORKLIFT
```

Table D-3. EAF (Case 1) Resource Usage, NRL

DESCRIPTION OF RECOURCE CODE:

RESOURCE NO. 1= SCRAPERS(MRS I110)
RESOURCE NO. 2= DOZERS(TD20U)
RESOURCE NO. 3= DOZERS(TD20A)
RESOURCE NO. 4= GRADERS(GAL 500T)
RESOURCE NO. 5= VIB ROLLERS(RAYGO 40)
RESOURCE NO. 6= END LOADERS
RESOURCE NO. 7= RT FORKLIFT

RESOURCE	1	2	3	4	5	6	7
DESIRED LIMIT	6	4	4	4	4	1	3
CRITICAL LIMIT	7	8	4	8	8	2	4

CRITICAL LIMITS ARE CHANGED

USAGE VS TIME:

1 PERIOD	0	8	4	0	0	0	1
2 PERIOD	0	8	4	0	0	0	1
3 PERIOD	0	8	4	0	0	0	1
4 PERIOD	6	6	3	0	0	0	1
5 PERIOD	6	4	3	0	0	0	1
6 PERIOD	6	0	3	1	1	0	3
7 PERIOD	6	0	3	1	1	0	3
8 PERIOD	6	0	3	2	2	0	3
9 PERIOD	6	0	3	2	2	0	3
10 PERIOD	6	0	3	2	2	0	3
11 PERIOD	6	0	3	2	2	0	3
12 PERIOD	6	2	1	1	1	0	3
13 PERIOD	6	2	1	1	1	0	3
14 PERIOD	6	4	1	2	2	0	3
15 PERIOD	6	4	1	2	2	0	3
16 PERIOD	7	4	1	3	2	1	3
17 PERIOD	7	4	1	3	2	1	3
18 PERIOD	7	2	1	3	2	1	3
19 PERIOD	7		1	3	2	1	3
20 PERIOD	7	2	1	3	2	1	3
21 PERIOD	7	2	1	3	2	1	3

continued

Table D-3. Continued

22 PERIOD	7	2	1	2	1	1	3
23 PERIOD	6	2	1	1	1	0	3
24 PERIOD	6	2	1	2	2	0	3
25 PERIOD	6		1	1	1	0	3
26 PERIOD	6	2	2	2	2	0	3
27 PERIOD	6	2	2	2	2	0	3
28 PERIOD	6	2	2	2	2	0	3
29 PERIOD	6	2	2	2	2	0	3
30 PERIOD	6	2	2	2	2	0	3
31 PERIOD	6	2	2	2	2	0	3
32 PERIOD	6	0	4	1	1	0	3
33 PERIOD	6	0	4	0	0	0	3
34 PERIOD	6	0	4	0	0	0	3
35 PERIOD	6	0	4	0	0	0	3
36 PERIOD	6	0	4	2	2	0	3
37 PERIOD	6	0	4	2	2	0	3
38 PERIOD	6	0	2	2	2	0	3
39 PERIOD	6	0	2	2	2	0	3
40 PERIOD	6	0	2	2	2	0	1
41 PERIOD	6	0	2	2	2	0	1
42 PERIOD	6	0	2	2	2	0	1
43 PERIOD	6	0	2	2	2	0	1
44 PERIOD	6	0	2	2	2	0	1
45 PERIOD	6	0	2	2	2	0	1
46 PERIOD	6	0	2	1	1	0	1
47 PERIOD	6	0	2	1	1	0	1
48 PERIOD	6	0	2	1	1	0	1
49 PERIOD	6	0	2	1	1	0	1
50 PERIOD	6	0	1	2	2	0	1
51 PERIOD	6	0	1	1	1	0	1
52 PERIOD	6	0	1	1	1	0	1
53 PERIOD	6	0	1	1	1	0	1
54 PERIOD	6	0	1	2	2	0	1
55 PERIOD	6	0	1	2	2	0	1
56 PERIOD	6	0	1	1	1	0	1
57 PERIOD	6	0	1	0	0	0	1
58 PERIOD	0	0	0	1	1	0	1
59 PERIOD	0	0	0	1	1	0	0
60 PERIOD	0	0	0	1	1	0	0
61 PERIOD	0	0	0	1	1	0	0
62 PERIOD	0	0	0	0	0	0	0
63 PERIOD	0	0	0	0	0	0	0
64 PERIOD	0	0	0	0	0	0	0
65 PERIOD	0	0	0	0	0	0	0
66 PERIOD	0	0	0	0	0	0	0

Table D-4. EAF (Case 1) Critical Path Solution, NRL

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	2	CLR A1	1	3	0
1	59	TRP STG MAT	1	58	8
1	5	CLR A2	1	2	9
1	6	CLR A3	1	2	11
1	32	CLR A5	1	11	12
1	7	CLR A4	1	2	14
2	3	STR A1	4	2	0
3	59	BRK DLVR MAT	6	34	27
3	39	LAY MAT 3,6,12A	6	10	37
3	4	STF A1	6	2	0
3	8	CRG A1	6	6	2
4	10	ST FG A1	8	6	11
4	8	FIN F A1	8	6	0
5	9	STR A2	3	2	9
6	15	STR A3	3	3	11
7	23	STR A4	3	3	14
8	10	DUMMY	14	0	11
8	13	CRG A2	14	3	0
8	9	DMY	14	0	0
9	11	ST F A2	14	1	0
9	12	CLR TAFDS U1	14	2	4
10	14	FIN FG A1	14	1	11
11	16	DMY	15	0	11
11	13	FIN F A2	15	2	0
12	27	CST TAFDS BRMS	16	7	26
12	24	CLR TAFDS 02,3	16	5	4
13	18	DMY	17	0	11
13	15	DMY	17	0	0
14	19	LAY MAT 1	15	1	32
14	16	DUMMY	15	0	11
15	21	CRG A3	17	2	1
15	17	ST F A3	17	1	0
16	18	ST FG A2	15	2	11
17	20	DMY	18	0	11
17	22	FIN F A3	18	2	0
18	20	FIN FG A2	17	1	11
19	39	LAY MAT 2	16	5	32
20	39	LAY MAT 4	18	4	31
20	26	ST FG A3	18	2	11
21	30	CRG A4	19	3	2
21	22	DMY	19	0	1
22	26	DMY	20	0	11
22	23	DMY	20	0	0

continued

Table D-4. Continued

23	25	ST F A4	20	1	0
24	27	DMY	21	0	28
24	44	CLR A6	21	11	4
25	29	DMY	21	0	11
25	30	FIN F A4	21	3	0
26	28	FIN FG A3	20	1	11
27	36	INST TAFDS TKS	23	2	26
28	39	LAY MAT 7,5	21	6	26
28	29	DMY	21	0	11
29	33	ST FG A4	21	3	11
30	33	DMY	24	0	11
30	42	CRG A5	24	9	3
30	31	DMY	24	0	0
31	35	ST SF A5	24	2	0
32	31	DMY	12	0	12
32	40	CLR A7	12	3	32
33	34	FIN FG A4	24	1	11
34	39	LAY MAT 8,9,10	25	2	26
34	37	DMY	25	0	11
35	37	DMY	26	0	10
35	42	FIN SF A5	26	10	0
36	39	FILL TKS	25	2	26
37	38	ST FG A5	26	2	10
38	39	DMY	28	0	25
38	41	CON FG A5	28	4	10
39	59	LAY MAT 12B	28	14	25
40	50	STR A7	15	3	32
41	45	FIN FG A5	36	2	6
42	41	DMY	36	0	6
42	43	DMY	36	0	0
43	46	ST SF A6	36	2	0
43	51	CRG A6	36	12	2
44	43	DMY	32	0	4
44	48	CLR A8	32	3	16
45	47	ST FG A6	38	2	6
46	45	DMY	38	0	6
46	50	FIN SF A6	38	12	0
47	59	LAY MAT 13	40	16	11
47	49	CON FG A6	40	6	6
48	54	STR A8	35	3	16
49	53	FN FG A6	50	2	2
50	49	DMY	50	0	2
50	52	ST F A7	50	1	0
51	50	DMY	48	0	2
51	54	CRG A7	48	3	3
52	53	DMY	51	0	3

continued

Table D-4. Continued

52	54	FIN F A7	51	3	0
53	55	ST FG A7	52	3	2
53	59	LAY MAT 14	52	9	6
54	55	DMY	54	0	3
54	56	FILL A8	54	4	0
54	57	CRG A8	54	3	1
55	56	FIN FG A7	55	1	2
56	58	FG A8	58	4	5
56	59	LAY MAT 11	58	9	0
57	56	DMY	57	0	1
58	59	DMY	62	0	5

TOTAL PROJECT DURATION= 66 PERIODS

Table D-5. EAF (Case 1) Resource Usage, RL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(MRS I110)
RESOURCE NO. 2= DOZERS(TD20U)
RESOURCE NO. 3= DOZERS(TD20A)
RESOURCE NO. 4= GRADERS(GAL 500T)
RESOURCE NO. 5= VIB ROLLERS(RAYGO 40)
RESOURCE NO. 6= END LOADERS
RESOURCE NO. 7= RT FORKLIFT

RESOURCE	1	2	3	4	5	6	7
DESIRED LIMIT	6	4	4	4	4	1	3
CRITICAL LIMIT	7	4	4	8	8	2	4

CRITICAL LIMITS ARE CHANGED

USAGE VS TIME:

1 PERIOD	0	4	4	0	0	0	1
2 PERIOD	0	4	4	0	0	0	1
3 PERIOD	0	4	4	0	0	0	1
4 PERIOD	6	2	3	0	0	0	1
5 PERIOD	6	2	3	0	0	0	1
6 PERIOD	6	2	3	1	1	0	3
7 PERIOD	6	4	3	1	1	0	3
8 PERIOD	6	4	3	2	2	0	3
9 PERIOD	6	4	3	2	2	0	3
10 PERIOD	6	2	3	2	2	0	3
11 PERIOD	6	2	3	2	2	0	3
12 PERIOD	6	2	1	1	1	0	3
13 PERIOD	6	2	1	1	1	0	3
14 PERIOD	6	4	1	2	2	0	3
15 PERIOD	6	4	1	2	2	0	3
16 PERIOD	6	4	1	2	2	0	3
17 PERIOD	6	4	1	2	2	0	3
18 PERIOD	6	2	1	2	2	0	3
19 PERIOD	6	2	1	2	2	0	3
20 PERIOD	6	2	1	2	2	0	3

continued

Table D-5. Continued

21 PERIOD	6	2	1	2	2	0	3
22 PERIOD	6	2	1	1	1	0	3
23 PERIOD	6	2	1	1	1	0	3
24 PERIOD	6	2	1	2	2	0	3
25 PERIOD	6	2	1	1	1	0	3
26 PERIOD	6	2	2	2	2	0	3
27 PERIOD	6	2	2	2	2	0	3
28 PERIOD	6	2	2	2	2	0	3
29 PERIOD	6	2	2	2	2	0	3
30 PERIOD	6	2	2	2	2	0	3
31 PERIOD	6	2	2	2	2	0	3
32 PERIOD	6	0	4	1	1	0	3
33 PERIOD	6	0	4	0	0	0	3
34 PERIOD	6	0	4	0	0	0	3
35 PERIOD	6	0	4	0	0	0	3
36 PERIOD	6	0	4	2	2	0	3
37 PERIOD	6	0	4	2	2	0	3
38 PERIOD	6	0	2	2	2	0	3
39 PERIOD	6	0	2	2	2	0	3
40 PERIOD	6	0	2	2	2	0	1
41 PERIOD	6	0	2	2	2	0	1
42 PERIOD	7	0	2	3	2	1	1
43 PERIOD	7	0	2	3	2	1	1
44 PERIOD	7	0	2	3	2	1	1
45 PERIOD	7	0	2	3	2	1	1
46 PERIOD	7	0	2	2	1	1	1
47 PERIOD	7	0	2	2	1	1	1
48 PERIOD	7	0	2	2	1	1	1
49 PERIOD	6	0	2	1	1	0	1
50 PERIOD	6	0	1	2	2	0	1
51 PERIOD	6	0	1	1	1	0	1
52 PERIOD	6	0	1	1	1	0	1
53 PERIOD	6	0	1	1	1	0	1
54 PERIOD	6	0	1	2	2	0	1
55 PERIOD	6	0	1	2	2	0	1
56 PERIOD	6	0	1	1	1	0	1
57 PERIOD	6	0	1	0	0	0	1
58 PERIOD	0	0	0	1	1	0	1
59 PERIOD	0	0	0	1	1	0	0
60 PERIOD	0	0	0	1	1	0	0
61 PERIOD	0	0	0	1	1	0	0
62 PERIOD	0	0	0	0	0	0	0
63 PERIOD	0	0	0	0	0	0	0
64 PERIOD	0	0	0	0	0	0	0
65 PERIOD	0	0	0	0	0	0	0
66 PERIOD	0	0	0	0	0	0	0

Table D-6. EAF (Case 1) Critical Path Solution, RL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	2	CLR A1	1	3	0
1	59	TRP STG MAT	1	58	8
1	5	CLR A2	6	2	0
1	6	CLR A3	7	2	0
1	32	CLR A5	1	11	0
1	7	CLR A4	1	2	0
2	3	STR A1	4	2	0
3	59	BRK DLVR MAT	6	34	27
3	39	LAY MAT 3,6,12A	6	10	37
3	4	ST F A1	6	2	0
3	8	CRG A1	6	6	2
4	10	ST FG A1	8	6	0
4	8	A1	8	6	0
5	9	STR A2	8	2	4
6	15	STR A3	9	3	5
7	23	STR A4	3	3	14
8	10	DUMMY	14	0	0
8	13	CRG A2	14	3	0
8	9	DMY	14	0	0
9	11	ST F A2	14	1	0
9	12	CLR TAFDS U1	14	2	0
10	14	FIN FG A1	14	1	0
11	16	DMY	15	0	0
11	13	FIN F A2	15	2	0
12	27	CST TAFDS BRMS	42	7	0
12	24	CLR TAFDS U2,3	16	5	0
13	18	DMY	17	0	0
13	15	DMY	17	0	0
14	19	LAY MAT 1	15	1	0
14	16	DUMMY	15	0	0
15	21	CRG A3	17	2	0
15	17	ST F A3	17	1	0
16	18	ST FG A2	15	2	0
17	20	DMY	18	0	0
17	22	FIN F A3	18	2	0
18	20	FIN FG A2	17	1	0
19	39	LAY MAT 2	16	5	32
20	39	LAY MAT 4	18	4	31
20	26	ST FG A3	18	2	0
21	30	CRG A4	19	3	2

continued

Table D-6. Continued

21	22 DMY	19	0	1
22	26 DMY	20	0	0
22	23 DMY	20	0	0
23	25 ST F A4	20	1	0
24	27 DMY	21	0	28
24	44 CLR A6	21	11	0
25	29 DMY	21	0	0
25	30 FIN F A4	21	3	0
26	28 FIN FG A3	20	1	0
27	36 INST TAFDS TKS	49	2	0
28	39 LAY MAT 7,5	21	6	26
28	29 DMY	21	0	0
29	33 ST FG A4	21	3	0
30	33 DMY	24	0	0
30	42 CRG A5	24	9	3
30	31 DMY	24	0	0
31	35 ST SF A5	24	2	0
32	31 DMY	12	0	12
32	40 CLR A7	12	3	0
33	34 FIN FG A4	24	1	0
34	39 LAY MAT 8,9,10	25	2	26
34	37 DMY	25	0	1
35	37 DMY	26	0	0
35	42 FIN SF A5	26	10	0
36	39 FILL TKS	51	2	0
37	38 ST FG A5	26	2	0
38	39 DMY	28	0	25
38	41 CON FG A5	28	4	4
39	59 LAY MAT 12B	53	14	0
40	50 STR A7	15	3	32
41	45 FIN FG A5	36	2	0
42	41 DMY	36	0	0
42	43 DMY	36	0	0
43	46 ST SF A6	36	2	0
43	51 CRG A6	36	12	0
44	43 DMY	32	0	4
44	48 CLR A8	32	3	0
45	47 ST FG A6	38	2	0
46	45 DMY	38	0	0
46	50 FIN SF A6	38	12	0
47	59 LAY MAT 13	40	16	11
47	49 CON FG A6	40	6	4
48	54 STR A8	35	3	16
49	53 FIN FG A6	50	2	0
50	49 DMY	50	0	0

continued

Table D-6. Continued

50	52	ST F A7	50	1	0
51	50	DMY	48	0	2
51	54	CRG A7	48	3	3
52	53	DMY	51	0	1
52	54	FIN F A7	51	3	0
53	55	ST FG A7	52	3	0
53	59	LAY MAT 14	52	9	6
54	55	DMY	54	0	1
54	56	FILL A8	54	4	0
54	57	CRG A8	54	3	0
55	56	FIN FG A7	55	1	2
56	58	FG A8	58	4	0
56	59	LAY MAT 11	58	9	0
57	56	DMY	57	0	1
58	59	DMY	62	0	5

TOTAL PROJECT DURATION= 66 PERIODS

Table D-7. EAF (Case 2) Network File

```
EAFNETB

10 1,2,1,2,4
20 1,59,30,6,1
30 1,5,2,2,1
40 1,6,2,2,1
50 1,32,4,2,2
60 1,7,2,2,1
70 2,3,1,1,6
80 3,59,26,6,2
90 3,39,10
100 3,4,1,1,6
110 3,8,5,3,2,4,2
120 4,10,1,3,2,4,2
130 4,8,3,1,6
140 5,9,1,2,2
150 6,15,2,2,1
160 7,23,3,2,1
170 8,10,0
180 8,13,2,3,2,4,2
190 8,9,0
200 9,11,1,1,6
210 9,12,2,2,1
220 10,14,4,3,2,4,2
230 11,16,0
240 11,13,1,1,6
250 12,27,7,3,1,5,1,7,1
260 12,24,4,2,1
270 13,18,0
280 13,15,0
290 14,19,1
300 14,16,0
310 15,21,2,3,2,4,2
320 15,17,1,1,6
330 16,18,1,3,2,4,2
340 17,20,0
350 17,22,1,1,6
350 18,20,1,3,2,4,2
370 19,39,5
380 20,39,4
390 20,26,1,3,2,4,2
410 21,30,2,3,2,4,2
420 21,22,0
430 22,26,0
440 22,23,0
450 23,25,1,1,6
460 24,27,0
470 24,44,5,2,2
480 25,30,1,1,6
490 25,30,1,1,6
500 26,28,1,3,2,4,2
510 27,36,2
520 28,39,6
530 28,29,0
540 23,33,2,3,2,4,2
550 30,33,0
560 3,42,5,3,2,4,2
570 30,31,0
580 31,35,2,1,6
590 32,31,0
600 32,40,2,2,1
610 33,34,1,3,2,4,2
620 34,39,2
630 34,37,0
640 35,37,0
650 35,42,6,1,6
660 36,39,2
670 37,38,2,3,2,4,2
680 38,39,0
690 38,41,3,3,2,4,2
700 39,59,14
710 40,50,2,2,1
720 41,45,1,3,2,4,2
730 42,41,0
740 42,43,0
750 43,46,1,1,6
760 43,51,6,3,2,4,2
770 44,43,0
780 44,48,2,2,1
790 45,47,1,3,2,4,2
800 46,45,0
810 46,50,6,1,6
820 47,59,16
830 47,49,5,3,2,4,2
840 48,54,2,2,1
850 49,53,1,3,2,4,2
860 50,49,0
870 50,52,1,1,6
```

continued

Table D-7. Continued

```
880 51,50,0
890 51,54,2,3,2,4,2
900 52,53,0
910 52,54,1,1,6
920 53,55,2,3,2,4,2
930 53,59,7
940 54,55,0
950 54,56,2,1,6
960 54,57,2,3,2,4,2
970 55,56,1,3,2,4,2
980 56,58,3,3,2,4,2
990 56,59,7
1000 57,56,0
1010 58,59,0
1030 1,6,6 SCRAPERS(CAT 637)
1040 2,3,6 DOZERS(CAT D8)
1050 3,4,6 GRADERS(GAL 500T)
1060 4,4,4 VIB ROLLERS(RAYGO400)
1070 5,1,2 END LOADERS
1080 6,3,4 RT FORKLIFT
1090 7,1,1 SCRAPER(MRS)
```

Table D-8. EAF (Case 2) Resource Usage, NRL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(CAT 637)
RESOURCE NO. 2= DOZERS(CAT D8)
RESOURCE NO. 3= GRADERS(GAL 500T)
RESOURCE NO. 4= VIB ROLLERS(RAYGO400
RESOURCE NO. 5= END LOADERS
RESOURCE NO. 6= RT FORKLIFT
RESOURCE NO. 7= SCRAPER(MRS)

RESOURCE	1	2	3	4	5	6	7
DESIRED LIMIT	6	3	4	4	1	3	1
CRITICAL LIMIT	6	9	6	4	2	4	1

CRITICAL LIMITS ARE CHANGED

USAGE VS TIME:

1 PERIOD	0	9	0	0	0	1	0
2 PERIOD	6	5	0	0	0	1	0
3 PERIOD	6	6	2	2	0	3	0
4 PERIOD	6	4	4	4	0	3	0
5 PERIOD	6	2	2	2	0	3	0
6 PERIOD	6	1	2	2	0	3	0
7 PERIOD	0	1	2	2	0	3	0
8 PERIOD	6	2	4	4	0	3	0
9 PERIOD	6	1	4	4	0	3	0
10 PERIOD	6	1	5	4	1	3	1
11 PERIOD	6	1	5	4	1	3	1
12 PERIOD	6	1	5	4	1	3	1
13 PERIOD	6	1	5	4	1	3	1
14 PERIOD	6	2	5	4	1	3	1
15 PERIOD	6	2	5	4	1	3	1
16 PERIOD	6	2	5	4	1	3	1
17 PERIOD	6	2	4	4	0	3	0
18 PERIOD	6	2	4	4	0	3	0
19 PERIOD	6	1	2	2	0	3	0
20 PERIOD	6	1	2	2	0	3	0

continued

Table D-8. Continued

21 PERIOD	6	1	2	2	0	3	0
22 PERIOD	6	1	4	4	0	3	0
23 PERIOD	6	0	4	4	0	3	0
24 PERIOD	6	0	4	4	0	3	0
25 PERIOD	6	0	4	4	0	3	0
26 PERIOD	6	0	4	4	0	3	0
27 PERIOD	6	0	4	4	0	3	0
28 PERIOD	6	0	4	4	0	3	0
29 PERIOD	6	0	4	4	0	1	0
30 PERIOD	6	0	2	2	0	1	0
31 PERIOD	6	0	4	4	0	0	0
32 PERIOD	6	0	4	4	0	0	0
33 PERIOD	0	0	2	2	0	0	0
34 PERIOD	0	0	2	2	0	0	0
35 PERIOD	0	0	2	2	0	0	0
36 PERIOD	0	0	2	2	0	0	0
37 PERIOD	0	0	2	2	0	0	0
38 PERIOD	0	0	0	0	0	0	0
39 PERIOD	0	0	0	0	0	0	0
40 PERIOD	0	0	0	0	0	0	0
41 PERIOD	0	0	0	0	0	0	0

Table D-9. EAF (Case 2) Critical Path Solution, NRL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	2	CLR A1	1	1	0
1	59	TRP STG MAT	1	30	11
1	5	CLR A2	1	2	6
1	6	CLR A3	1	2	7
1	32	CLR A5	1	4	11
1	7	CLR A4	1	2	8
2	3	STR A1	2	1	0
3	59	BRK DLVR MAT	3	26	13
3	39	LAY MAT 3,6,12A	3	10	15
3	4	ST F A1	3	1	1
3	8	CRG A1	3	5	0
4	10	ST FG A1	4	1	3
4	8	FIN F A1	4	3	1
5	9	STR A2	3	1	6
6	15	STR A3	3	2	7
7	23	STR A4	3	3	8
8	10	DUMMY	8	0	0
8	13	CRG A2	6	2	2
8	9	DMY	8	0	2
9	11	ST F A2	8	1	2
9	12	CLR TAFDS U1	8	2	5
10	14	FIN FG A1	8	4	0
11	16	DMY	9	0	3
11	13	FIN F A2	9	1	2
12	27	CST TAFDS BRMS	10	7	7
12	24	CLR TAFDS U2,3	10	4	5
13	18	DMY	10	0	3
13	15	DMY	10	0	2
14	19	LAY MAT 1	12	1	10
14	16	DUMMY	12	0	0
15	21	CRG A3	10	2	2
15	17	ST F A3	10	1	2
16	18	ST FG A2	12	1	0
17	20	DMY	11	0	3
17	22	FIN F A3	11	1	2
18	20	FIN FG A2	13	1	0
19	39	LAY MAT 2	13	5	10
20	39	LAY MAT 4	14	4	10
20	26	ST FG A3	14	1	0
21	30	CRG A4	12	2	2

continued

Table D-9. Continued

21	22	DMY	12	0	2
22	26	DMY	12	0	3
22	23	DMY	12	0	2
23	25	ST F A4	12	1	2
24	27	DMY	14	0	10
24	44	CLR A6	14	5	5
25	29	DMY	13	0	3
25	30	FIN F A4	13	1	2
26	28	FIN FG A3	15	1	0
27	36	INST TAFDS TKS	17	2	7
28	39	LAY MAT 7,5	16	6	6
28	29	DMY	16	0	0
29	33	ST FG A4	16	2	0
30	33	DMY	14	0	4
30	42	CRG A5	14	5	5
30	31	DMY	14	0	2
31	35	ST SF A5	14	2	2
32	31	DMY	5	0	11
32	40	CLR A7	5	2	22
33	34	FIN FG A4	18	1	0
34	39	LAY MAT 8,9,10	19	2	7
34	37	DMY	19	0	0
35	37	DMY	16	0	3
35	42	FIN SF A5	16	6	2
36	39	FILL TKS	19	2	7
37	38	ST FG A5	19	2	0
38	39	DMY	21	0	7
38	41	CON FG A5	21	3	0
39	59	LAY MAT 12B	22	14	6
40	50	STR A7	7	2	22
41	45	FIN FG A5	24	1	0
42	41	DMY	22	0	2
42	43	DMY	22	0	2
43	46	ST SF A6	22	1	2
43	51	CRG A6	22	6	3
44	43	DMY	19	0	5
44	48	CLR A8	19	2	10
45	47	ST FG A6	25	1	0
46	45	DMY	23	0	2
46	50	FIN SF A6	23	6	2
47	59	LAY MAT 13	26	16	0
47	49	CON FG A6	26	5	0
48	54	STR A8	21	2	10
49	53	FN FG A6	31	1	0
50	49	DMY	29	0	2

continued

Table D-9. Continued

50	52	ST F A7	29	1	2
51	50	DMY	28	0	3
51	54	CRG A7	28	2	3
52	53	DMY	30	0	2
52	54	FIN F A7	30	1	2
53	55	ST FG A7	32	2	0
53	59	LAY MAT 14	32	7	3
54	55	DMY	31	0	3
54	56	FILL A8	31	2	2
54	57	CRG A8	31	2	2
55	56	FIN FG A7	34	1	0
56	58	FG A8	35	3	4
56	59	LAY MAT 11	35	7	0
57	56	DMY	33	0	2
58	59	DMY	38	0	4

Table D-10. EAF (Case 2) Resource Usage, RL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(CAT 637)
RESOURCE NO. 2= DOZERS(CAT D8)
RESOURCE NO. 3= GRADERS(GAL 500T)
RESOURCE NO. 4= VIB ROLLERS(RAYGO400
RESOURCE NO. 5= END LOADERS
RESOURCE NO. 6= RT FORKLIFT
RESOURCE NO. 7= SCRAPER(MRS)

RESOURCE	1	2	3	4	5	6	7
DESIRED LIMIT	6	3	4	4	1	3	1
CRITICAL LIMIT	6	6	6	4	2	4	1
USAGE VS TIME:							
1 PERIOD	0	6	0	0	0	1	0
2 PERIOD	6	2	0	0	0	1	0
3 PERIOD	6	1	2	2	0	3	0
4 PERIOD	6	1	4	4	0	3	0
5 PERIOD	6	1	2	2	0	3	0
6 PERIOD	6	2	2	2	0	3	0
7 PERIOD	0	1	2	2	0	3	0
8 PERIOD	6	3	4	4	0	3	0
9 PERIOD	6	2	4	4	0	3	0
10 PERIOD	6	3	2	2	0	3	0
11 PERIOD	6	3	2	2	0	3	0
12 PERIOD	6	3	4	4	0	3	0
13 PERIOD	6	3	4	4	0	3	0
14 PERIOD	6	3	4	4	0	3	0
15 PERIOD	6	3	4	4	0	3	0
16 PERIOD	6	3	2	2	0	3	0
17 PERIOD	6	3	5	4	1	3	1
18 PERIOD	6	2	5	4	1	3	1
19 PERIOD	6	1	5	4	1	3	1
20 PERIOD	6	1	5	4	1	3	1
21 PERIOD	6	1	5	4	1	3	1

continued

Table D-10. Continued

22 PERIOD	6	1	5	4	1	3	1
23 PERIOD	6	0	5	4	1	3	1
24 PERIOD	6	0	4	4	0	3	0
25 PERIOD	6	0	4	4	0	3	0
26 PERIOD	6	0	4	4	0	3	0
27 PERIOD	6	0	4	4	0	3	0
28 PERIOD	6	0	4	4	0	3	0
29 PERIOD	6	0	4	4	0	1	0
30 PERIOD	6	0	2	2	0	1	0
31 PERIOD	6	0	4	4	0	0	0
32 PERIOD	6	0	4	4	0	0	0
33 PERIOD	0	0	2	2	0	0	0
34 PERIOD	0	0	2	2	0	0	0
35 PERIOD	0	0	2	2	0	0	0
36 PERIOD	0	0	2	2	0	0	0
37 PERIOD	0	0	2	2	0	0	0
38 PERIOD	0	0	0	0	0	0	0
39 PERIOD	0	0	0	0	0	0	0
40 PERIOD	0	0	0	0	0	0	0
41 PERIOD	0	0	0	0	0	0	0

Table D-11. EAF (Case 2) Critical Path Solution, RL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	2	CLR A1	1	1	0
1	59	TRP STG MAT	1	30	11
1	5	CLR A2	1	2	3
1	6	CLR A3	1	2	4
1	32	CLR A5	10	4	0
1	7	CLR A4	1	2	0
2	3	STR A1	2	1	0
3	59	BRK DLVR MAT	3	26	13
3	39	LAY MAT 3,6,12A	3	10	15
3	4	SF A1	3	1	0
3	8	CRG A1	3	5	0
4	10	ST FG A1	4	1	3
4	8	FIN F A1	4	3	1
5	9	STR A2	6	1	1
6	15	STR A3	7	2	1
7	23	STR A4	3	3	6
8	10	DUMMY	8	0	0
8	13	CRG A2	8	2	0
8	9	DMY	8	0	0
9	11	ST F A2	8	1	0
9	12	CLR TAFDS U1	8	2	0
10	14	FIN FG A1	8	4	0
11	16	DMY	9	0	3
11	13	FIN F A2	9	1	0
12	27	CST TAFDS BRMS	17	7	0
12	24	CLR TAFDS U2,3	10	4	0
13	18	DMY	10	0	3
13	15	DMY	10	0	0
14	19	LAY MAT 1	12	1	0
14	16	DUMMY	12	0	0
15	21	CRG A3	12	2	0
15	17	ST F A3	10	1	0
16	18	ST FG A2	12	1	0
17	20	DMY	11	0	3
17	22	FIN F A3	11	1	0
18	20	FIN FG A2	13	1	0
19	39	LAY MAT 2	13	5	10
20	39	LAY MAT 4	14	4	10
20	26	ST FG A3	14	1	0
21	30	CRG A4	14	2	-2

continued

Table D-11. Continued

21	22 DMY	14	0	-2
22	26 DMY	12	0	3
22	23 DMY	14	0	-2
23	25 ST F A4	12	1	0
24	27 DMY	14	0	10
24	44 CLR A6	14	5	0
25	29 DMY	13	0	3
25	30 FIN F A4	13	1	0
26	28 FIN FG A3	15	1	0
27	36 INST TAFDS TKS	24	2	0
28	39 LAY MAT 7,5	16	6	6
28	29 DMY	16	0	0
29	33 ST FG A4	16	2	0
30	33 DMY	14	0	4
30	42 CRG A5	17	5	0
30	31 DMY	16	0	-2
31	35 ST SF A5	14	2	0
32	31 DMY	14	0	0
32	40 CLR A7	14	2	0
33	34 FIN FG A4	18	1	0
34	39 LAY MAT 8,9,10	19	2	7
34	37 DMY	19	0	0
35	37 DMY	16	0	3
35	42 FIN SF A5	16	6	0
36	39 FILL TKS	26	2	0
37	38 ST FG A5	19	2	0
38	39 DMY	21	0	7
38	41 CON FG A5	21	3	0
39	59 LAY MAT 12B	28	14	0
40	50 STR A7	16	2	11
41	45 FIN FG A5	24	1	0
42	41 DMY	22	0	2
42	43 DMY	22	0	0
43	46 ST SF A6	22	1	0
43	51 CRG A6	22	6	0
44	43 DMY	19	0	3
44	48 CLR A8	19	2	0
45	47 ST FG A6	25	1	0
46	45 DMY	23	0	2
46	50 FIN SF A6	23	6	0
47	59 LAY MAT 13	26	16	0
47	49 CON FG A6	26	5	0
48	54 STR A8	21	2	8
49	53 FN FG A6	31	1	0
50	49 DMY	29	0	2

continued

Table D-11. Continued

50	52 ST F A7	29	1	0
51	50 DMY	28	0	1
51	54 CRG A7	28	2	1
52	53 DMY	30	0	2
52	54 FIN F A7	30	1	0
53	55 ST FG A7	32	2	0
53	59 LAY MAT 14	32	7	3
54	55 DMY	31	0	3
54	56 FILL A8	31	2	2
54	57 CRG A8	31	2	0
55	56 FIN FG A7	34	1	0
56	58 FG A8	35	3	0
56	59 LAY MAT 11	35	7	0
57	56 DMY	33	0	2
58	59 DMY	38	0	4

Table D-12. 5,000 ST ASP Network and Network Description Files

ASPDESCA

```
10 1 2 CLR A1 RDS
20 1 5 CLR A2 RDS
30 1 11 CLR A3 RDS
40 1 19 CLR A4 RDS
50 1 6 ST CLR A3 RVTS
60 1 7 ST CLR A1 RVTS
62 1 28 CLR PERIM
70 2 3 ST SHP A1 RDS
80 2 4 STR A1 RDS
90 3 8 FIN SHP A1 RDS
100 4 3 DMY
110 4 5 DMY
120 5 8 DMY
130 5 10 STR A2 RDS
140 6 12 FIN CLR A3 RVTS
150 6 13 ST CST A3 RVT BRMS
160 7 14 FIN CLR A1 RVTS
170 7 15 ST CST A1 RVT BRMS
180 8 9 ST SHP A2 RDS
190 9 16 FIN SHP A2 RDS
200 10 9 DMY
210 10 11 DMY
220 11 16 DMY
230 11 18 STR A3 RDS
240 12 20 ST CLR A4 RVTS
250 12 13 DMY
260 13 21 FIN CST A3 RVT BRMS
270 14 22 ST CLR A2 RVTS
280 14 15 DMY
290 15 23 FIN CST A1 RVT BRMS
300 16 17 ST SHP A3 RDS
310 17 24 FIN SHP A3 RDS
320 18 17 DMY
330 18 19 DMY
340 19 24 DMY
350 19 27 STR A4 RDS
360 20 25 FIN CLR A4 RVTS
370 20 21 DMY
380 21 25 ST CST A4 RVT BRMS
390 22 26 FIN CLR A2 RVTS
400 22 23 DMY
410 23 26 ST CST A2 RVT BRMS
420 24 27 ST SHP A4 RDS
430 25 28 FIN CST A4 RVT BRMS
440 26 28 FIN CST A2 RVT BRMS
450 27 28 FIN SHP A4 RDS
```

ASPNETA

```
10 1,2,4,2,2,3,2
20 1,5,3,2,2,3,2
30 1,11,7,2,2
40 1,19,7,2,2
50 1,6,2,2,2
60 1,7,2,3,2
62 1,28,15,7,3
70 2,3,2,3,1,5,1,6,1
80 2,4,6,1,4,3,1
90 3,8,1,3,1,5,1,6,1
100 4,3,0
110 4,5,0
120 5,8,0
130 5,10,3,1,6,3,2
140 6,12,1,2,2
150 6,13,3,1,1,4,2,5,1
160 7,14,1,3,2
170 7,15,3,1,1,4,2,5,1
180 8,9,2,3,1,5,1,6,1
190 9,16,1,3,1,5,1,6,1
200 10,9,0
210 10,11,0
220 11,16,0
230 11,18,4,1,6,3,2
240 12,20,2,2,2
250 12,13,0
260 13,21,1,1,1,4,2,5,1
270 14,22,2,3,2
280 14,15,0
290 15,23,1,1,1,4,2,5,1
200 16,17 2,3,1,5,1,6,1
310 17,24,1,3,1,5,1,6,1
320 18,17,0
330 18,19,0
340 19,24,0
350 19,27,4,1,6,3,2
360 20,25,1,2,2
370 20,21,0
380 21,25,3,1,1,4,2,5,1
```

continued

Table D-12. Continued

```
390 22,26,1,3,2
400 22,23,0
410 23,26,3,1,1,4,2,5,1
420 24,27,2,3,1,5,1,6,1
430 25,28,1,1,1,4,2,5,1
440 26,28,1,1,1,4,2,5,1
450 27,28,1,3,1,5,1,6,1
460 1,5,6 SCRAPERS(MRSI110)
470 2,4,4 DOZERS(TD20U)
480 3,4,4 DOZERS(TD20A)
490 4,4,6 END LOADER(2.25LCY)
500 5,3,6 GRADER(GAL500T)
510 6,1,4,VIB ROLLER(RAYGO400)
520 7,2,4 DOZERS(CAT D8)
```

Table D-13. 5,000-ST ASP Resource Usage, NRL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(MRSI110)
RESOURCE NO. 2= DOZERS(TD20U)
RESOURCE NO. 3= DOZERS(TD20A)
RESOURCE NO. 4= END LOADER(2.25LCY)
RESOURCE NO. 5= GRADER(GAL500T)
RESOURCE NO. 6= VIB ROLLER(RAYGO400)
RESOURCE NO. 7= DOZERS(CAT D8)

RESOURCE	1	2	3	4	5	6	7
DESIRED LIMIT	5	4	4	4	3	1	2
CRITICAL LIMIT	6	10	6	6	6	4	4

CRITICAL LIMITS ARE CHANGED

USAGE VS TIME:

1 PERIOD	0	10	6	0	0	0	3
2 PERIOD	0	10	6	0	0	0	3
3 PERIOD	2	10	6	4	2	0	3
4 PERIOD	2	8	4	4	2	0	3
5 PERIOD	6	6	4	4	3	1	3
6 PERIOD	6	6	4	4	3	1	3
7 PERIOD	6	4	1	4	2	0	3
8 PERIOD	6	0	1	4	2	0	3
9 PERIOD	6	0	1	4	2	0	3
10 PERIOD	6	0	1	4	2	0	3
11 PERIOD	6	0	3	0	1	1	3
12 PERIOD	6	0	3	0	1	1	3
13 PERIOD	6	0	3	0	1	1	3
14 PERIOD	6	0	3	0	1	1	3
15 PERIOD	6	0	3	0	1	1	3
16 PERIOD	6	0	3	0	1	1	0
17 PERIOD	6	0	2	0	0	0	0
18 PERIOD	6	0	3	0	1	1	0
19 PERIOD	6	0	3	0	1	1	0
20 PERIOD	6	0	3	0	1	1	0
21 PERIOD	6	0	2	0	0	0	0
22 PERIOD	0	0	1	0	1	1	0

Table D-14. 5,000-ST ASP Critical Path Solution, NRL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	2	CLR A1 RDS	1	4	0
1	5	CLR A2 RDS	1	3	7
1	11	CLR A3 RDS	1	7	6
1	19	CLR A4 RDS	1	7	10
1	6	ST CLR A3 RVTS	1	2	12
1	7	ST CLR A1 RVTS	1	2	12
1	28	CLR PERIM	1	15	7
2	3	ST SHP A1 RDS	5	2	6
2	4	STR A1 RDS	5	6	0
3	8	FIN SHP A1 RDS	11	1	2
4	3	DMY	11	0	2
4	5	DMY	11	0	0
5	8	DMY	11	0	3
5	10	STR A2 RDS	11	3	0
6	12	FIN CLR A3 RVTS	3	1	13
6	13	ST CST A3 RVT BRMS	3	3	12
7	14	FIN CLR A1 RVTS	3	1	13
7	15	ST CST A1 RVT BRMS	3	3	12
8	9	ST SHP A2 RDS	12	2	2
9	16	FIN SHP A2 RDS	14	1	2
10	9	DMY	14	0	2
10	11	DMY	14	0	0
11	16	DMY	14	0	3
11	18	STR A3 RDS	14	4	0
12	20	ST CLR A4 RVTS	4	2	13
12	13	DMY	4	0	14
13	21	FIN CST A3 RVT BRMS	6	1	12
14	22	ST CLR A2 RVTS	4	2	13
14	15	DMY	4	0	14
15	23	FIN CST A1 RVT BRMS	6	1	12
16	17	ST SHP A3 RDS	15	2	2
17	24	FIN SHP A3 RDS	18	1	1
18	17	DMY	18	0	1
18	19	DMY	18	0	0
19	24	DMY	18	0	2
19	27	STR A4 RDS	18	4	0
20	25	FIN CLR A4 RVTS	6	1	15
20	21	DMY	6	0	13
21	25	ST CST A4 RVT BRMS	7	3	12
22	26	FIN CLR A2 RVTS	6	1	15

continued

Table D-14. Continued

22	23	DMY	6	0	13
23	26	ST CST A2 RVT BRMS	7	3	12
24	27	ST SHP A4 RDS	19	2	1
25	28	FIN CST A4 RVT BRMS	10	1	12
26	28	FIN CST A2 RVT BRMS	10	1	12
27	28	FIN SHP A4 RDS	22	1	0

TOTAL PROJECT DURATION= 22 PERIODS

Table D-15. 5,000-ST ASP Resource Usage, RL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(MRSI110)
RESOURCE NO. 2= DOZERS(TD20U)
RESOURCE NO. 3= DOZERS(TD20A)
RESOURCE NO. 4= END LOADERS(2.5LCY)
RESOURCE NO. 5= GRADERS(GAL 500T)
RESOURCE NO. 6= VIB ROLLERS(RAYGO400
RESOURCE NO. 7= DOZERS(CATD8)

RESOURCE	1	2	3	4	5	6	7
DESIRED LIMIT	5	4	4	4	3	1	4
CRITICAL LIMIT	7	4	4	6	6	4	4

CRITICAL LIMITS ARE CHANGED

USAGE VS TIME:

1 PERIOD	0	4	4	0	0	0	3
2 PERIOD	0	4	4	0	0	0	3
3 PERIOD	1	4	4	2	1	0	3
4 PERIOD	1	4	4	2	1	0	3
5 PERIOD	5	2	4	2	2	1	3
6 PERIOD	5	2	4	2	2	1	3
7 PERIOD	5	2	1	2	1	0	3
8 PERIOD	6	4	3	4	2	0	3
9 PERIOD	6	4	3	4	2	0	3
10 PERIOD	6	4	3	4	2	0	3
11 PERIOD	7	4	3	2	2	1	3
12 PERIOD	7	4	3	2	2	1	3
13 PERIOD	7	4	3	2	2	1	3
14 PERIOD	7	2	3	2	2	1	3
15 PERIOD	6	2	3	0	1	1	3
16 PERIOD	6	2	3	0	1	1	0
17 PERIOD	6	2	2	0	0	0	0
18 PERIOD	6	0	3	0	1	1	0
19 PERIOD	6	0	3	0	1	1	0
20 PERIOD	6	0	3	0	1	1	0
21 PERIOD	6	0	2	0	0	0	0
22 PERIOD	1	0	1	2	2	1	0

Table D-16. 5,000-ST ASP Critical Path Solution, RL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	2	CLR A1 RDS	1	4	0
1	5	CLR A2 RDS	8	3	0
1	11	CLR A3 RDS	7	7	0
1	19	CLR A4 RDS	11	7	0
1	6	ST CLR A3 RVTS	1	2	0
1	7	ST CLR A1 RVTS	1	2	0
1	28	CLR PERIM	1	15	7
2	3	ST SHP A1 RDS	5	2	4
2	4	STR A1 RDS	5	6	0
3	8	FIN SHP A1 RDS	11	1	0
4	3	DMY	11	0	0
4	5	DMY	11	0	0
5	8	DMY	11	0	1
5	10	STR A2 RDS	11	3	0
6	12	FIN CLR A3 RVTS	3	1	0
6	13	ST CST A3 RVT BRMS	3	3	0
7	14	FIN CLR A1 RVTS	3	1	0
7	15	ST CST A1 RVT BRMS	8	3	0
8	9	ST SHP A2 RDS	12	2	0
9	16	FIN SHP A2 RDS	14	1	0
10	9	DMY	14	0	0
10	11	DMY	14	0	0
11	16	DMY	14	0	1
11	18	STR A3 RDS	14	4	0
12	20	ST CLR A4 RVTS	4	2	0
12	13	DMY	4	0	2
13	21	FIN CST A3 RVT BRMS	6	1	0
14	22	ST CLR A2 RVTS	4	2	0
14	15	DMY	4	0	7
15	23	FIN CST A1 RVT BRMS	11	1	0
16	17	ST SHP A3 RDS	15	2	1
17	24	FIN SHP A3 RDS	18	1	0
18	17	DMY	18	0	0
18	19	DMY	18	0	0
19	24	DMY	18	0	1
19	27	STR A4 RDS	18	4	0
20	25	FIN CLR A4 RVTS	6	1	3
20	21	DMY	6	0	1
21	25	ST CST A4 RVT BRMS	7	3	0
22	26	FIN CLR A2 RVTS	6	1	15

continued

Table D-16. Continued

22	23	DMY	6	0	6
23	26	ST CST A2 RVT BRMS	12	3	7
24	27	ST SHP A4 RDS	19	2	1
25	28	FIN CST A4 RVT BRMS	10	1	12
26	28	FIN CST A2 RVT BRMS	22	1	0
27	28	FIN SHP A4 RDS	22	1	0

TOTAL PROJECT DURATION= 22 PERIODS

Table D-17. MSR Network and Network Description Files

MSRNET

```
10 1,12,11,2,4
20 1,3,6,2,4
30 1,3,3,1,6,3,2
40 2,3,4,1,6,3,2
50 2,5,2,3,1,4,1,5,1
60 3,4,2,1,6,3,2
70 4,6,3,1,6,3,2
80 4,5,0
90 5,8,4,3,1,4,1,5,1
100 5,19,9,4,1,6,2
110 6,7,2,1,6,3,2
120 7,8,0
130 7,9,2,1,6,3,2
140 8,11,3,3,1,4,1
150 8,19,10,4,1,6,2
160 9,10,2,1,6,3,2
170 10,13,7,1,6,3,2
180 10,11,0
190 11,15,6,3,1,4,1,5,1
200 12,16,9,2,4
210 12,13,0
220 13,14,2,1,6,3,2
230 14,16,8,1,6,3,2
240 14,15,0
250 15,18,7,3,1,4,1,5,1
260 16,17,2,1,6,3,2
270 17,19,6,1,6,3,2
280 17,18,0
290 18,19,6,3,1,4,1,5,1
300 1,6,6 SCRAPERS(MRSI110)
310 2,4,4 DOZERS(TD20U)
320 3,4,4 DOZERS(TD20A)
330 4,2,6 GRADERS(GAL500T)
340 5,1,4 VIB ROLLERS(RAYGO400)
350 6,4,6 AMSS LRU
```

MSRDESC

```
10 1 12 CLR MSR 3
20 1 3 CLR MSR2
30 1 2 ST STR MSR 1A
40 2 3 FIN STR MSR 1A
50 2 5 SHP MSR 1A
60 3 4 ST STR MSR2
70 4 6 FIN STR MSR 2
80 4 5 DMY
90 5 8 SHP MSR2
100 5 19 AMSS SFG MSR 1A
110 6 7 ST STR MSR 1B
120 7 8 DMY
130 7 9 FIN STR MSR 1B
140 8 11 SHP MSR 1B
150 8 19 AMSS SFG MSR2
160 9 10 ST STR MSR 1C
170 10 13 FIN STR MSR 1C
180 10 11 DMY
190 11 15 SHP MSR 1C
200 12 16 CLR MSR 4
210 12 13 DMY
220 13 14 ST STR MSR3
230 14 16 FIN STR MSR3
240 14 15 DMY
250 15 18 SHP MSR3
260 16 17 ST STR MSR4
270 17 19 FIN STR MSR4
280 17 18 DMY
290 18 19 SHP MSR4
```

Table D-18. MSR Resource Usage, NRL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(MRSI110)
RESOURCE NO. 2= DOZERS(TD20U)
RESOURCE NO. 3= DOZERS(TD20A)
RESOURCE NO. 4= GRADERS(GAL500T)
RESOURCE NO. 5= VIB ROLLERS(RAYGO400
RESOURCE NO. 6= AMSS LRU

RESOURCE	1	2	3	4	5	6
DESIRED LIMIT	6	4	4	2	1	4
CRITICAL LIMIT	6	8	4	6	4	6

CRITICAL LIMITS ARE CHANGED

USAGE VS TIME:

1 PERIOD	6	8	2	0	0	0
2 PERIOD	6	8	2	0	0	0
3 PERIOD	6	8	3	1	1	0
4 PERIOD	6	8	3	1	1	0
5 PERIOD	6	8	2	0	0	0
6 PERIOD	6	8	2	0	0	0
7 PERIOD	6	4	2	0	0	0
8 PERIOD	6	4	2	0	0	0
9 PERIOD	6	4	3	2	1	2
10 PERIOD	6	4	3	2	1	2
11 PERIOD	6	4	3	2	1	2
12 PERIOD	6	4	3	2	1	2
13 PERIOD	6	4	2	1	0	2
14 PERIOD	6	4	3	3	0	4
15 PERIOD	6	4	3	3	0	4
16 PERIOD	6	4	3	3	0	4
17 PERIOD	6	4	2	2	0	4
18 PERIOD	6	4	3	2	1	2
19 PERIOD	6	4	3	2	1	2
20 PERIOD	6	4	3	2	1	2
21 PERIOD	6	0	3	2	1	2

continued

Table D-18. Continued

22 PERIOD	6	0	3	2	1	2
23 PERIOD	6	0	3	2	1	2
24 PERIOD	6	0	2	0	0	0
25 PERIOD	6	0	2	0	0	0
26 PERIOD	6	0	2	0	0	0
27 PERIOD	6	0	3	1	1	0
28 PERIOD	6	0	3	1	1	0
29 PERIOD	6	0	3	1	1	0
30 PERIOD	6	0	3	1	1	0
31 PERIOD	6	0	3	1	1	0
32 PERIOD	6	0	3	1	1	0
33 PERIOD	6	0	3	1	1	0
34 PERIOD	6	0	2	0	0	0
35 PERIOD	6	0	2	0	0	0
36 PERIOD	6	0	2	0	0	0
37 PERIOD	6	0	3	1	1	0
38 PERIOD	6	0	3	1	1	0
39 PERIOD	6	0	3	1	1	0
40 PERIOD	6	0	3	1	1	0
41 PERIOD	6	0	3	1	1	0
42 PERIOD	6	0	3	1	1	0

Table D-19. MSR Critical Path Solution, NRL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	12	CLR MSR 3	1	11	13
1	3	CLR MSR2	1	6	0
1	2	ST STR MSR 1A	1	2	0
2	3	FIN STR MSR 1A	3	4	0
2	5	SHP MSR 1A	3	2	12
3	4	ST STR MSR2	7	2	0
4	6	FIN STR MSR 2	9	3	0
4	5	DMY	9	0	8
5	8	SHP MSR2	9	4	8
5	19	AMSS SFG MSR 1A	9	9	25
6	7	ST STR MSR 1B	12	2	0
7	8	DMY	14	0	7
7	9	FIN STR MSR 1B	14	2	0
8	11	SHP MSR 1B	14	3	7
8	19	AMSS SFG MSR2	14	10	19
9	10	ST STR MSR 1C	16	2	0
10	13	FIN STR MSR 1C	18	7	0
10	11	DMY	18	0	6
11	15	SHP MSR 1C	18	6	6
12	16	CLR MSR 4	12	9	14
12	13	DMY	12	0	13
13	14	ST STR MSR3	25	2	0
14	16	FIN STR MSR3	27	8	0
14	15	DMY	27	0	3
15	18	SHP MSR3	27	7	3
16	17	ST STR MSR4	35	2	0
17	19	FIN STR MSR4	37	6	0
17	18	DMY	37	0	0
18	19	SHP MSR4	37	6	0

TOTAL PROJECT DURATION= 42 PERIODS

Table D-20. MSR Resource Usage, RL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(MRSI110)
RESOURCE NO. 2= DOZERS(TD20U)
RESOURCE NO. 3= DOZERS(TD20A)
RESOURCE NO. 4= GRADERS(GAL500T)
RESOURCE NO. 5= VIB ROLLERS(RAYGO400
RESOURCE NO. 6= AMSS LRU

RESOURCE	1	2	3	4	5	6
DESIRED LIMIT	6	4	4	2	1	4
CRITICAL LIMIT	6	4	4	6	4	6

USAGE VS TIME:

1 PERIOD	6	4	2	0	0	0
2 PERIOD	6	4	2	0	0	0
3 PERIOD	6	4	3	1	1	0
4 PERIOD	6	4	3	1	1	0
5 PERIOD	6	4	2	0	0	0
6 PERIOD	6	4	2	0	0	0
7 PERIOD	6	0	2	0	0	0
8 PERIOD	6	0	2	0	0	0
9 PERIOD	6	0	3	2	1	2
10 PERIOD	6	0	3	2	1	2
11 PERIOD	6	0	3	2	1	2
12 PERIOD	6	0	3	2	1	2
13 PERIOD	6	0	2	1	0	2
14 PERIOD	6	4	3	3	0	4
15 PERIOD	6	4	3	3	0	4
16 PERIOD	6	4	3	3	0	4
17 PERIOD	6	4	2	2	0	4
18 PERIOD	6	4	3	2	1	2
19 PERIOD	6	4	3	2	1	2
20 PERIOD	6	4	3	2	1	2
21 PERIOD	6	4	3	2	1	2
22 PERIOD	6	4	3	2	1	2

continued

Table D-20. Continued

23 PERIOD	6	4	3	2	1	2
24 PERIOD	6	4	2	0	0	0
25 PERIOD	6	4	2	0	0	0
26 PERIOD	6	4	2	0	0	0
27 PERIOD	6	4	3	1	1	0
28 PERIOD	6	4	3	1	1	0
29 PERIOD	5	4	3	1	1	0
30 PERIOD	6	4	3	1	1	0
31 PERIOD	6	4	3	1	1	0
32 PERIOD	6	4	3	1	1	0
33 PERIOD	6	4	3	1	1	0
34 PERIOD	6	0	2	0	0	0
35 PERIOD	6	0	2	0	0	0
36 PERIOD	6	0	2	0	0	0
37 PERIOD	6	0	3	1	1	0
38 PERIOD	6	0	3	1	1	0
39 PERIOD	6	0	3	1	1	0
40 PERIOD	6	0	3	1	1	0
41 PERIOD	6	0	3	1	1	0
42 PERIOD	6	0	3	1	1	0

Table D-21. MSR Critical Path Solution, RL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	12	CLR MSR 3	14	11	0
1	3	CLR MSR2	1	6	0
1	2	ST STR MSR 1A	1	2	0
2	3	FIN STR MSR 1A	3	4	0
2	5	SHP MSR 1A	3	2	4
3	4	ST STR MSR2	7	2	0
4	6	FIN STR MSR 2	9	3	0
4	5	DMY	9	0	0
5	8	SHP MSR2	9	4	1
5	19	AMSS SFG MSR 1A	9	9	25
6	7	ST STR MSR 1B	12	2	0
7	8	DMY	14	0	0
7	9	FIN STR MSR 1B	14	2	0
8	11	SHP MSR 1B	14	3	1
8	19	AMSS SFG MSR2	14	10	19
9	10	ST STR MSR 1C	16	2	0
10	13	FIN STR MSR 1C	18	7	0
10	11	DMY	18	0	0
11	15	SHP MSR 1C	18	6	3
12	16	CLR MSR 4	25	9	1
12	13	DMY	25	0	0
13	14	ST STR MSR3	25	2	0
14	16	FIN STR MSR3	27	8	0
14	15	DMY	27	0	0
15	18	SHP MSR3	27	7	3
16	17	ST STR MSR4	35	2	0
17	19	FIN STR MSR4	37	6	0
17	18	DMY	37	0	0
18	19	SHP MSR4	37	6	0

TOTAL PROJECT DURATION= 42 PERIODS

Table D-22. POL Network and Network Description Files

POLNET

```
5 14,3
10 1,2,2,2,10
20 1,3,3,1,3,2,1,3,3
30 1,4,5,2,6
40 1,5,8,1,2,2,1,3,3
50 2,7,2,2,10
55 2,3,0
60 3,6,2,1,3,2,1,3,3
70 4,5,0
80 5,10,2,1,2,2,1,3,3
90 6,8,3,1,3,2,1,3,3
100 7,10,2,2,10
110 7,8,0
120 8,9,2,1,3,2,1,3,3
130 9,10,4,1,3,2,1,3,3
140 1,5,5 SCRAPER(TAMB1900)
150 2,18,36 DOZER(TAM B2462)
160 3,6,6 LOADER(TAM B2465)
```

POLDESC

```
10 1 2 CLR AAFS 1,2,3
20 1 3 ST BRM CST AAFS 1,2,3
30 1 4 CLR AAFS G1-4
40 1 5 ST BRM CST AAFS G1-4
50 2 7 CLR AAFS 4,5,6
55 2 3 DMY
60 3 6 FIN BRM CST AAFS 1,2,3
70 4 5 DMY
80 5 10 FIN BRM CST AAFS G1-4
90 6 8 ST BRM CST AAFS 4,5,6
100 7 10 CLR AAFS 7,8
110 7 8 DMY
120 8 9 FIN BRM CST AAFS 4,5,6
130 9 10 CST BRMS AAFS 7,8
```

Table D-23. POL Resource Usage, NRL and RL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPER(TAMB1900)
RESOURCE NO. 2= DOZER(TAM B2462)
RESOURCE NO. 3= LOADER(TAM B2465)

RESOURCE	1	2	3
DESIRED LIMIT	5	18	6
CRITICAL LIMIT	5	36	6
USAGE VS TIME:			
1 PERIOD	5	18	6
2 PERIOD	5	18	6
3 PERIOD	5	18	6
4 PERIOD	5	18	6
5 PERIOD	5	18	6
6 PERIOD	5	12	6
7 PERIOD	5	2	6
8 PERIOD	5	2	6
9 PERIOD	5	2	6
10 PERIOD	5	2	6
11 PERIOD	3	1	3
12 PERIOD	3	1	3
13 PERIOD	3	1	3
14 PERIOD	3	1	3

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	2	CLR AAFS 1,2,3	1	2	1
1	3	ST BRM CST AAFS 1,2,3	1	3	0
1	4	CLR AAFS G1-4	1	5	7
1	5	ST BRM CST AAFS G1-4	1	8	4

continued

Table D-23. Continued

2	7	CLR AAFS 4,5,6	3	2	4
2	3	DMY	3	0	1
3	6	FIN BRM CST AAFS 1,2,3	4	2	0
4	5	DMY	6	0	7
5	10	FIN BRM CST AAFS G1-4	9	2	4
6	8	ST BRM CST AAFS 4,5,6	6	3	0
7	10	CLR AAFS 7,8	5	2	8
7	8	DMY	5	0	4
8	9	FIN BRM CST AAFS 4,5,6	9	2	0
9	10	CST BRMS AAFS 7,8	11	4	0

TOTAL PROJECT DURATION= 14 PERIODS

Table D-24. LSA Network and Network Description Files

```
LSANET

10 1,10,1,2,1
20 1,2,3,2,4
30 1,5,2,2,4
40 1,3,1,2,3
50 1,4,2,2,4
60 2,7,4,1,3,2,1
70 3,6,1,1,2,2,1
80 4,11,5,2,4
90 5,12,3,2,4
100 6,8,1,1,2,2,1
110 6,13,1,3,1,4,1
120 7,9,2,1,3,2,1
130 7,14,4,3,1,4,2
135 7,20,2,2,1
140 8,19,2,5,1
150 8,17,2,3,1,4,1
160 8,11,1,1,2,2,1
170 9,25,10,5,2
180 9,15,4,3,2,4,1
190 9,12,6,1,3,2,1
200 10,25,1,3,1,4,1
210 11,18,2,1,2,2,1
220 11,13,0
230 12,16,2,1,3,2,1
240 12,14,0
250 13,24,4,3,1,4,2
260 14,21,2,3,1,4,2
270 15,25,7,5,2
280 15,22,3,3,2,4,1
290 16,15,0
300 16,20,3,1,3,2,1
310 17,19,0
320 17,24,2,3,2,4,1
330 18,17,0
340 18,24,9,1,2,2,1
350 19,25,10,5,2
360 20,23,2,1,3,2,1
370 20,21,0
380 21,25,3,3,1,4,1
390 22,25,2,3,1,4,1
400 23,22,0
410 23,25,3,1,3,2,1
420 24,25,2,3,2,4,1
430 1,5,5 SCRAPERS(TAMB1900)
440 2,12,19 DOZERS(TAMB2462)
450 3,6,8 GRADERS(TAMB1080)
460 4,6,6 VIB ROLLERS
470 5,4,6 AMSS LRU
```

```
LSADESC

10 1 10 CLR PALLET STG AREA
20 1 2 CLR A1
30 1 5 CLR A2
40 1 3 CLR AA UA
50 1 4 CLR A3
60 2 7 STR A1
70 3 6 STR AA/UA
80 4 11 STR A3
90 5 12 STR A2
100 6 8 ST F AA/UA
110 6 13 CRG AA/UA
120 7 9 ST F A1
130 7 14 CRG A1
135 7 20 CLR TRK LDG AREA
140 8 19 AMSS SFG UA
150 8 17 FG AA/UA
160 8 11 FIN F AA/UA
170 9 25 AMSS SFG A1
180 9 15 FG A1
190 9 12 FIN F A1
200 10 25 FG PALLET STG AREA
210 11 18 ST F A3
220 11 13 DMY
230 12 16 ST F A2
240 12 14 DMY
250 13 24 CRG A3
260 14 21 CRG A2
270 15 25 AMSS SFG A2
280 15 22 FG A2
290 16 15 DMY
300 16 20 FIN F A2
310 17 19 DMY
320 17 24 ST FG A3
330 18 17 DMY
340 18 24 FIN F A3
350 19 25 AMSS SFG A3
360 20 23 ST F TRK LDG AREA
370 20 21 DMY
380 21 25 CRG TRK LDG AREA
390 22 25 FG TRK LDG AREA
400 23 22 DMY
410 23 25 FIN F TRK LDG AREA
420 24 25 FIN FG A3
```

Table D-25. LSA Resource Usage, NRL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(TAMB1900)
RESOURCE NO. 2= DOZERS(TAMB2462)
RESOURCE NO. 3= GRADERS(TAMB1080)
RESOURCE NO. 4= VIB ROLLERS
RESOURCE NO. 5= AMSS LRU

RESOURCE	1	2	3	4	5
DESIRED LIMIT	5	12	6	6	4
CRITICAL LIMIT	5	19	8	6	6
USAGE VS TIME:					
1 PERIOD	0	16	0	0	0
2 PERIOD	2	13	1	1	0
3 PERIOD	2	13	1	1	0
4 PERIOD	5	10	1	1	1
5 PERIOD	3	9	1	1	1
6 PERIOD	3	5	0	0	0
7 PERIOD	3	5	0	0	0
8 PERIOD	5	3	2	4	0
9 PERIOD	5	3	2	4	0
10 PERIOD	5	2	6	6	4
11 PERIOD	5	2	6	6	4
12 PERIOD	5	2	2	1	4
13 PERIOD	5	2	2	1	4
14 PERIOD	5	2	0	0	4
15 PERIOD	5	2	0	0	4
16 PERIOD	5	2	1	2	4
17 PERIOD	5	2	1	2	4
18 PERIOD	5	2	2	1	6
19 PERIOD	3	1	4	2	6
20 PERIOD	3	1	5	3	2
21 PERIOD	3	1	1	1	2
22 PERIOD	3	1	2	2	2
23 PERIOD	3	1	1	1	2
24 PERIOD	3	1	0	0	2

Table D-26. LSA Critical Path Solution, NRL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	10	CLR PALLET STG AREA	1	1	22
1	2	CLR A1	1	3	0
1	5	CLR A2	1	2	10
1	3	CLR AA UA	1	1	7
1	4	CLR A3	1	2	4
2	7	STR A1	4	4	0
3	6	STR AA/UA	2	1	7
4	11	STR A3	3	5	4
5	12	STR A2	3	3	10
6	8	ST F AA/UA	3	1	7
6	13	CRG AA/UA	3	1	15
7	9	ST F A1	8	2	0
7	14	CRG A1	8	4	8
7	20	CLR TRK LDG AREA	8	2	10
8	19	AMSS SFG UA	4	2	9
8	17	FG AA/UA	4	2	9
8	11	FIN F AA/UA	4	1	7
9	25	AMSS SFG A1	10	10	5
9	15	FG A1	10	4	4
9	12	FIN F A1	10	6	0
10	25	FG PALLET STG AREA	2	1	22
11	18	ST F A3	8	2	4
11	13	DMY	8	0	11
12	16	ST F A2	16	2	0
12	14	DMY	16	0	4
13	24	CRG A3	8	4	11
14	21	CRG A2	16	2	4
15	25	AMSS SFG A2	18	7	0
15	22	FG A2	18	3	2
16	15	DMY	18	0	0
16	20	FIN F A2	18	2	0
17	19	DMY	10	0	5
17	24	ST FG A3	10	2	11
18	17	DMY	10	0	5
18	24	FIN F A3	10	9	4
19	25	AMSS SFG A3	10	10	5
20	23	ST F TRK LDG AREA	20	2	0
20	21	DMY	20	0	2

continued

Table D-26. Continued

21	25	CRG TRK LDG AREA	20	3	2
22	25	FG TRK LDG AREA	22	2	1
23	22	DMY	22	0	1
23	25	FIN F TRK LDG AREA	22	3	0
24	25	FIN FG A3	19	2	4

TOTAL PROJECT DURATION= 24 PERIODS

Table D-27. LSA Resource Usage, RL

TABLE OF RESOURCE USAGE FOR ALL RESOURCES

DESCRIPTION OF RESOURCE CODE:

RESOURCE NO. 1= SCRAPERS(TAMB1900)
RESOURCE NO. 2= DOZERS(TAMB2462)
RESOURCE NO. 3= GRADERS(TAMB1080)
RESOURCE NO. 4= VIB ROLLERS
RESOURCE NO. 5= AMSS LRU

RESOURCE	1	2	3	4	5
DESIRED LIMIT	5	12	6	6	4
CRITICAL LIMIT	5	19	8	6	6

USAGE VS TIME:

1 PERIOD	0	12	0	0	0
2 PERIOD	2	9	1	1	0
3 PERIOD	2	9	1	1	0
4 PERIOD	5	6	1	1	1
5 PERIOD	3	9	1	1	1
6 PERIOD	3	9	0	0	0
7 PERIOD	3	9	0	0	0
8 PERIOD	5	7	2	4	0
9 PERIOD	5	7	2	4	0
10 PERIOD	5	2	6	6	0
11 PERIOD	5	2	6	6	0
12 PERIOD	5	2	2	1	0
13 PERIOD	5	2	2	1	0
14 PERIOD	5	2	0	0	0
15 PERIOD	5	2	0	0	4
16 PERIOD	5	2	1	2	4
17 PERIOD	5	2	1	2	4
18 PERIOD	5	2	2	1	6
19 PERIOD	3	1	4	2	6
20 PERIOD	3	1	5	3	6
21 PERIOD	3	1	1	1	6
22 PERIOD	3	1	2	2	6
23 PERIOD	3	1	1	1	6
24 PERIOD	3	1	0	0	6

Table D-28. LSA Critical Path Solution, RL

TABLE OF SCHEDULED STARTS:

ACTIVITY		DESCRIPTION	SCHEDULED START	DURATION	REMAINING SLACK
1	10	CLR PALLET STG AREA	1	1	0
1	2	CLR A1	1	3	0
1	5	CLR A2	1	2	4
1	3	CLR AA/UA	1	1	0
2	7	STR A1	4	4	0
3	6	STR AA/UA	2	1	0
4	11	STR A3	3	5	0
5	12	STR A2	7	3	6
6	8	ST F AA/UA	3	1	0
6	13	CRG AA/UA	3	1	4
7	9	ST F A1	8	2	0
7	14	CRG A1	8	4	4
7	20	CLR TRK LDG AREA	8	2	10
8	19	AMSS SFG UA	4	2	9
8	17	FG AA/UA	4	2	4
8	11	FIN F AA/UA	4	1	3
9	25	AMSS SFG A1	15	10	0
9	15	FG A1	10	4	4
9	12	FIN F A1	10	6	0
10	25	FG PALLET STG AREA	2	1	22
11	18	ST F A3	8	2	0
11	13	DMY	8	0	0
12	16	ST F A2	16	2	0
12	14	DMY	16	0	0
13	24	CRG A3	8	4	7
14	21	CRG A2	16	2	2
15	25	AMSS SFG A2	18	7	0
15	22	FG A2	18	3	1
16	15	DMY	18	0	0
16	20	FIN F A2	18	2	0
17	19	DMY	10	0	5
17	24	ST FG A3	10	2	7
18	17	DMY	10	0	0
18	24	FIN F A3	10	9	0
19	25	AMSS SFG A3	15	10	0
20	23	ST F TRK LDG AREA	20	2	0
20	21	DMY	20	0	0
21	25	CRG TRK LDG AREA	20	3	2
22	25	FG TRK LDG AREA	22	2	1
23	22	DMY	22	0	0
23	25	FIN F TRK LDG AREA	22	3	0
24	25	FIN FG A3	19	2	4

TOTAL PROJECT DURATION= 24 PERIODS